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UNITED NATIONS INDUSTRIAL DEVELOPMENT ORGANIZATION
Vienna International Centre, P.O. Box 300, 1400 Vienna, Austria
Tel: (+43-1) 26026-0 · www.unido.org · unido@unido.org

Chiller Replacements

Linking the Montreal Protocol and the Kyoto Protocol: Modalities for Implementation and Avenues of Financing

UNITED NATIONS
INDUSTRIAL DEVELOPMENT ORGANIZATION

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UNITED NATIONS INDUSTRIAL DEVELOPMENT ORGANIZATION
VIENNA, 2008

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The publication also benefited from relevant information accumulated in the course of preparation and implementation of UNIDO's ongoing regional projects in the chiller sector financed by the Multilateral Fund for the Implementation of the Montreal Protocol and the French Global Environment Facility. Specifically from the projects:

1) West Asia: Demonstration Project on the Replacement of CFC Centrifugal Chillers in Syria

2) Eastern Europe: Demonstration Project on the Replacement of CFC Centrifugal Chillers (Croatia, Macedonia, Romania and Serbia and Montenegro)

3) Africa: Strategic Demonstration Project for Accelerated Conversion of CFC Chillers in six African Countries (Cameroon, Egypt, Namibia, Nigeria, Senegal and Sudan) - African Fund for the Replacement of Chillers (AFROC).

FOREWORD

Global problems, by their nature, require global collective action, where the collaborative roles of local, regional and international organizations can lead to the resolution of difficulties and repairing of damage.

When providing the needed support, international institutions such as the United Nations and its specialized agencies can serve as a driving force for these global initiatives.

Such has been the role of UNIDO as an implementing agency in addressing ozone depletion under the Montreal Protocol on Substances that Deplete the Ozone Layer. This is the treaty, signed in September 1987, in which the international community agreed to take specific measures to protect human beings and the environment from adverse effects caused by ozone depletion. The Montreal Protocol was designed in such a manner that the phase-out schedule for ozone-depleting substances could be reviewed on the basis of periodic scientific and technological assessments. The Protocol has been amended four times (London–1990, Copenhagen–1992, Montreal–1997 and Beijing–1999) in order to either accelerate the phase-out schedules, to introduce other types of control measures or to add new substances to the list of controlled substances. Ozone-depleting substances are or were once used in several industrial sectors, e.g., foam blowing, aerosol propellants, refrigeration/air conditioning, solvents, and fire extinguishants. In addition, methyl bromide is also an ozone-depleting substance and is used as a fumigant in the agricultural sector or as a chemical for the quarantine and preshipment treatment of products. CFCs in particular are (or were once) used in the refrigeration, air conditioning (especially for larger sized air conditioning systems such as chillers), foam, tobacco fluffing and solvent sectors.

Article-5 Countries[1] are encountering a major challenge in meeting the milestone for a total phase-out of CFCs by the year 2010. The remaining consumption is mostly in the refrigeration-servicing sector, and in many countries also specifically in centrifugal chiller servicing, hence the need to focus on CFC chiller replacement initiatives.

Replacement of CFC-based chillers with new energy-efficient ones results in the phase-out of the CFC refrigerant, as well as in the reduction of greenhouse gas emissions. Hence, the replacement of CFC-based chillers has direct implications for protecting the ozone layer and alleviating global warming and related climate change.

Taking steps towards chiller replacement entails, *inter alia,* strengthening and enforcing policies and legislation, setting up financial mechanisms and building technical capacities.

To fulfil this purpose, UNIDO has initiated technical assistance programmes, training, capacity-building and policy-assistance measures in a number of regions.

This report is a contribution to UNIDO's ongoing programme in the chiller sector and should serve to guide countries in preparing strategies for the replacement of CFC-based chillers. It presents the issue of chiller replacements in connection with ozone depletion and energy efficiency/climate change, while outlining mechanisms that may be employed to support and accelerate chiller replacements. The report targets stakeholders that are involved in chiller replacement projects, such as engineering facilities and energy contracting providers, investors, financial institutions, government entities and private sector stakeholders.

[1] Article 5 Countries are developing countries whose annual calculated level of consumption of the controlled substances in Annex A is less than 0.3 kilograms per capita

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1. Purpose and target group

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The purpose of the present report is to serve as a guidance document for countries preparing strategies for chiller replacements. It allows stakeholders to identify additional financial, technical and regulatory incentives in order to remove local barriers to new chiller investments. It addresses stakeholders such as engineering facilities and energy contracting providers, investors, financial institutions, government entities and private-sector stakeholders that are involved in CFC-based chiller replacement projects.

