UNITED
NATIONS

EP

United Nations
Environment
Programme

Distr.
GENERAL

UNEP/OzL.Pro/ExCom/46/37
10 June 2005

ORIGINAL: ENGLISH

EXECUTIVE COMMITTEE OF
THE Multilateral Fund FOR THE
IMPLEMENTATION OF THE MONTREAL PROTOCOL
Forty-sixth Meeting
Montreal, 4-8 July 2005

STUDY ON CRITERIA AND MODALITIES FOR CHILLER DEMONSTRATION PROJECTS (decisions 45/4 (d) and 45/60)

For reasons of economy, this document is printed in a limited number. Delegates are kindly requested to bring their copies to the meeting and not to request additional copies.

Introduction

1. On the basis of decision XVI/13 of the 16th Meeting of the Parties and the Executive Committee's decision 43/4(d) of the 45th Meeting, the Secretariat has prepared a policy paper regarding criteria and modalities for chiller demonstration projects for the consideration of the Executive Committee. The paper provides a basis for the preparation and subsequent evaluation of demonstration projects for submission to the 47th Meeting of the Executive Committee, to be funded from a funding window of US $15.2 million approved at the 45th Meeting of the Executive Committee. The technical aspects and characteristics of the chiller sub-sector in Article 5 countries, are followed by a section on existing policies and the experience of the Multilateral Fund on the chiller sub-sector, a discussion on incentives and barriers, and the study is concluded by a recommendation for the Executive Committee's consideration.

2. The remaining CFC consumption in almost all countries is related to the refrigeration sector (including Mobile Air Conditioning and servicing of existing systems). Most CFC refrigeration systems in Article 5 countries, in particular Mobile Air Conditioning systems, have only a short remaining lifetime. In addition, there are a number of technical possibilities available to convert refrigeration systems with a life beyond 2010 into non-CFC alternatives, to avoid premature replacement needs; these conversions can be carried out during a scheduled maintenance and might not increase the costs of that maintenance significantly.

3. The exception in the refrigeration sector is centrifugal chillers, where the estimated conversion costs are substantially higher than typical maintenance costs. Despite potentially significant gains realized through energy savings, centrifugal chiller owners are hesitant to convert. Consequently, it has been recognized that although these centrifugal chillers cause only a relatively low level of ODS consumption, this might still pose a certain impediment for Article 5 countries in achieving compliance.

4. Upon receiving a report from the TEAP Chiller Task Force, the 16th Meeting of Parties subsequently requested the Executive Committee of the Multilateral Fund through decision XVI/13 to consider:

(a) Funding of additional demonstration projects to help demonstrate the value of replacement of CFC-based chillers, pursuant to relevant decisions of the Executive Committee;

(b) Funding actions to increase awareness of users in countries operating under paragraph 1 of Article 5 of the impending phase out and options that may be available for dealing with their chillers and to assist Governments and decision makers; and

(c) Requesting those countries preparing or implementing refrigerant management plans to consider developing measures for the effective use of the ozone depleting substances recovered from the chillers to meet servicing needs in the sector.

5. The Secretariat provided the Executive Committee in preparation for its 45th Meeting with a "Review of the Executive Committee's Activities in the Chiller sub-sector" (document UNEP/OzL.Pro/ExCom/45/Inf.4). As part of the discussion on business planning, at its 45th Meeting, the Executive Committee reviewed the issue of projects in the chiller sub-sector in the light of decision XVI/13 of the Parties. The Executive Committee subsequently decided to establish a funding window in 2005 amounting to US $15.2 million for the chiller sub-sector from funds which remained uncommitted in the 2003-2005 triennium.

6. The Executive Committee also decided (decision 45/4 (d)) to request the Secretariat to prepare a study on criteria and modalities on how a regional fund for the chiller sub-sector might come into operation, taking into account proposals submitted and comments made during the 45th Meeting, for consideration at the 46th Meeting, examining issues such as fairness of funding and any limits on the number or cost of projects to be funded, etc.. Consequently, it was also decided to remove the chiller projects and activities from the 2005-2007 business plans of implementing and bilateral agencies and to invite demonstration projects and project preparation for chiller projects to be presented at the 47th Meeting of the Executive Committee within the funding window for a global programme, based on the criteria agreed at the 46th Meeting of the Executive Committee.

Technical and sub-sector characteristics

7. Water chillers, shortly termed "chillers", are refrigeration systems that cool water or a water/antifreeze mixture. The larger systems of this type are virtually the only refrigeration machines using centrifugal compressors as their main component, and are therefore called centrifugal chillers. These cannot be converted easily to another non-CFC refrigerant. Challenges in conversion and the long economic life pertain only to centrifugal chillers, and therefore this paper focuses exclusively on these centrifugal chillers as they pose a specific challenge for the phase out of CFCs in the refrigeration sector.

8. Centrifugal chillers are long-term investment goods with a maximum economic life of 30 years. The report of the Chiller TEAP Task Force provides an estimate of the total number of CFC-based centrifugal chillers which varies from 15,000 units to 20,000 units in Article 5 countries, while the global inventory of CFCs in those chillers is estimated to be within the range of 6,000 to 8,000 ODP tonnes. If the number of CFC-based centrifugal chillers in Article 5 countries remains unchanged for the next two and a half years, the CFC consumption for centrifugal chiller servicing needs would represent 7.5% of the total global CFC consumption in Article 5 countries. The report of the Chiller TEAP Task Force also stresses the need to take a look at the whole chiller sub-sector in a given country, in order to arrive at an optimum phase-out strategy for this sub-sector. Because of progress in the chiller technology achieved already today, a replacement of the existing CFC chillers with newly designed, optimised machines would lead to reductions in energy consumption between 28% and 45%. More detailed information can be found in Annex I of this paper.

Existing policies and experience of the Multilateral Fund in the chiller sub-sector

9. As early as its 8th Meeting, the Executive Committee approved projects for retrofitting 25 chillers and replacing four chillers. Subsequently, one project involving retrofitting 21 chillers was cancelled, one project for replacement of three chillers was implemented without assistance from the Multilateral Fund, and two projects were completed. After considering a report on retrofits of MAC and chillers (document UNEP/OzL.Pro/12/33) at its 12th Meeting, the Executive Committee adopted decision 12/28 which included the following recommendations on chiller project proposals:

(a) Refrigerant containment and better operation and maintenance practices, including recovery, recycling and reclamation should be considered;

(b) The Executive Committee approved replacement of CFC chillers as a first priority, taking into consideration energy savings when calculating the incremental costs of replacement; however, the Executive Committee deferred consideration of projects to retrofit chillers, except in special cases and when definite substitutes were used; and

(c) The Executive Committee encouraged Article 5 countries to give full consideration to appropriate regulatory and legislative action facilitating the implementation of CFC phase-out projects in the chiller sub-sector.

