Distr.
LIMITED

UNEP/OzL.Pro/ExCom/18/73
31 October 1995

ORIGINAL: ENGLISH

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

Eighteenth Meeting
Vienna, 22-24 November 1995

TECHNOLOGY UPGRADES

This revised paper was prepared by the World Bank with input from the Fund Secretariat and incorporates comments from some members of the Executive committee on an earlier draft (UNEP/OzL.Pro/ExCom/16/15). The Executive Committee may wish to consider the relevance of the arguments presented in paragraphs 32-35; and the recommendation in paragraph 41 in respect of calculation of incremental cost.

Request from the Executive Committee

1. The Multilateral Fund is charged with channeling grant resources provided to developing countries to meet the incremental costs associated with the phaseout of Ozone-Depleting Substances (ODS). The broad policy of the Fund is set out in the Montreal Protocol (article 10) and in the *Indicative List of Categories of Incremental Costs* (Appendix I to Decision II/8, adopted by the Second Meeting of the Parties in London in June, 1990). The Executive Committee of the Multilateral Fund has the leading role in interpreting these broad policy instruments while approving grants for ODS phaseout projects. In general, grants are made only for agreed incremental costs; that is, for eligible expenditures that are incremental to expenditures that would *otherwise have been incurred* to achieve essentially the *same level of service* to the country concerned.

2. At the Fifteenth Meeting of the Executive Committee, “A number of projects submitted had components which the Secretariat, and, in some cases, the implementing agencies considered an upgrade of existing technology, not essential for conversion. The Executive Committee requested the Secretariat to consult with sector experts and implementing agencies on how to deal with this issue before the Sixteenth Meeting” (UNEP/OzL.Pro/ExCom/15/45, para 125). The Fund Secretariat requested the World Bank to be the lead agency in the preparation of this paper.

3. From the perspective of that EC directive, this paper examines the issues related to technological upgrading in projects submitted for funding, and recommend policies for evaluating incremental costs in such projects. A working definition of technological upgrading is provided in the next section. Technological upgrading is then categorized, and the issues related to technological upgrading in each category are identified through case studies and several examples. The methodologies for the quantification of technical upgrades in incremental cost calculations are then examined from the perspective of these case studies and recommendations are formulated for consideration by the Executive Committee.

Definition of Technological Upgrade

4. The concern with technological upgrading in the Montreal Protocol grant making process arises because of the change in the level of services that is introduced as a consequence of the conversion process. This is particularly applicable in the case of those enterprises which, prior to phaseout, produced products (or had production processes) that were less sophisticated than the norm in their sector. These enterprises may be able to get additional advantages such as superior quality of their products, increased production capacity, reduced energy consumption and labour and/or other advantages as a result of the non-ODS (or low-ODS) technology adopted by them during the phaseout conversion process. This might increase their competitiveness in the market relative to other enterprises (that had comparatively more sophisticated technology prior to phaseout).

Categorization of Technological Upgrade

5. The following two categories of technological upgrade have been identified in analyzing the projects considered by the Executive Committee :

Category One: Upgrading happens as a conscious selection for the better. In other words, upgrading is an add-on to functional conversion. (Add-On Technological Upgrading).

Category Two: Upgrading happens inadvertently as an inevitable result of the advancement of science and technology. In other words, it is part-and-parcel of the conversion. (Inevitable Technological Upgrading)

Category One: **Add-On Technological Upgrading**

6. Category One is related to ODS phaseout projects when an upgrade of existing technology is not critical or essential for conversion but rather associated with the technical policy of the enterprise to bring its operation to a higher level of technological sophistication. While the equipment included in these projects are needed for conversion, their level of technological sophistication is not conversion driven.

7. Equipment where varying levels of technological upgrading could be encountered include:

(a) Refrigerant charging machines when additional capacity and optimal features are not required, e.g., in the conversion from CFC-12 to HFC-134a;
(b) Foam machines when higher capacity and optional features not essential for conversion are requested in project proposals;
(c) Helium leak detector and Helium recovery unit, when existing halogen leak detector can be replaced with less expensive gas detecting systems applicable for conversion;
(d) Test equipment for domestic refrigerator projects, when retrofitting of existint facilities can be applied, and including Refrigerator computerized performance testing systems, if similar level of testing and quality control was not in place before the conversion;
(f) Replacement vacuum pumps (as opposed to retrofits) in domestic refrigerator projects;
(g) Plant reconfiguration to accommodate more sophisticated foaming lines and multi-headed foam injection machines, if such facilities machines were not in place before the conversion;
(h) Forced cooling in flexible foams, for some technologies like acetone based technology;
(i) Replacement of batch cleaning systems with continuous cleaning systems, if the batch-cleaning systems can be adapted/modified for use with non-ODS, or low-ODS substitutes;
(j) Sophisticated monitoring, and process and quality control systems, if similar systems were not in place before the conversion, and are not required because of process or safety reasons associated with the conversion.