The report touches on elements that need to be addressed to promote CFC-free chiller replacements. These include among others:

- Increasing public awareness of the impending phase-out and options that may be available for dealing with chillers;
- Identifying applications of strategic importance for an accelerated replacement that would facilitate the compliance of countries with their national phase-out targets;
- Providing advice on decision-making in respect of the best technical option and support for innovative financial acquisition;
- Assisting financial institutions in evaluating chiller replacement projects;
- Advising governments on regulatory measures that may support accelerated centrifugal chiller replacements;
- Demonstrating the benefits of investments in CFC-free chiller technologies among investors, governments and financial institutions;
- Developing strategies for managing the entire CFC-based chiller sector, including a plan to handle the existing and future demand for CFCs for servicing remaining chillers.

The data and analyses in this report can serve different purposes and focus on various stakeholders. Policy-makers and government entities have a central role to play in creating the needed regulatory infrastructure for chiller replacement initiatives, as well as in addressing and countering problems and barriers. Hence, this report contains sections that address the global context (2.1), the experience on chiller replacements under the Montreal Protocol (2.2), the barriers to chiller replacements (3.1) and social, economic, and environmental impacts (3.2.1, 3.2.2, 3.2.3); these will be especially useful to government institutions and policy-makers in generating national plans that will contribute to successful chiller replacements.

Chiller end-users, engineering facilities and energy contracting providers need to consider essential criteria for chiller replacement, and require technical information on viable options for chiller replacement and background on available financial mechanisms before commencing such projects. Returns or benefits that result from chiller replacement emerge following a long-term investment. Thus, investors and financial institutions have a very central role to play in supporting the process of chiller replacement. For such purposes, both specialized engineering or energy facilities and financial institutions will benefit from this guide. Sections 3.3 on the criteria for chiller replacement, 4.1 and 4.2 on technical opportunities and avenues for finance, as well as 5.2, 5.3, 5.4 and 5.5 on analysis, design, implementation and monitoring information will be extremely useful for chiller end-users, engineering facilities and energy contracting providers, as well as investors and financial institutions.

The templates contained in appendices B (draft initial project proposal) and C (detailed project description / project appraisal) to this document are intended for use by the end-user as well as the financier of the chiller replacement. Technical consultants may use these templates to technically evaluate the application. Funding institutions may use these forms to recommend projects for grants. The templates include information on the technical data of the existing chiller, along with information on the techno-economic feasibility of the replacement under consideration. Environmentally relevant costs such as energy efficiency and CO2 emissions of the old plant versus the new one are also factored into the final technical and economic statement. Appendix D comprises a case study of a shoe factory that applied for an environmental grant in order to partially finance its project to retrofit an R-22 chiller into an R-407C chiller. The case study will serve the reader as a sample for the use of such templates.

2. Introduction

2. Introduction

2.1. General context

Chillers are refrigeration systems that produce chilled water for cooling air in commercial, residential and industrial processes or food preservation. Such chiller applications are usually operated under a variety of ownership structures including:

- Chillers operated by private entities, such as industrial facilities, hotels and banks;
- Chillers operated by public entities at the State level, such as ministerial buildings and airports;
- Chillers operated by public entities at the municipal level, such as municipal buildings and hospitals.

Chiller systems use either reciprocating or rotary or, particularly for large capacities, centrifugal compressors. Centrifugal chillers manufactured before 1993-1995 typically use a CFC refrigerant, which is listed among the substances controlled under the Montreal Protocol on Substances that Deplete the Ozone Layer. In developed countries, almost all chillers of this age have been retrofitted. This, however, is seldom the case in developing countries, except for chillers installed in international chains. Replacing CFC-based centrifugal chillers with new efficient chillers, whether centrifugal or of another type, can significantly reduce electricity consumption and peak electricity demand. The replacement results in the reduction of greenhouse gas emissions as well as the phase-out of the CFC refrigerant. Therefore, this type of project achieves a dual environmental impact by: (1) protecting the ozone layer; and (2) offsetting global warming and related climate change.

The underlying problem is that, despite the widely demonstrated technical and economic benefits of new CFC-free chiller technologies, old CFC-based chillers are being replaced slowly in most Article-5 countries. However, the continued use of CFC-based centrifugal chillers is an obstacle to the countries' compliance with the final CFC phase-out targets.

2.2. Experience regarding chiller replacements under the Montreal Protocol

Since October 1992, a number of projects involving the retrofitting and the replacement of CFC-based (centrifugal) chillers have been approved by the Executive Committee of the Multilateral Fund for the Implementation of the Montreal Protocol, e.g., in Côte d'Ivoire, Mexico, Syria, Thailand and Vietnam. Different methodologies were followed in each project. While some projects focused on refrigerant containment, on recovery and recycling of the refrigerant from chillers and on emission reductions, more recent ones established specific financial mechanisms to facilitate the replacement of chillers.