10. Following decision 12/28, two chiller replacement projects using loan mechanisms were approved for Thailand (at the 26th Meeting) and for Mexico as part of the United Kingdom's bilateral assistance project (at the 28th Meeting). At the 35th Meeting, an Agreement for the total phase out of CFCs in Turkey was approved by the Executive Committee, which included a significant chiller component. One additional chiller replacement project was approved at the 37th Meeting for Côte d'Ivoire as part of France's bilateral assistance activities. The Executive Committee approved the latter project on the understanding that it would complete the cycle of demonstration projects in the chiller sub-sector for each region, and that no further chiller demonstration projects would be forthcoming (decision 37/27). Other projects approved between the 26^{th} and the 37^{th} Meetings are: one project that focussed on emission reduction, refrigerant containment, recovery and recycling in chillers installed in Viet Nam, and another project for emission reduction and refrigerant containment in four chillers in Syria, both being approved as part of France's bilateral activities, and both not yet in a position to report substantive results.

11. Mexico and Argentina submitted annual work programmes including reallocation of approved funds within their national phase-out plans, allowing for a second phase of a chiller replacement programme for Mexico, and in the case of Argentina for a new chiller replacement programme on the basis of a revolving fund with national co-financing. A reallocation of US $500,000 was requested through the Annual Implementation Programmes for both plans.

Project experience

12. From the projects, sub-projects, demonstration projects and project preparations funded for the chiller sub-sector, there are a number of important insights which can form the basis for criteria and modalities on how future demonstration projects for the chiller sub-sector might come into operation:

(a) The Executive Committee approved a stand-alone loan project for Thailand with subsequent international co-financing through the GEF, matching the Multilateral Fund contribution. The World Bank has already returned part of the allocated loan to the Multilateral Fund. The project covers 50 of Thailand's estimated 1,478 chillers. The stated purpose of the project is an evaluation of the feasibility of using a revolving fund mechanism. The initial demonstration of savings achieved facilitated the creation of similarly targeted, but larger loan programmes in Thailand driven by national banks and centrifugal chiller manufacturers without the involvement of the Multilateral Fund;

(b) For Mexico, the Executive Committee approved the first phase of a two-phase project as a bilateral contribution from the United Kingdom, and a subsequent second phase as part of a phase-out plan. This first phase was co-financed nationally with matching funds through an energy-saving fund. A second phase of the project was recently approved as part of Mexico's 2005 annual work programme of its National phase-out plan. Phase 1 of the project was targeted towards a particular region in Mexico, targeting 12 centrifugal chillers out of Mexico's estimated total of 1,500 chillers; phase 2 is targeting another ten chillers. Both phases are open, i.e. more chillers will enter the programme until the funding is completely used up;

(c) For Turkey, a chiller sub-project was integrated into the National phase-out plan, creating an interest-free revolving fund utilizing the high share of the total funding disbursed in the early annual tranches of the National phase-out plan. Effectively, Turkey managed to use front-loaded multi-year, performance-based funding to create a revolving fund with minimum costs for other components of the phase-out programme. In total, there are an estimated 2,500 centrifugal chillers installed in Turkey, of which 19 are so far addressed through the project. Similar to Mexico, the number of chillers to be converted is open until depletion of funds; the target value is 65 chillers; and

(d) Preparations for a chiller replacement project were carried out in India where in total, more than 1,100 chillers are installed. It was found that a large number of centrifugal chillers more than 30 years old are still operating. However, under the specific local conditions, the annual costs of owning and operating a chiller are increasing after 10 years, if normal business calculation models are used. The energy savings would normally pay back the investment of new chillers within 4 to 6 years under the local conditions in India.

13. The above activities have provided a number of important lessons for the preparation and implementation of projects in the centrifugal chiller sub-sector:

(a) It was found that different methodologies are necessary containing a high degree of flexibility to adapt a programme to the needs in different countries;

(b) Support for the replacement of existing chillers, short of funding full replacement, can be provided in a number of different ways such as rebates, loans to the owner, or performance contracting where the technology provider guarantees energy efficiency;

(c) An apparent high degree of initial scepticism among owners requires effective communication to dispel, particularly during the start-up phase. Experience shows that once the benefits of chiller replacement became clear, the motivation of the owners usually turned out to be good;

(d) One driving factor for replacements is the perception of phase out of CFC supply in the near future. National policies regarding the phase out of CFCs have turned out to be a precondition for the interest of a large number of centrifugal chiller owners in replacement projects;

(e) There is significant interest from the chiller manufacturers who wish to market their products. Their marketing effort includes activities such as identifying chiller owners, awareness, assessing the owners need for replacement, their interest and potential for support. Manufacturers of centrifugal chillers have excellent avenues for communicating with chiller owners; and

(f) The demonstration projects have shown that replacement of existing chillers can take place in the case of partial grants as well as on a loan basis. At the same time it has become clear that the amount of financial support required for chiller replacement varies depending on national conditions.

Existing positive incentives

14. Replacement of a CFC-chiller by a new non-CFC type leads to significant benefits in terms of reduced consumption of electrical energy, so benefiting owners, countries and the global environment. These benefits vary for different framework conditions. The most important framework conditions are:

(a) The quality of the present CFC chiller, influencing strongly the difference between the present status and a potential replacement;

(b) The local climate and the task of the chiller, influencing the number of operating hours per year under partial and full load conditions;

(c) The costs of electricity; and

(d) The amount of CO_2 emitted per kWh produced relevant to the respective country.