8. The following case study describes a project where “add-on” technological upgrade was noted.

Case Study of a Mobile Air Conditioner (MAC) Project

9. The enterprise that submitted the project for funding is a manufacturer the heat exchanger assemblies (consisting mainly of evaporators and condensers) for MACs. The estimated cost of

the heat exchanger conversion project, including contingency, was US$4.8 million; US$4.23 million was requested as incremental costs from the Fund. The project included an aluminum/aluminum brazing capacity. This capacity was required as many MAC customers specified aluminum/aluminum serpentine heat exchangers in the new HFC-134a evaporator and condenser designs.

10. The Secretariat noted that a heat exchanger conversion project at another enterprise in the same country had been approved for US$3.7 million; a comparison of the two projects indicated that the difference in funding requests was largely because the project from the other enterprise excluded an aluminum/aluminum brazing capacity that was included in the project under consideration instead of existing copper/aluminum tube-fin heat exchangers. The other enterprise (whose conversion project had been approved earlier) had established an aluminum/aluminum brazing facility prior to conversion, and had been offering aluminum/aluminum heat exchanger assemblies with the CFC-12 MACs as well.

11. This raised the technical question whether the shift to aluminum-aluminum heat exchangers from copper-aluminum heat exchangers was an integral part of the conversion to HFC-134a systems. The enterprise noted that their customers required the shift from copper to aluminum for HFC-134a MAC systems to avoid a potential degradation in service due to perceived interaction between copper and HFC-134a.. However, the technical reports presented as part of project evaluation documentation dismissed concerns that copper/HFC-134a would lead to greater copper contamination, and, consequently, in HFC-134a systems, copper contamination would not be expected. In the context of the conversion to HFC-134a MAC systems, the aluminum/aluminum brazing facility was an “add-on” upgrade.

12. In the proposal, project costs were separated into components associated with the conversion of evaporator line and the condenser line; the balance being treated as common costs. Initially, it was agreed that the incremental costs associated with condenser conversion were eligible for 100 percent grant financing; it was further agreed that at least some fraction of the incremental costs associated with evaporator conversion and those in the common costs category were eligible.

13. The Secretariat suggested that the list of customers requiring design changes (provided by the enterprise in the project document) be used to calculate the fraction of evaporators that would be supplied to these customers. The incremental evaporator-line conversion costs would be reduced by this fraction when calculating the grant. Similarly, the incremental costs in the common category would be reduced by the fraction that represented the evaporators supplied to the change-requiring customers in the total number of evaporators and condensers manufactured. Based on this methodology, US$427,680 were calculated as ineligible evaporator-line conversion costs (from a requested amount of US$891,000), and US$59,675 were calculated as ineligible costs in the common costs category (from the requested US$420,200). The total grant approved was US$3.74 million; US$487, 355 less than the requested amount of US$4.23 million.

Category Two: **Inevitable Technological Upgrading**

14. In order to bring out the issues involved in determining inevitable technological upgrading, two projects are discussed in detail. The two projects are a set of six commercial refrigeration projects, and a compressor production conversion project.

Case Study of a Set of Six Commercial Refrigeration Projects

15. This proposal was submitted by a country where there is a very large amount of CFC-12 consumption in the commercial refrigeration sector; about 70 percent of which is for service and maintenance. The national strategy for ODS phaseout in this sector originally called for the development of indigenous HCFC-22 compressor technology for a variety of applications in the subsector. The time scale for this development, the availability of proven international technology, and the non-recognition of development costs as eligible incremental costs persuaded the national government to acquire international technology.

16. The CFC-12 based compressor manufacturing technology in use in the country had also been developed indigenously, and is relatively unsophisticated in terms of process automation, control systems, etc. The import of HCFC-22 compressor production facilities on a turnkey basis implied the establishment of technologically-sophisticated compressor manufacturing lines based on numerically-controlled multitask machining centers.