The "lessons learned" from chiller replacement projects implemented by the World Bank in Mexico, Turkey and India concluded that, in chiller replacement projects, one or more of the following factors is crucial:

- A clear technical opportunity to reduce both CFC and energy consumption;
- Tailor-made implementation;
- Effective communication with chiller owners;
- Technical assistance.

2.3. New direction

Through decision XIV/9, the Meeting of the Parties to the Montreal Protocol requested the Technology and Economic Assessment Panel (TEAP) to globally collect data and assess problems related to CFC phase-out in the chiller sector and to identify incentives for adopting non-CFC equipment. Based on TEAP's findings, the forty-fifth meeting of the Executive Committee of the Multilateral Fund, held in December 2004, requested the Multilateral Fund Secretariat to prepare a study on modalities that may be applied for the development of chiller projects.

At its forty-sixth meeting, in July 2005, the Executive Committee considered the report of the Secretariat and opened a limited window of USD 15.2 million for financing further chiller demonstration projects, conditional on the availability of external resources associated with improvements in the energy efficiency of new chillers. Decision 46/33 invites the implementing agencies to submit project proposals that demonstrate the feasibility of and the modalities for replacing chillers through the use of additional resources outside the Multilateral Fund.

The forty-seventh and forty-eighth meetings of the Executive Committee considered eight project proposals submitted by UNDP, UNIDO and the World Bank. The projects covered chiller conversions in countries in the Africa, Eastern Europe and Central Asia, Latin America and the Caribbean, South Asia, South East Asia and the Pacific, and West Asia regions. UNIDO's projects focus on the regions of Africa, Eastern Europe and Central Asia, as well as West Asia. The Executive Committee approved three regional demonstration projects for implementation by UNIDO at a total cost to the Multilateral Fund of USD 3,462,535.

The focus of these projects is mainly on the energy-efficiency gains of chiller replacement, rather than on the phase-out of CFCs. Therefore, the projects need to clearly display actual energy savings resulting from chiller replacements and to attract external lending based on reasonably short pay-back periods and cost-recovery mechanisms. To overcome the perceived technology deficiency that is often encountered, the actual energy consumption of the old and the new chiller systems will be measured before and after replacement, based on an approved methodology and guidelines.

Replicability is a main objective of the approved demonstration projects. Therefore, the strategy of the new projects is reoriented to introduce the Montreal Protocol into the energy financing sector and make use of the lessons learned from the preparation and implementation of projects in the centrifugal chiller sector. Such projects should use financial support mainly in the form of direct capital grants and technical assistance. The reason for this is that the willingness of building owners to replace chillers is currently quite low, although banks are in principle prepared to finance such projects. The introduction of a financial incentive may influence the decision of building owners and accelerate the replacement of CFC-based chillers. However, without an incentive, the decision to implement such a replacement project could easily be postponed.

3. Strategic context

3. Strategic context

3.1. Major barriers to chiller replacements

High initial investment costs, lack of a conducive government policy, deficiency in technical know-how and restricted access to financial support create barriers to chiller replacements, especially in the case of the more costly centrifugal types. Demonstration projects will give local commercial banks, suppliers and project promoters more comfort and flexibility in implementing and financing such projects on a stand-alone basis. This would ensure the sustainability of chiller replacement projects without grant support.

In many countries classified as Article-5 countries (recipient countries), the continued use of CFC-based centrifugal chillers hinders compliance with the final CFC phase-out targets. Apart from the use of these chillers in public and private buildings, chillers may play an essential role in the tourism industry (hotels) and in industry in those countries. However, despite the technical and economic benefits of new CFC-free chiller technologies, old (centrifugal) CFC-based chillers are generally slow to be replaced (e.g. in Africa).

The major obstacles to efficient chiller replacements can mainly be found in:

- **Unfamiliarity** with new chiller technologies;
- **Limited technical capacity** in design, procurement and maintenance;
- **Relatively high initial investment costs** and **lack of awareness** among investors about the future savings in energy costs achieved by chiller replacement (since savings are normally not perceived as an element of real cash flow);
- **Reluctance to prioritize investments** to improve energy efficiency among enterprises;
- **Restricted access to commercial loans** due to small project sizes, a sometimes poor creditworthiness and the lack of collateral efforts;
- **Perception of high risk** in energy-efficiency investments and a lack of skills among banks. Bankability is strongly related to policy factors such as price levels, and many banks also see the energy-efficiency market as a narrow segment with a low profit potential.