15. The different beneficiaries benefiting from replacement of out dated and inefficient chillers through a chiller demonstration project are shown in the following table. It also contains indications of which financial mechanisms could be used to raise income for a centrifugal chiller replacement programme:

Advantage	Beneficiary	Potential funding	
		Source	Use
Reduction of electricity costs	Owner or lessee	Reduced electricity cost	Payback into fund used for purchase of new chiller
Reduction of load on local and national electricity supply during peak consumption time (in particular in tropical countries), with the additional benefit of lower needs for national power plant capacity and reducing the dependence on imports, where valid	Electricity companies, national government	Energy saving funds	Payback into fund for purchase of new chiller
Reduction of consumption and emission of ODS	Global environment	Multilateral Fund	Establishment of fund for purchase of new chiller or replenishment of regional / global fund
Reduction of emission of CO_2 through reduced use of electrical energy	Global environment	National environment or greenhouse gases fund, international finance instruments such as GEF[1], CDM[2]	Payment into fund for purchase of new chiller or replenishment of regional / global fund

16. Some available data facilitates the development of an understanding of the financial benefits of chiller replacement outside the Montreal Protocol, such as a reduced need for investments into peak capacity of the national electricity supply infrastructure. The annual reduction in emission of CO_2, depending on the electricity generation, would be in the order of 100 to 500 tonnes of CO_2/chiller/year. If tradable, e.g. through a CDM approach, emission reduction of this magnitude would generate an income between US $10,000 and US $50,000[3].

17. Despite these benefits and the general possibility to undertake efforts to secure additional funding, there has been no trend until now or initiative to replace chillers in large numbers in Article 5 countries.

[1] The GEF, Global Environment Facility, grants support, typically as co-funding, to projects related inter alia to climate change

[2] The CDM, Clean Development mechanism, is an instrument of the Kyoto Protocol. Proven reductions in CO_2 emissions, resulting for example from energy efficiency gains, can be transferred into Carbon Emission Rights, a tradable commodity. These rights can be purchased for a market price by interested government, industry etc. Presently, the price per tonne CO_2equivalent is in the order of US $6 to $10 on the World market and up to US $15/tonne CO_2e in Europe.

[3] Using a carbon price of US $10/tonne CO_{2e} for a 10 year period

Barriers

18. Although typically the savings relate to reductions in energy consumption, which alone make the replacement of old chillers an economically viable option, such replacement often does not take place without additional external stimuli. Possible reasons for the reluctance to replace old chillers consist of a number of barriers, such as:

(a) Lack of trust in the claim of lower-energy consumption;

(b) Building is on lease, thus investment and operating costs are covered by different entities;

(c) Non-availability of any investment budget (in particular in public buildings);

(d) Alternative investments offer a better return on investment than chiller replacement;

(e) Lack of perception of need to change; and

(f) Access to financing is difficult, or costs of loans are prohibitive.

Discussion of criteria and modalities

General

19. The Executive Committee requested the Secretariat to prepare a study, with input from the implementing agencies, on criteria and modalities for chiller demonstration projects. The Secretariat held a co-ordination meeting for that purpose with the three implementing agencies specialising in investment projects (UNDP, UNIDO and the World Bank) on 20 May 2005, in Montreal.

20. In this meeting, all participants mutually agreed that, as a preliminary step, a general set of criteria and modalities based on existing experience within the Multilateral Fund should be used. On the basis of first experience of the agencies during project preparation, the general set of modalities and criteria can be reviewed and developed further. This would require, during the post 46^{th} Meeting period and before the 47th Meeting of the Executive Committee, a significant effort by the agencies with proactive co-ordination by the Secretariat to ensure that the evolving lessons learned are immediately universally discussed and, where applicable, used by all agencies.

21. A study undertaken by the World Bank showed a possibility of quantifying the barriers to change in financial terms; an abbreviated version of this study is attached to this document as Annex II. The World Bank uses the discount rate to quantify this barrier, and essentially specifies how attractive the chiller replacement has to be for the owner to initiate conversion. The discount rate defines in this case the ratio between future annual profits and today's investment needs. In many business environments, positive investment decisions are being taken if the discount rate is in the order of 10% to 15%, as an annual return on the initial investment.

The World Bank, using data on the timing, cost and benefits of investment decisions by chiller owners to replace their chillers, in particular in India, compared the actual data to different discount rates and found that a discount rate of 30% models best the behaviour of the chiller owners.

22. As specified above, a number of framework conditions can influence the owner's benefits from the replacement of a chiller. If it can be assumed that the owner will react and replace the chiller once a certain level of incentive is reached, this can be used to determine the maximum funding needs for a phase-out programme. In this case, a mathematical and business model was developed by the World Bank, also described in the same Annex II which requires data allowing quantification of various advantages of conversion. This data consists of the age of the present chiller, its energy consumption, the expected energy consumption of a new chiller, running hours per year and similar inputs. It can then be calculated how much funding is needed to make the project attractive to the chiller owner, the attractiveness being defined through the discount rate. This funding need might subsequently be catered for either through the Multilateral Fund or by other funding sources or both.

23. The meeting between the Secretariat, UNDP, UNIDO and the World Bank came to the mutual conclusion that the country-specific and chiller-specific framework conditions regarding the benefits of chiller replacements should be taken into account in determining the project and country-specific level of funds needed to implement a chiller demonstration project, and that this mathematical and business model represents presently the best basis for such calculations. One important consequence is that chiller projects will typically, depending on the conditions in the country, receive funding between approximately 10% and 25% of the replacement costs of the chillers concerned; the remaining costs will have to be covered by income from other benefits of the replacements, in particular energy savings.

24. The meeting also agreed that agencies would develop their own methodologies and projects, funded through project preparation approvals for the agencies. The issue of regionalisation was discussed at length, and it was felt that it would not be possible to have regionalisation of revolving funds as a precondition for project approval for two reasons. Firstly, even in the case of regional programmes, potential fund backflow from payments constitutes currency transfer outside the country of the beneficiary, a condition potentially not acceptable to all countries. Secondly, some agencies pointed to the difficulties of balancing the different stakeholders and beneficiaries in regional projects, leading sometimes to serious implementation impediments. While regionalisation could not therefore form a firm requirement, the participants agreed that it might be a useful way forward, where applicable.

25. The necessity to have the CFC phase-out policies in place in the countries of operation was seen as a necessary precondition for projects. Similarly, the meeting felt that the availability of financial resources outside the Multilateral Fund such as national programmes, GEF funding or other programmes should form mutually agreed preconditions for the disbursement of funds. The mutual views of the agencies and the Secretariat, based on widespread and extensive experience, was used as one important input into this document.