17. The implementing agency noted the technological upgradation of the assembly lines implicit in this conversion, and the associated potential increases in productivity. This raised the question of whether the change in production facilities was an integral part of the conversion to HCFC-22 systems, or associated with the import of technology.

18. The higher system pressures and pressure differences in HCFC-22 systems (compared to those in CFC-12 systems) imply the need for high-accuracy machining of the interfaces between the high and low pressure sides of the compressor in order to contain leakages. In addition, the greater forces resulting from higher system pressures require moving parts to be machined more accurately.

19. The consequences of utilizing the existing production facilities to manufacture HCFC-22 compressors would result in compressors with lower energy efficiency (since the increased leakages would lead to higher amounts of gas being uselessly recompressed), and with lower reliability (owing to the greater forces that would be acting on the moving surfaces formed with low accuracy). Both of these effects would result in a loss of service to the national economy; clearly in contradiction to the central principles of Fund operation.

20. Technological upgrading associated with the conversion to HCFC-22 compressors was found to be an inevitable feature of the conversion. The upgrading, however, does imply a potential increase in the future productivity and quality of the product (and hence future profits) of the enterprises. In the short-term, however, these potential profits would not be attained as the existing plant capacities are in excess of the demand, and because the HCFC-22 compressors might be introduced in the market at the same price as the existing CFC-12 compressors in order to enable phaseout.

21. The cost of the six commercial refrigeration projects, encompassing the conversion of CFC-12 compressor assembly lines to HCFC-22 assembly lines in five enterprises (and to ammonia in one enterprise), was calculated as about US$20 million (100 percent grant financing of capital costs). At this level of financing, the financial internal rate of return (FIRR) for each of the enterprises ranged between 9.3 percent and 17.7 percent (at a discount rate of 12 percent, which is used for projects in the country). The current opportunity cost of capital in the country is assessed to be 15 percent; three of the enterprises had FIRRs higher than that.

22. It was calculated that with grants which were 80 percent of the incremental costs, the FIRR of the projects was between 7.8 and 11.7 percent. Consequently, all enterprises would assume a minimum cost of using capital to carry out the project. If the grants were lower than 80 percent of incremental costs, the resulting rates of return would be correspondingly lower. This would jeopardize project implementation as the enterprise would likely be unable to obtain the needed domestic counterpart funding, or the enterprise would incur a loss in implementing the project. The national government agreed with this methodology, and requested US$16 million (that is, 80 percent of the incremental costs) from the Multilateral Fund; this grant was approved by the Executive Committee as the incremental cost of the projects.

Case Study of a Compressor Manufacturing Plant

23. The enterprise, a large manufacturer of household compressors, produced about 600,000 CFC-12 units in 1993. In July 1994, the company entered into a joint venture agreement with a firm based in a non-Article-5 country. Under the agreement, the foreign firm acquired a 35% holding in the Article-5 compressor manufacturer in exchange for new technology that would allow production of a more energy-efficient model. The enterprise had been producing dated compressor designs using equipment that was mostly acquired in 1977. The new joint venture agreement also included plans to triple the plants production capacity to 1.8 million units and convert to production of HFC-134a compressors by 1995. The enterprise submitted a proposal based on 65% local ownership.

24. The joint venture agreement, to upgrade the compressor technology, triple production, and convert to HFC-134a contained elements eligible for financing, but presented challenges in distinguishing eligible capital expenditures from those being undertaken to improve the compressor’s efficiency and expand the plant’s capacity. To ensure that only eligible expenses were included in the project proposal, the proposal was careful to exclude any of the costs associated with the basic technology upgrade to meet the new energy efficiency standards. Next, because the costs associated with the conversion to HFC-134a included expenses related to production expansion, costs were re-assessed to include only those items which would have been required had production been maintained at existing levels. This was done by pro-rating total costs to reflect existing capacity. The project was consequently approved for MP financing.

Identification of Technological Upgrade

25. Ideally, technological upgrade components must be identified and recognized by the implementing agencies during project formulation as ineligible incremental cost

26. The process of identification of technological upgrade will be greatly assisted by the development of generic project phaseout specifications and designs which are under preparation now. The meeting of consultants working on Multilateral Fund activities (Paris, 5-8 July 1995) discussed and agreed on development of “templates” on several conversion options in different sectors. The generic technology options are being developed in conjunction with associated price ranges, scaling factors and applicable site specific caveats and/or variables. Technology options and individual project components and their individual technological sophistication levels should be compared against these agreed standards. This will facilitate the identification of technological upgrade. Templates on several CFC phase-out sectors will be submitted to the next Executive Committee Meeting.