In the case of centrifugal chiller projects, the chiller owners often do not realize the benefits of chiller replacements. Conversely, they recognize that chillers are efficient and reliable equipment whose economic life, especially in developing countries, is thought to exceed 30 years. Normally, the annual cost of maintaining the old centrifugal chillers is much lower than the initial cost in the short run of replacing the chiller. An early chiller replacement rarely occurs under normal market conditions. Chiller end-users normally wait until a chiller frequently fails (is reaching the end of its technical life) and is practically also at the end of its economic life before they consider replacing it. Without proper interventions, CFC-based centrifugal chillers produced before 1995 may continue to operate well beyond the year 2020; this, of course, depends on the precise year of manufacture. Hence, chiller owners will not be motivated to change. In this case, the driving factor to encourage replacements is the stimulus of public awareness of the mandatory phase-out of CFCs in 2010, as required by the Montreal Protocol. Major barriers are the following:

a. **Technical barriers** include unfamiliarity with new chiller technologies and limited technical capacity in chiller design and maintenance. These barriers were also experienced in similar projects, for example, in the World Bank project "Building Chiller Replacement Project in Thailand".

b. **Regulatory barriers** are mostly related to the lack of a conducive government policy that includes the introduction of tax incentives for end-users who invest in energy-efficient technologies or the promotion of a tariff policy for electricity that stimulates the efficient use of energy.

c. **Financial barriers** mainly arise from restricted access to loans from commercial banks at competitive rates and/or maturities. This is mainly due to relatively small individual project sizes (and thus loan amounts) and below-average creditworthiness of potential borrowers (which are often small and medium-sized enterprises without any credit rating). Furthermore, many commercial banks lack know-how and experience in financial and credit analysis in respect of energy-efficiency investments. Energy-efficiency investments derive their economic value through energy cost savings, in contrast to "traditional" investment projects, which do not derive their economic value from additional cash flows.

3.2. Country-specific issues

Countries that aim to entirely phase out the consumption of CFCs by replacing the remaining CFC-based centrifugal chillers with new high-efficiency chillers directly achieve significant savings in their level of energy consumption. Thus, the replacement of CFC-based centrifugal chillers will tackle two global environmental problems. It will directly phase out CFCs, which are classified as ozone-depleting substances, and at the same time have a high global warming potential. In addition, the replacement promotes energy-efficient technologies, and that benefits the environment. The replacement sustains the phase-out of ozone-depleting substances in the countries involved, ensuring their compliance with their Montreal Protocol obligations on the one hand, and reducing emissions of greenhouse gases on the other. Furthermore, countries stimulate the development of their own energy sector towards higher efficiency by the integration of chiller replacements into this development strategy, thereby linking Montreal Protocol objectives with energy consumption and efficiency and related carbon dioxide emissions.

They also promote business development in the chiller sector through direct involvement of the suppliers in the projects, thereby expanding the market sector. Countries involved may seek to strengthen their national capacities related to the technical analysis of refrigeration circuits and the modification of existing systems, to financial analysis and policy advice and to the transfer of technology. They should provide assistance in the selection of the appropriate technology strategies and in the identification, selection and evaluation of such technologies, taking into consideration the availability of refrigerants in the specific country. They should also evaluate and demonstrate incentives and, through appropriate coordination, remove the barriers perceived by operators to the replacement of CFC-based centrifugal chillers. This coordination specifically applies to inputs from engineering facilities and energy contracting providers, investors, financial institutions, and government and private sector stakeholders in the region. This will clearly have to be tailored to each country's needs and capacities. Countries should consider and evaluate their own strategic context, while aiming at creating a national framework making possible replacement of CFC-based chillers.

3.2.1. Local economic and social environment

In many countries CFC-based centrifugal chillers are commonly used in hospitals, public and private buildings such as hotels, offices and shopping centres, and for industrial applications. Hospitals may typically be among the most important CFC consumers, as hospital services need chillers to provide hygienic, dry and chilled air conditions, which play a crucial role in the operation of operating theatres, neonatology units, burns units, blood banks, laboratories, etc. In addition to hospitals, government offices and other public buildings, such as storehouses, research institutions, schools and universities, etc., have an important function in a country, which is directly related to the operation of air conditioning systems. In the private sector, there are basically two types of chiller owners: (1) commercial owners with good investment capacities, such as hotels and banks, and (2) private owners with low investment capacities, such as owners of old local properties. Any disruption of these services would have a negative impact on the public health services of these countries and, consequently, on local development. Creating a viable financial mechanism for facilitating replacement of CFC-based chillers and demonstrating the value of these chiller replacements will help to sustain the operation of these services and ensure their continued contribution to growth, to employment, and to income generation. Both the public- and the private-sector end-users potentially benefit from projects for the replacement of CFC-based chillers, and these are therefore generally accepted as sustainable technological measures. In addition, the availability of the newly chosen refrigerant on the local market is considered in order to ensure easy servicing of the newly installed chillers and will therefore contribute to a wide acceptability by end-users.