Specific issues for consideration

26. The Executive Committee had requested the Secretariat to examine issues such as the fairness of funding, funding levels, and number of projects. Based on the opinions voiced during the discussion of the Executive Committee, fairness is being interpreted as equity, here defined as a wide access to information leading to funding for the phase out of CFC-based centrifugal chillers. Given the significant benefits of chiller replacements, such equity is not contingent upon the provision of Multilateral Fund resources. Past decisions of the Executive Committee on eligibility, incrementality and cost effectiveness of projects under the Multilateral Fund do not at present suggest a policy change towards large-scale funding of chiller replacement programmes through the Multilateral Fund. On that basis, fairness might be achieved by concentrating on the additional benefits of chiller replacements other than reduction of CFC consumption, and by optimising the efforts to mobilise funding based on those benefits.

27. The existing experience suggests that funding levels of US $500,000 to US $1,000,000 (grant) or US $2,500,000 (loan) have been sufficient to create significant replacement programmes in a country, provided that additional financial resources were available. Canada proposed at the 45th Meeting a maximum grant funding level of US $1,000,000 per project. In terms of funding per chiller, taking into account the specific conditions of the country and the chiller itself, it has been shown that chiller owners are willing to invest if they can expect annually between 15% (typical) and 30% return on their initial investment.

28. The number of projects will be limited by the funding available, with prioritisation, if necessary, on the basis of share of financial resources outside the Multilateral Fund and discount rate used, as well as regional distribution. The proposal by Canada, at the 45th Meeting of the Executive Committee, suggested four regions as the basis to determine regional distribution: East Asia, West Asia, Africa and Latin America and the Caribbean. A further criterion for priorities could be the share of consumption in the servicing of centrifugal chillers as compared to the total CFC consumption of the country.

Non-investment activities

29. Decision XVI/13 of the Meeting of the Parties requests the Executive Committee to fund actions to increase awareness of users in countries operating under paragraph 1 of Article 5 of the impending phase out and options that may be available for dealing with their chillers and to assist Governments and decision makers.

30. Intensive exchanges with UNEP on the possible role of non-investment projects were conducted by phone, letters and e-mail. It should be noted that national commercial stakeholders, in particular banks and centrifugal chiller manufacturers and their affiliates, might very effectively reach out to individual owners. The role of the Multilateral Fund could be limited to ensuring that unbiased information is available for interested chiller owners, and that the respective governments are fully aware of the issues relating to the chiller sub-sector. The availability of useful information might include assembly and distribution of detailed reports

about technologies, operational procedures, funding methodologies, sources for additional funds and other matters. As part of a consultative dialogue with the Secretariat, UNEP has provided a number of ideas on this issue, which have influenced the preparation of this paper.

Conclusions

31. The 45th Meeting of the Executive Committee created a funding window of US $15.2 million for the year 2005, the final year of the 2003-2005 triennium, for demonstration projects in the chiller sub-sector. The Secretariat incorporated the input of members of the Executive Committee and implementing agencies to arrive at a proposed decision meant to reflect and capture, to the extent possible, the input received. The decision is intended to facilitate the co-ordinated preparation of projects for the chiller funding window, with the aim of receiving proposals for such projects in September 2005 for discussion at the 47th Meeting of the Executive Committee.

32. On the basis of existing experience in the Multilateral Fund a number of significant criteria for demonstration projects could be formulated, which are sufficient to initiate project preparation for chiller replacement projects by the relevant implementing agencies. In addition, a non-investment component is needed to ensure creation of, and access to, technical and operational information for governments and chiller owners. The objective of these activities is to initiate a process leading to replacement of a considerable number of chillers through the use of additional funds related to the energy-efficiency gains from the replacement of old chillers. The funding level should be determined as a combination of country-specific funding per chiller and a maximum grant funding per country. The decision proposed should not be prescriptive of implementation modalities. It would therefore be possible to propose projects on the basis of various methodologies, such as revolving funds, subsidies, or other types of support.

33. In terms of process, the Secretariat proposes that preliminary guidelines are agreed for the preparation of projects and their evaluation and that project preparation funding be approved for all agencies at the 46th Meeting. On that basis, the agencies would develop methodologies and projects for the 47th Meeting. To ensure sufficient coherence of the proposals and to avoid double counting and similar issues, the Secretariat would be requested to co-ordinate the preparation activities.

34. In terms of conditions for projects, five preconditions have been proposed. These cover ODS phase-out legislation, financial resources outside the Multilateral Fund, limited funding per chiller that would be determined in a way that takes into account for the situation of the country and the chiller, maximum funding per country of US $1,000,000, and a general strategy for the chiller sub-sector in the countries concerned. The maximum funding per chiller would incorporate the variety of conditions in the different countries into the decision, such as e.g. different climatic conditions. As a consequence, , chillers with low energy-related savings would receive more support than those with high savings, in order to ensure fairness in the process.

35. The decision would request the Secretariat to evaluate projects using a number of criteria, such as regional distribution and the percentage of the centrifugal chillers consumption in relation to total consumption. These evaluation criteria incorporate a number of suggestions made during the discussion at the 45th Meeting of the Executive Committee, such as the

composition of regional groups and regional funds. The remaining parts of the decision define UNEP's project preparation as well as the funding for all agencies in relation to project preparation.

36. UNDP, UNEP and UNIDO submitted detailed requests for project preparation funding to the Secretariat shortly after the meeting in Montreal on 20 May 2005, referred to in paragraph 19. The Secretariat discussed the requests with the agencies. Subsequently the Secretariat and agencies agreed on substantially revised figures, which are presented in the Secretariat's recommendation below. The World Bank submitted a request for project preparation funding, but upon finalization of this document, the Secretariat and the World Bank had not achieved agreement on the appropriate funding level.

Recommendation

37. The Executive Committee might consider utilizing the funding window of US $15.2 million for additional demonstration projects in the chiller sub-sector as follows:

(a) UNDP, UNIDO and the World Bank are requested to submit to the 47th Meeting of the Executive Committee project proposals to demonstrate the feasibility of and modalities for replacing centrifugal chillers through, in the future, use of resources outside the Multilateral Fund, and which could be replicated in other countries. The agencies are encouraged to submit such projects on a regional basis;

(b) Conditions for such investment demonstration projects are:

(i) The relevant countries have enacted and are enforcing legislation to phase out ODS;

(ii) The project intends to use financial resources outside the Multilateral Fund such as national programmes, GEF funding or other sources. The credibility of those financial resources has to be demonstrated before disbursement of funds approved under the Multilateral Fund can commence;

(iii) The total funding per chiller is determined using a mathematical and/or business model, taking into account relevant decisions of the Executive Committee, such as the share of transnational ownership as per decision 20/5;

(iv) The maximum Multilateral Fund grant for a particular country is US $1,000,000; for regional projects, approval of additional funding on a revolving fund basis could be decided case-by-case; and

(v) The project proposal includes a general strategy for managing the entire CFC chiller sub-sector in the countries concerned.