27. Comprehensive technical appraisal should decide the presence or absence of technological upgrade. If technical appraisal identifies technological upgrade, it should advise on a methodology to be applied for quantification of this technological upgrade.

Quantification of Technological Upgrade

28. Several methodologies for the quantification of technological upgrades could be considered.

Comparison with established standards

29. One method is the comparison of requested technologies and equipment against the established standards taking into account the existing level of technological sophistication at the enterprise. The enterprise might insist on having more sophisticated technology and equipment for its own specific reasons. The costs applicable to the basic standard option will be considered as eligible incremental costs. The additional costs might be financed by the enterprise itself. This approach has been exercised in several projects.

Pro-rata division of project costs

30. The second method is associated with the pro-rata division of project costs into eligible and ineligible incremental costs on the basis of the list customers requiring design changes related to technological upgrade. This approach was used in the MAC project. The list of automotive companies who wanted aluminum-aluminum evaporators was identified and used for evaluating the fraction of eligible incremental costs.

31. The third method is based on the pro-rating of costs to reflect the ratio of existing and increased capacity resulting from technological upgrade. Cost associated with increased capacity are not eligible incremental costs. This method was used in the project on conversion of compressor manufacturing plant. This methodology can be applied in projects when technological upgrade is directly related to increase of capacity of the enterprise.

Analysis of financial position of the enterprise

32. The commercial refrigeration project accepted the principle that as a result of the conversion process, enterprises should receive benefit streams that are reasonably commensurate

with the average level of financial returns in the country. The grant amounts for the projects is determined by comparison of FIRRs and the opportunity cost of capital in the country. This methodology was applied in calculating the technology upgrade in six commercial refrigeration projects in China.

33. This methodology focuses on the financial analysis of the enterprise, and addresses the technology upgradation issue only indirectly within this specific context. The economic dynamics of the enterprise are considered to reflect the average in a fully competitive market, thus limiting the application of this methodology.

Analysis of future market conditions

34. The technological upgrade may result in an expansion of the market share of the enterprise, resulting in benefits which are additional in comparison to the baseline. The grant amount is calculated by comparing the cash flows (benefits and investments) with and without the conversion project.

35. The methodology requires two assessments of the future economic dynamics of the enterprise (one with the conversion project, and the other without it); similar to those carried out by enterprises while requesting commercial loans. This is a resource-intensive exercise in terms of both time and money.

Recommendations

36. To ascertain whether the proposed ODS conversion is yielding a technical benefit to the enterprise beyond the conversion to non-ODS technology, project proposals should include additional information on the company's baseline position. In particular, under the sections on Sector and Enterprise Background, proposals should describe the size of the market in which the firm operates and its relative market position. The Enterprise Background section should also comment on the current level of the technology being used by the enterprise in the context of both national and international standards. Finally, in the Project Description section, the proposal should note whether or not the conversion away from ODS is expected to change the enterprise's level of technology vis-à-vis the baseline.

37. The technical appraisal and review of projects are the key activities in determining the occurrence of technical upgrading.

38. Generic ODS phase-out project specification and design should be developed and used as a tool to identifying and quantifying the technological upgrade.

39. Costs associated with technological upgrade exceeding the basic standard cost should not be considered as eligible incremental costs. The additional costs may be financed by the enterprise itself.

40. In conversion projects where standard costs are not available, pro-rating methodologies can be applied for quantification of technological upgrade when production and/or market

expansion are known. In such cases, the incremental costs would be reduced in proportion to the increase in the production capacity and/or market expansion to calculate the grant amount.

41. In projects where add-on technological upgrading is established, but standard projects and production capacity/market expansion are not determined, the baseline scenarios should be constructed with respect to future investment and benefits streams. The projected investment and benefits profiles of the enterprise (with and without the conversion project) should be reviewed by the technical reviewer and the Implementing Agency to ensure broad consistency with the technological and commercial practices of the enterprise. The incremental costs would be calculated as:

$$IC = [CC - NPV(FI)] + NPV[FB_b - Fb_p],$$

where,

IC is the incremental cost,
CC is the capital cost of the conversion project,
FI is future baseline investments (that would have occurred absent the conversion),
Fb_b is the future baseline benefits (that would have occurred absent the conversion),
and Fb_p is the future benefits with the conversion project.
NPV refers the net present value of a stream of costs/benefits.