3.2.2. Economic and financial sustainability of projects

As chiller replacements are usually not a priority for investors, countries play a key role in placing the chiller replacement issue in the energy-efficiency market. Although there is a wide range of chiller owners, the high initial cost of replacing an old chiller system, together with the lack of awareness by owners as to the why and how of chiller replacements, often poses a major obstacle; this entails financial constraints for the chiller owners, who often do not have readily available capital to finance chiller replacements. On the other hand, taking into consideration the steadily increasing price of energy and the pressure coming from the growing demand for servicing chillers, in combination with the requirement of the Montreal Protocol that CFC production be phased out by 2010, chiller owners have a real incentive for change. The amount of energy savings that can be realized depends on a number of variables, such as the number of operating hours per year, the number of operating hours at partial load and the energy consumption of the old versus the new chiller product, including all auxiliaries. All this can be directly translated into cost savings by considering the energy costs.

It is important that developing countries in particular try to stimulate the market for energy efficient, non-ODS chillers through a demonstration of the viability of chiller replacement projects (by means of some initial replacement demonstration projects selected from the overall chiller population). The selection should be based on detailed criteria to ensure that a representative sample of chiller owners is being addressed. Furthermore, countries need to assure that demonstration projects serve as an example for the remaining end-users, who are not involved in the first instance, and who should replicate the replacements by making use of the skills acquired and the financial mechanisms established through such initial demonstration projects. If favourable conditions for replacement of CFC-based chillers are created at the national level and adequate financial mechanisms are established, the end-users in a country will not continue to depend heavily on subsidized activities and the chances are good that replacements of CFC-based chillers will be replicated in future.

3.2.3. Environmental impacts

The approval and implementation of projects for the replacement of CFC-based chillers significantly contribute to a country's total CFC phase-out in the last stage of this phase-out process. However, depending on prevailing technical conditions, a certain quantity of CFC-11 and -12 from stockpiles or from recovery and recycling may be used in the commercial and industrial refrigeration sub-sectors (for the maintenance and repair of old CFC-based refrigeration and air-conditioning equipment until the end of its technical and economic life).

Usually, countries involved do have regulations controlling the import/export of ozone-depleting substances and equipment containing ozone-depleting substances designed to ensure their compliance with the total CFC phase-out target of 2010. The refrigerant contained in chillers (which may be CFCs, but could also be HCFCs, HFCs, or even natural refrigerants), may only affect the environment when a chiller breaks down and/or requires maintenance. Under such circumstances, the refrigerant will be emitted into the atmosphere and will pose a threat to the ozone layer, as well as contributing to climate change. It has therefore been the practice of the Montreal Protocol and its Multilateral Fund to support Refrigerant Management Plan projects to train and certify technicians in applying good maintenance practices to refrigeration and air-conditioning equipment. It is therefore essential for countries to build national institutional capacities for conducting training on refrigeration and air-conditioning equipment and to establish a recovery and recycling scheme for refrigerants at the national level under a Refrigerant Management Plan. Countries should provide service workshops with servicing tools and recovery units in order to enable technicians to implement good practices; they should also establish central recovery and recycling centres that collect CFCs and recycle them for reuse in other equipment after servicing. Contaminated CFCs that cannot be recycled should be destroyed. Given the lack of destruction facilities in developing countries, particularly in Africa, the usual practice has been to supply those countries with storage cylinders in which to keep the contaminated CFCs until it becomes possible to destroy them. It should be noted that the implementation of such activities, as well as the approaching milestone of the January 2010 total phase-out of CFCs, have been two major factors that have caused drastic increases in the price of CFCs in most countries.

CFCs belong to the list of substances controlled under the Montreal Protocol on Substances that Deplete the Ozone Layer. The replacement of existing chillers with new non-CFC, energy-efficient chillers will result in significant savings in energy consumption. The replacement therefore results in the phase-out of the CFC refrigerant and the reduction of both direct and indirect greenhouse gas emissions. The direct emission of greenhouse gases is related to the CO_2 equivalent emission of the CFCs that leak out, while the indirect emission is related to the CO_2 emissions associated with the energy consumption of the chillers. The actual amount of CFCs eliminated will depend on the number of chillers replaced, the size of the chillers, the refrigerant content and their leakage rate, which is related to the age of the chillers. More precisely, the amount of CFCs phased out is equivalent to the amount that leaks out each year. This is a result of the inventory times the leakage percentage per year.