(c) In order to ensure a co-ordinated process, the Executive Committee requests the Secretariat to hold co-ordination meetings with all agencies, to evaluate and, if necessary, prioritize demonstration project proposals for subsequent decision by the Executive Committee using the following criteria:

(i) Fulfilment of requirements under sub-paragraph (b) above;

(ii) Cost justification;

(iii) Inter-linkage with existing phase-out plan (if relevant);

(iv) Regional balancing of projects according to the main regions East Asia, West Asia, Africa as well as Latin America and the Caribbean;

(v) The total funding per chiller, taking into account relevant national and local conditions (can be determined by a mathematical and business model and the annual return on their investment);

(vi) CFC consumption for the servicing of centrifugal chillers as a share of total 2004 CFC consumption in the country; and

(vii) The level and source of probable financial resources outside the Multilateral Fund to be utilized for the project.

(d) UNEP is requested to submit a project proposal regarding establishment of relevant information, dissemination and awareness activities on a global level. At the same time, the project preparation funding should be used to make information rapidly available for CAP teams to distribute in network meetings;

(e) For the project preparation, including participation in co-ordination meetings with the Secretariat and, where relevant, development of suitable methodologies for the preparation of projects referred to in sub-paragraph (a) above, the agencies receive the following project preparation funding:

(i) UNDP: US $122,000;

(ii) UNEP: US $40,000; and

(iii) UNIDO: US $119,000.

(f) The Secretariat is requested to report to the 47th Meeting of the Executive Committee on the experiences gained during project preparation and any need for changes in or amendments to the criteria and modalities proposed above;

(g) Resources remaining unspent after approval of the proposals submitted to the 47th Meeting of the Executive Committee should remain as uncommitted obligations from the 2005 Business Plan.

Annex I

BACKGROUND INFORMATION ON TECHNICAL AND SUB-SECTOR CHARACTERISTICS

Technical characteristics

1. Water chillers, or in brief "chillers", are refrigeration systems that cool water or a water/antifreeze mixture, which in turn provides comfort air-conditioning in buildings through a heat distribution system, or is used in industrial processes, or for food preservation.

2. Smaller chillers, typically up to the order of 350 kW refrigeration capacity, are technically very similar to other refrigeration machines used in refrigerators, supermarkets and other applications. The typical life time of this equipment is around 7-15 years, in some cases up to 20 years. For these smaller chillers, a number of conversion options, such as use of a drop-in refrigerant and retrofitting are available for costs which are significantly lower than the costs of new equipment. Conversions of such machines can typically be performed on a need-to basis with a very short lead time or during a repair. As a result, non-availability of virgin CFCs does not necessarily lead to the need to replace (CFC) refrigeration equipment still in good-working condition.

3. Larger chillers are virtually the only refrigeration equipment using centrifugal compressors as their main component. These so-called centrifugal chillers cannot be converted easily to another non-CFC refrigerant. Instead they require either substantial retrofitting procedures on often already worn machinery, or replacement with new systems. Centrifugal chillers manufactured prior to 1995 are based on CFC -11, CFC-12, CFC-13B1, R-500, and HCFC-22 refrigerants; with CFC-11 being the most common refrigerant; in 1995, production of CFC centrifugal chillers ceased. Centrifugal chillers with capacities in the range of the typical 1400 kW capacity have a charge of 300 to 500 kg CFC. Those chillers are long-term investment goods with a maximum economic life of 30 years. Because of a limited number of suppliers for both conversion as well as replacement, such activities have to be planned between one and two years ahead. Challenges in conversion and the long economic life pertain only to centrifugal chillers, and therefore this paper focuses exclusively on these centrifugal chillers as they pose a specific challenge for the phase out of CFCs in the refrigeration sector.

Chiller sub-sector in Article 5 countries

4. There are no accurate statistics regarding the total number of CFC-based centrifugal chillers in all 139 Article 5 countries. The report of the Chiller TEAP Task Force provides an estimate of the total number of CFC -based centrifugal chillers which varies from 15,000 units to 20,000 units depending on the source of information used. On the basis of a CFC consumption analysis for centrifugal chiller servicing in several Article 5 countries, the report made an assumption that 1500 ODP tonnes of CFC consumption can be attributed to servicing centrifugal chillers in Article 5 countries.

5. If the average charge of CFC refrigerant per centrifugal chiller (400 kg) is applied to the total number of CFC based centrifugal chillers, the global inventory of CFCs in Article 5 country chillers would be within the range of 6,000 to 8,000 ODP tonnes.

6. There is only limited information available regarding the distribution of centrifugal chillers in different Article 5 Countries. The application of centrifugal chillers exclusively to very large cooling needs provides some indications. Typically centrifugal chillers used for air conditioning are related to high-rise buildings and large buildings with specific air -temperature needs (such as hospitals, tourism facilities, and office buildings). Centrifugal chillers in non-air conditioning uses, such as chemical and food processing applications are usually limited to large, highly centralised plants. In addition, centrifugal chillers rarely exist in areas with shortages in the electrical power supply, since their large cooling capacities are difficult to substitute by other means, in case of power failure.

7. The database available in the Secretariat indicates that the total current level of CFC consumption in refrigeration servicing in Article 5 countries is slightly above 35,000 ODP tonnes per year. Consequently, the CFC consumption related to centrifugal chillers represents in the order of 4% of the total consumption. Again on the same basis, if after 2007, the number of CFC-based centrifugal chillers in Article 5 countries remains unchanged, the CFC consumption for centrifugal chiller servicing needs would represent up to 7.5% of the total global CFC consumption in Article 5 countries.