1. ***Direct impacts (due to CFC elimination following chiller replacement)***
   The actual amount of CFCs eliminated in a country depends on the number of chillers replaced, the size of chillers, their design, leakage rate, etc. The direct impact is based on the aggregated volume of the refrigerant emitted from the chillers that are actually replaced. According to the assessment of the Scientific Assessment Panel in 2006, direct (greenhouse gas) emissions related to CFC leakage may amount to as much as 4,700 kg CO_2eq. from 1 kg of R11 emitted and to 10,700 kg CO_2eq. from 1 kg of R12 emitted.

2. ***Indirect impacts (from electricity savings)***
   The replacement of the existing CFC-based chillers with energy-efficient chillers results in significant savings in energy consumption of up to 40%. Such energy efficiency can be translated into the substitution of energy amounts from the

country's electricity grid, which leads to a reduction in CO_2 emissions that would otherwise be caused by the burning of fossil fuels for the generation of electricity. The actual reduction in CO_2 emissions from electricity generation depends on the country-specific energy (fossil fuel) mix that is used to produce electricity in the country.

The average energy-efficiency benefits of the replacement of one chiller are demonstrated in the table below. The quantity of CFCs leaked out and the CO_2 emissions from the energy use of an old CFC-based centrifugal chiller are compared to those of a new non-CFC chiller, which is assumed to be 30% more efficient. The CO_2 emissions related to the energy consumption of the chillers (indirect emissions) are significantly reduced; this also holds for the CFC refrigerants emitted in CO_2-equivalent terms (direct emissions).

CO_2 abatement benefit from energy savings

	Existing chiller	*New chiller*
Cooling capacity, TR (kW)	300 (1055)	300 (1055)
Energy consumption (kW/TR)	1.0	0.70
Operating hours (hrs/yr)	2,000	2,000
Energy consumption (kWh/yr)	600,000	420,000
Energy savings (kWh/yr)	-	180,000
CO_2 intensity of power sector ($kgCO_2$/kWh)	0.65	0.65
CO_2 emission (tCO_2/yr)	390	273
Reduction of CO_2 emission per year (tCO_2/yr)	-	117

Climate change abatement/mitigation from refrigerant substitution

(Chiller 300 tons refrigeration (1,055 kW), 400 kg inventory)

	Existing chiller	*Existing chiller*	*New chiller*
Refrigerant	CFC 11	CFC 12	HFC 134a
Leakage average at old chiller (kg/yr)	150	150	8
Global warming potential	4,600	10,600	1,300
CO_2-eq emission (tCO_2/yr)	690	1,590	10
CO_2-eq reduction (tCO_2/yr)	680	1,580	-

3.3. Criteria for chiller replacement

Governments, together with National Competence Partners, National Ozone Units, financial institutions and implementing agencies, have to evaluate the strategic context under which chiller replacement projects are to be implemented, recognizing the country-specific chiller environment.

Thus, they must raise the awareness of building owners as to the advantages and the potential financial feasibility of chiller replacements in terms of decreased energy costs. This should be done by presenting several concrete examples and case studies on individual projects to stakeholders so that they become aware of the positive consequences of replacing a chiller. Consequently, countries should present available technologies, the basics of financial analysis, the requirements of commercial banks (evaluation of the creditworthiness of the borrower and available collateral) and available chiller suppliers and energy service companies.

Country criteria must be clear in relation to the size and specifics of the chiller population in order to correctly address adequate technologies and financial instruments. A minimum quality in terms of technical standards as well as financial criteria is needed in order to appropriately support the chiller replacement, depending on local conditions in a sector or a country. Using the sector representation as the highest valid criterion reflects the intention to create policy lessons for country phase-out strategies for CFCs.

Site selection criteria are necessary in order to select the most suitable projects in the various sub-sectors identified in each country. Among all the potential projects, the most advantageous (in terms of potential for energy savings, level of preparedness–both technical and financial–and creditworthiness of the project promoters) may be identified and selected through the application of suitable criteria. Project promoters may then be assisted in the technical and financial follow-up analysis and potential modifications with a view to achieving the highest efficiency gains. Furthermore, project promoters may be assisted in determining how to obtain the optimal financing package as a combination of own funds, loans from commercial banks or suitable grant schemes. Site selection criteria therefore should be as concise as possible so that all relevant partner organizations understand them well and anticipate their potential for obtaining project support.

Quality criteria reflect the effort and capacity of owners and engineering companies who prepare chiller replacement project proposals. These criteria are decisive in countries with larger chiller populations, since conditions such as water and electricity prices are similar for many projects within a specific sector. These financial and technical criteria concern first of all the precision of the calculations provided.

Summary of criteria for chiller replacement	

Country criterion
◆ Are the three sectors—commercial, industrial, public—represented?

Quality of financial and technical criteria	
◆ Chiller capacity and efficiency	◆ Refrigeration demand over time
◆ Baseline electricity consumption	◆ Refrigerant leakage
◆ Electricity consumption with new chillers	◆ Technical condition
◆ Water consumption with new chillers	◆ Solvency of company
◆ Estimated running time	◆ Legal status of the buildings
◆ Baseline water consumption	◆ Availability of qualified technicians
◆ Simple payback period	◆ Purchase price of new chiller
◆ Application of Clean Development Mechanism (CDM) methodology	◆ Approval from UNFCCC-designated national authority
◆ Specifications for auxiliary equipment such as fans and pumps	◆ Specifications for heat exchangers

Criterion for otherwise equivalent chillers
◆ Low grant component

The last criterion, the low grant component, is suitable to reflect the interest of the chiller owner in supporting the replacement by his own means. It can be used to decide between proposals of similar financial and technical quality by reflecting the overall concern to make the most efficient use of available financial resources.

4. Opportunities for chiller replacement

4. Opportunities for chiller replacement

4.1. Technological choices

Chillers are applied in (1) large commercial buildings and building complexes such as airports, hospitals, shopping malls, etc. as well as in (2) industrial facilities, e.g., in the food and beverage industry, chemical processing, pharmaceutical formulation, the plastics industry, and manufacturing of semiconductors. Depending on the chiller types, the area of application, their capacity and the control system used, chillers require substantial investments. Such investments are utilized either to retrofit existing chillers or to replace old ones with new non-ODS chillers.

4.1.1. Retrofitting

In general, newer CFC-based chillers should be considered for a retrofit, since this provides an opportunity to decrease the operating and maintenance costs, while improving the chiller plant's performance. The selection of an HFC or HCFC refrigerant depends on the type of CFC contained in the chiller being considered for a retrofit. Chiller retrofits cost 30 – 60% less than chiller replacements, even though some parts of the chiller have to be replaced. Retrofits are an interesting conversion option; however, this is only the case when the compressor, which is the most expensive component of a water-cooled chiller, is in good condition, and when the old CFC-based chiller achieves a good level of efficiency, i.e., less than 0.75 kW/kW. Retrofitting can never be successful if the CFC-based chillers are very old and are in a very poor technical condition, subject to frequent failures, and have a very high refrigerant leakage rate (thus operating at lower efficiency).

Generally, retrofits replacing CFCs with HCFCs result in a slight loss in cooling capacity and efficiency, and require many parts of the chiller to be changed. HCFCs are transitional substances, which, according to the Montreal Protocol, should ultimately be phased out in developing countries by the year 2040.

4.1.2. Replacement with new non-ODS chillers

A variety of types of chillers are available and could potentially be installed, depending on technical conditions and regional specificities, including climatic conditions, the capacity of local engineering companies, technology diffusion, existing legislation and the banking system. Chillers could be operated in air-cooled or water-cooled versions. In particular, chiller types have to be selected according to their designated field of operation in industrial facilities or in the commercial and public-building sector. Water-cooled chillers incorporate the use of cooling towers, which improves the thermodynamic effectiveness of the chiller system as compared to air-cooled chillers. Water-cooled chillers will result in a constant temperature in the condenser that is lower than that in the case of an air-cooling system. Therefore, air-cooled chillers are substantially less energy efficient.

The water consumption in water-cooling systems is an important factor (around 0.650 kg/kWh refrigeration). Air-cooled systems are a more appropriate option if water is not easily available due to the high water price or inappropriate water quality. There are a number of non-ODS chiller technologies available on the market. The selection of the ideal technology option depends on the cooling capacity required, the compressor type, the refrigerant, safety and life-cycle cost.

- **Scroll chiller for capacity 75–300 kW** (20-80 tons refrigeration). Scroll chillers are microprocessor-based, and are especially suited for process cooling applications from (+) 25 deg. C to (-) 10 deg. C.

- **Reciprocating chiller for capacity 75–500 kW** (20-50 tons refrigeration). Reciprocating chillers can serve the smallest loads efficiently. The motors of reciprocating chillers are enclosed inside the refrigerant circuit. The pistons are small in size. These chillers are noisy because of the reciprocating movements of the pistons. They commonly use HCFC-22 as a refrigerant and very often include air-cooled condensers.

- **Screw chiller for cooling capacity up to 1,500 kW** (450 tons refrigeration). This type is more competitive for the smaller capacity range of 300 to 1,000 kW than centrifugal ones. Several refrigerants can be used: R-134a, R-407C and R-717 (ammonia). Ammonia chillers are particularly recommended for industrial applications. However, in recent years, many ammonia chillers have been installed in residential air-conditioning systems (including safety features) in Northern Europe.