8. According to the Report of the TEAP Chiller Task Force, the energy efficiency in 24 Article 5 countries and regions where data was available ranged from a COP[4] of 4.3 to 5.6 with an average COP of 5.0. Modern chillers have energy efficiencies up to a COP of 7.8. The energy consumption is reduced proportional to the increase in chillers efficiency, leading to possible reductions in energy consumption between 28% and 45%, with an average of 36% if the presently used systems would be replaced with up-to-date technology. A typical centrifugal chiller of 1,400 kW, running 11 months per year, 12 hours per day with an efficiency of 5.0 consumes in the order of 1,125 MWh per year, with the possibility to reduce this consumption by about 400 MWh/year through the use of modern chillers.

9. The energy consumption can be further decreased by reducing the necessary cooling capacity a chiller needs to provide; this can be achieved through a variety of different measures, among them improvements of insulation of pipes and the building itself, improvements of heat exchanger water/air, use of efficient water pumps. Given that these improvements are not related to the refrigeration system containing CFC, these are equally not relevant for the purpose of the replacement of CFCs, and are thus not considered in the context of CFC phase out.

- - - -

[4] The efficiency, called "Coefficient of Performance" or COP, is measured in cooling capacity [kW] divided by electrical power needs [kW]. The higher the COP value, the lower the energy consumption for a given cooling need.

ANNEX II

OPPORTUNITY COST MODEL
FOR
CFC CHILLER REPLACEMENT

PREPARED BY

WORLD BANK MONTREAL PROTOCOL OPERATIONS

OPPORTUNITY COST MODEL FOR CHILLER REPLACEMENT

Introduction

Chillers manufactured today are more energy efficient that those manufactured prior to 1995 as reported in the TEAP chiller report. All chiller manufacturers offer chillers with energy consumption of less than 0.6 kW/ton refrigeration (TR) in comparison with 0.8 kW/TR or more for those manufactured prior to 1995. A simple cash-flow analysis would suggest that investment in new non-CFC chillers could provide return on investment within 5 years or less depending on energy cost, climate conditions, investment cost, and cost of capital. While potential energy savings from replacing old CFC centrifugal chillers with new non-CFC centrifugal chillers are apparent, replacement of old CFC chillers has not taken place in a large scale in Article 5 countries nor Article 2 countries. Replacement of CFC chillers in Article 2 countries has been attributed mainly to either the scarce supply of CFCs or the regulatory requirements.

A few chiller replacement projects financed both as stand-alone projects by the Multilateral Fund (Mexico and Thailand) or, in case of Turkey the chiller replacement component is part of the Refrigeration Sector Plan. The results of those demonstration projects are encouraging. Incentives provided by the chiller replacement programs in the three countries in a form of concessional loans, for Mexico and Thailand, or 25% grant financing, in case of Turkey, have attracted interest of building owners. All these three projects have attracted counterpart funding from the private and public sectors. Energy savings have been confirmed.

Based on the initial success of these projects, three countries are continuing with follow-on projects. In case of Mexico, additional funding was injected to the project by the MLF and the local energy conservation organization. In case of Thailand, the national energy conservation fund has continued to provide concessional financing similar to the model employed by the MLF funded project. For Turkey, the continuing replacement of chillers is possible through the on-lending of the grant funds from its Montreal Protocol revolving fund. The conclusion is that some sorts of subsidy are still required in spite of the fact that energy savings have been proven.

Based on experience from the above projects, it could be concluded in addition to perceived risk of the new non-CFC chiller technology, there are other barriers critical to CFC chiller replacement. As pointed out in the previous projects, other barriers include, among others, access to capital, other competing investment priorities, long-term commitments of companies' resources, the level of technical capacity required for proper maintenance of new non-CFC chillers, and investors' view on the value of the cash inflows in the future. All of the mentioned barriers, except the access to capital, could be considered in aggregate as opportunity costs to investors.

Opportunity Cost Model

The India Chiller Sector Strategy financed by the Multilateral Fund and carried out in 2001 and 2002 by the World Bank aimed to quantify opportunity costs of replacing CFC chillers in

India. The national survey was conducted to identify all CFC centrifugal chillers that were still in operation at that time. The survey also included interviews with building owners and chiller suppliers in India to determine performance characteristics and age distribution of the CFC chillers. Efforts were spent on determining the relationship between the age of chillers and energy consumption, maintenance costs, and down-time as these parameters constitute operating costs of chillers.

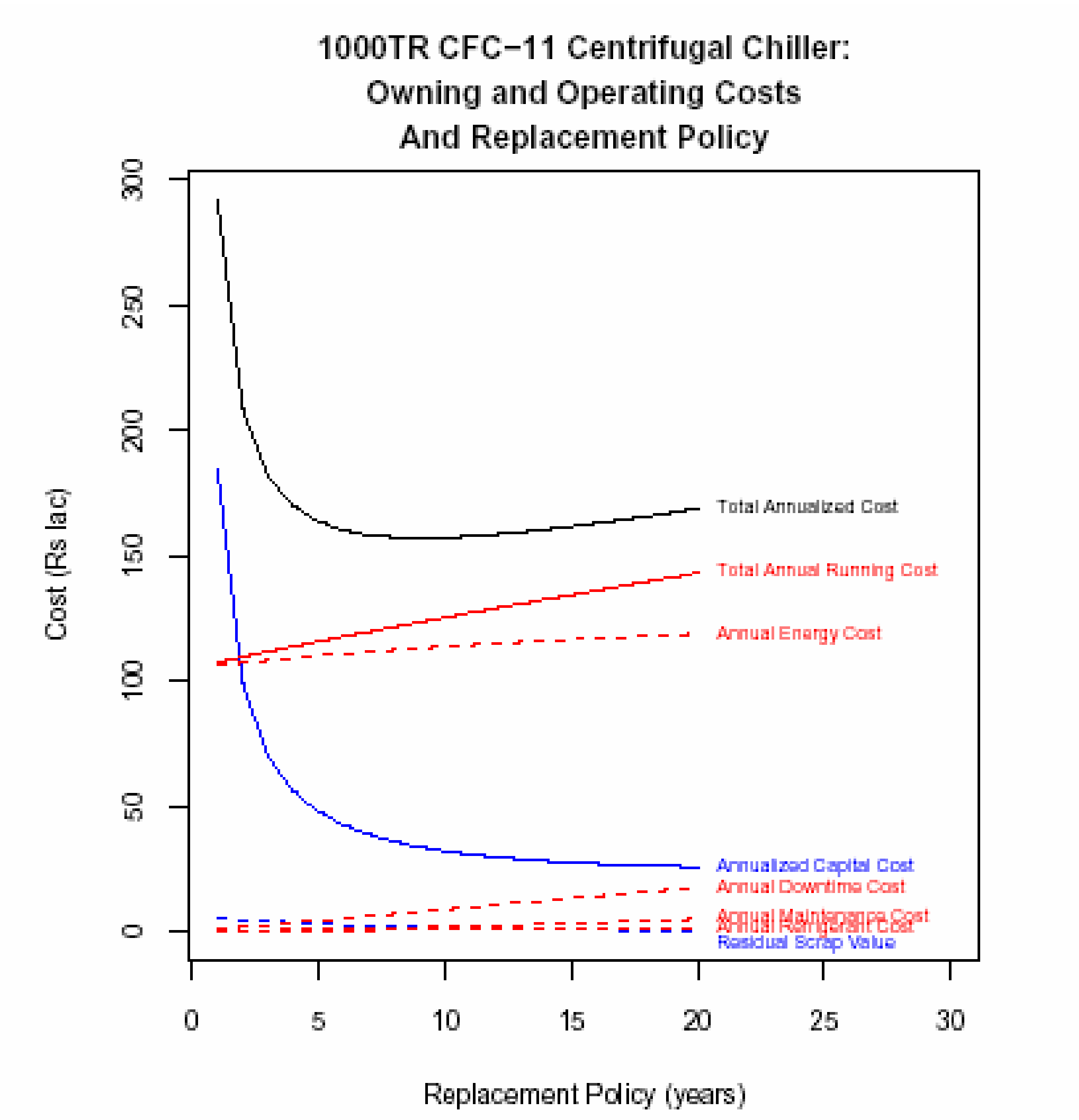

Fig. 1: Replacement policy for a1000 ton CFC chiller based on the total owing cost

The model assumes that chiller owners will decide to replace their equipment when the owning cost or total annualized cost, comprising of annualized capital cost and running cost, passes its minimum value. As running costs represent additional cash outflows in the future, the stream of cash outflows in the future is discounted to reflect the time value of the money. In Fig. 1, a discount rate of 15% was applied to all streams of recurrent costs. Based on this replacement policy model with a 15% discount rate, the optimal time for replacing this 1,000 ton CFC centrifugal chiller is when it has aged more than 12 to 15 years. Replacement would take place later if the discount rate becomes higher.

According to the survey finding, chillers are, in average, replaced when they are more than 30 years old. Based on the 30 years replacement policy, a CFC chiller phase-out schedule for India was determined.

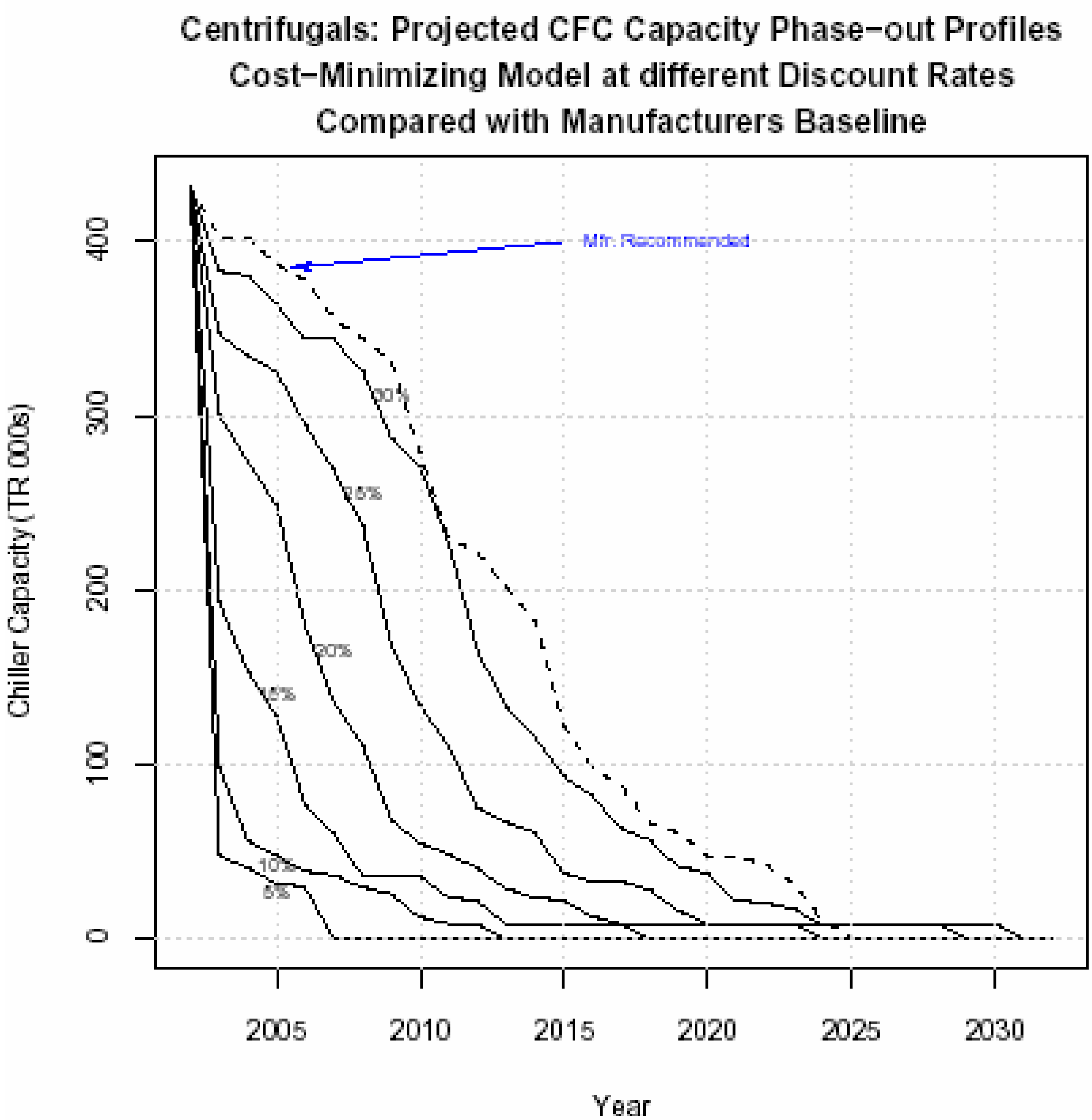

Fig. 2: Phase-out scenarios of CFC centrifugal chillers in India

In Fig. 2, the vertical axis “chiller capacity” represents the total cooling capacity of CFC centrifugal chillers installed in India. The chiller capacity at any given year is determined by adding up cooling capacity of each of the CFC centrifugal chillers that are still in operations. Based on the manufacturer’s recommended life of chillers or the 30 years replacement policy, CFC chillers will be replaced over time from 2002 to 2030. Replacement or retirement of CFC chillers will result in the reduction of the total installed cooling capacity. The phase-out of CFC chillers, therefore, represents by the broken line in Fig. 2.

To model chiller owners’ decision to replace their CFC chillers, a replacement model based on individual units described in Fig. 1 was conducted for each of the 1,500 units installed in India. Different values of discount rates were used in order to determine the level of opportunity costs acceptable by the Indian industry. According to Fig. 2, the discount rate that best reflects the 30 years replacement policy is about 30%. Since most chillers in Article 5 countries are normally replaced when they are more than 30 years old, it is reasonable to assume that the same discount rate or opportunity costs would be applicable for all Article 5 countries.

Analysis of Opportunity Cost of Chillers Replacement

To demonstrate the relationship between the opportunity cost and the investment decision of chiller owners, a case study of replacing an existing 500 TR CFC chiller with a new non-CFC chiller of the same capacity is shown below.

	Existing Chiller	**New Chiller**
Cooling Capacity (TR)	500	500
Energy Consumption (kW/TR)	1.0	0.63
Electricity Cost (US$/kWh)	0.07	0.07
Operating Hours (hrs/day)	16	16
Operating Days (days/month)	30	30
Energy Consumption (kWh/year)	2,880,000	1,814,400
Cost of New Chiller (US$)		200,000
Annual Cost of Energy (US$)	198,720	125,194
Carbon Emission [0.22kgC/kWh] (tC)	13,090.91	8,247.27

Table 1: Replacement of 500 TR CFC chiller with new non-CFC chiller

Existing CFC chillers, which are more than 10 years old, would typically consume energy within the range of 0.85 to 1 kW/TR while it is common to find new chillers offered in the market today have an energy consumption rate of less than 0.6 kW/TR. For this analysis, 1.0 kW/TR is used as energy consumption of the existing CFC chiller and 0.63 kW/TR for the new non-CFC chiller.

Based on the operating conditions described above, this proposed replacement results in an energy consumption reduction by over a million kWh per year. This will result in an annual energy cost saving of $73,526. This annual energy cost saving represents the constant cash inflow for the next five years after installation of the new non-CFC chiller.

Year		Opportunity Cost of 30%
0	Capital Investment	200,000
1	Inflows	56,558
2	Inflows	43,507
3	Inflows	33,467
4	Inflows	25,743
5	Inflows	19,803
		(20,922)

Table 2: Cash-flow analysis for replacing a 500 TR chiller

Without taking the time value of the money into consideration, the annual savings of $73,526 would result in a return on investment within less than 3 years. However, in the view of investors, the future stream of cash inflows has a much lesser value as demonstrated by the India Chiller Sector Strategy. Investing of $200,000 in the new chiller would require investors to postpone their investment in other activities that could generate faster return for their investment. When the opportunity cost of 30% is applied to the future cash inflows, investment in the new chiller becomes undesirable as the net present value of this investment becomes negative. To make this investment desirable or all opportunity costs are covered, capital investment should be reduced by $20,922. This could be considered as an incremental cost of replacing this CFC centrifugal chiller.

The opportunity cost of replacing CFC chillers would be higher for younger chillers, particularly those with lower energy consumption per ton of refrigeration. For example, replacement of a 500 TR CFC chiller with energy consumption of 0.83 kW/TR would incur an opportunity cost of more than $100,000.

Year		Opportunity Cost of 30%
0	Capital Investment	200,000
1	Inflows	30,572
2	Inflows	23,517
3	Inflows	18,090
4	Inflows	13,915
5	Inflows	10,704
		(103,201)

Table 3: Opportunity cost of replacing 0.83 kW/TR 500 ton CFC chiller

For older chillers whose energy consumption is higher than 1.0 kW/TR, replacement of such chillers would be desirable without incurring any additional opportunity cost. In fact, such a replacement decision would result in an internal rate of return of more than 30%. This is shown in Table 4.

Year		**Opportunity Cost of 30%**
0	Capital Investment	200,000
1	Inflows	71,845
2	Inflows	55,265
3	Inflows	42,512
4	Inflows	32,701
5	Inflows	25,155
		27,478

Table 4: Opportunity cost of replacing 1.1 kW/TR 500 ton CFC chiller

Conclusions and Next Steps

Energy savings from replacing chillers alone would not be sufficient to promote chiller replacement or CFC phase-out in this sector unless all costs including opportunity costs are addressed. Opportunity costs could be determined on the basis of a 30% discount rate. The actual opportunity costs (in the dollar term) could vary depending on operating environment (cost of energy, operating hours, and energy consumption rate). Replacing chillers with higher efficiency units could result in a significant reduction of carbon emissions. This provides possibility for co-financing the cost of CFC phase-out in the chiller sector.

Phasing out of medium age CFC chillers (in the range of 10 – 25 years) would incur opportunity costs to chiller owners approximately 10% - 30% of initial cost of the new chillers. These costs would be higher in case of younger and more efficient CFC chillers. For older chillers whose energy consumption is higher than 1.0 kW/TR, energy savings generated from replacing the old chillers would offset any opportunity costs. Given that the chiller replacement would generate significant energy savings and carbon emission reduction, it would be desirable to seek co-financing from other sources (e.g., Clean Development Mechanism, local energy conservation funds, and etc.) to supplement funds to be provided by the Multilateral Fund. This would enable Article 5 countries to address the whole range of CFC chillers remaining in the countries.

The barrier related to access to capital should also be addressed. To ensure that all countries, large and small, will benefit from the CFC phase-out program in the chiller sector, an innovative approach to channel required financial incentives to all countries should be considered. In this regard, the World Bank is proposing to develop the operational modalities for a global funds or regional funds to support this activity. The aim of the proposed operational procedures would be to the establishment a global/regional fund accessible to CFC chiller owners in general. An operational mechanism must take into consideration potential local and regional participation of financial institutes, role of global chiller suppliers, role of national Ozone Units etc.