- **Centrifugal chiller for capacity range above 700 kW** (200 tons refrigeration). Modern centrifugal chillers use the medium-pressure refrigerant R-134a or HCFC-123. They are especially more competitive for capacities above 1,500 kW, where they show high energy efficiency at full and partial load. The refrigerant leakage is estimated at 1 to 3%. HCFC-22 is still being used in centrifugal chillers, although its use is rapidly decreasing. Ammonia cannot be used in a centrifugal chiller, as its specific weight is too low.

- **Sorption chillers,** which could be either absorption or adsorption chillers. Absorption chillers are used for capacities between 100 and 1,500 kW. Absorption chillers use heat instead of mechanical energy to provide cooling and have a lower coefficient of performance compared to mechanical chillers. However, absorption chillers involve higher initial investment costs, but could substantially reduce operating costs, since they are powered by a low-grade waste heat. Therefore, they are a particularly attractive option whenever a source of waste heat is available in the vicinity of the existing chiller. The two most common refrigerant/absorbent mixtures used in absorption chillers are water/lithium bromide and ammonia/water. The coefficient of performance of absorption chillers varies from 0.7 to 1.4 depending on the system applied (one-stage or two-stage) and the working temperatures.

Adsorption chillers use a refrigerant/adsorbent mixture of water/silica gel. Solar heated water can be used to steer the adsorption chiller. Adsorption chillers are more expensive than absorption chillers and are of limited availability in the market.

Solar energy used in conjunction with a sorption chiller is an interesting option for one-family homes and small blocks of flats, but it is not feasible on a larger scale. The solar panel surface needed is more than $2m^2$ per kW, to refresh ambient air. Another disadvantage of solar-assisted air conditioning is that a backup cooling system is necessary during the night (depending on night temperatures) or on cloudy days, which would further increase the necessary installation costs.

Table 1: Chiller technology alternatives

Compressor	*Typical capacity range*	*Refrigerant alternative*
Centrifugal, water-cooled	>700 kW (200 ton)	HCFC-123, HFC-134a, HCFC-22
Centrifugal, air-cooled	630-1,200 kW (180-400 ton)	HCFC-123, HFC-134a, HCFC-22
Screw	200-1,500 kW (50-400 ton)	HFC-134a, HCFC-22, R-407C R-410A , R-717
Scroll	75-300 kW (20-80 ton)	HFC-134a, HCFC-22 R-407C, R-410A
Reciprocating	75-500 kW (20-150 ton)	HCFC-22, R-407C, R-410A, R-717
Absorption	100-1,500 kW	Lithium bromide or ammonia
Adsorption		Water

4.1.3. Environmental considerations in selecting chiller technologies

The alternative refrigerants R-134a, R-407C and R-717 (ammonia) are the three alternative (to CFCs) refrigerants most commonly used in air-conditioning applications. Hydrocarbon fluids such as propane are highly flammable gases, for which reason they can only be used in specific cases where the chiller capacity is lower than 200 tons refrigeration, or where the refrigerant inventory is limited.

Hydrofluorocarbon refrigerants such as R-134a and R-407C have special requirements as regards the lubricants to be applied, and the substances have a significant global warming potential (although it has to be noted that the global warming potential of HFCs is much lower than that of the CFCs being replaced). The HFC refrigerants require greater care in handling than established refrigerants such as R-22 because of the very low residual humidity requirements. If these conditions are not met, the result could be a complete shut-down of the refrigeration plant. R-407C is a mixture and a zeotropic fluid. That means that, in case of a leak in the refrigerant circuit (especially in the gas part), the whole installation has to be completely emptied and refilled with R-407C having the proper composition. HFC-134a has been used in new chillers all over the world and has become the refrigerant of choice in many chiller conversions. The effectiveness of the HFC-134a chillers is well proven in many countries around the world, and equipment and services are widely available.

Ammonia (NH_3) is a natural refrigerant, and its characteristics are positive in comparison to other refrigerants in terms of ozone-depleting potential, global warming potential and energy efficiency. However, ammonia-based chillers have to be handled with particular care (e.g., it would be dangerous to install such chillers in the basement of public buildings or hotels). Accordingly, the following should be taken into account when considering the use of natural refrigerants such as ammonia:

- The machine room needs to be hermetically sealed and a water supply tank provided that is sufficient for 10 litres of water per kg of ammonia. The pipework from the safety valve is to be connected to this tank;
- A second optional water tank can be provided to ensure as completely as possible that noxious fumes are not discharged into the environment;
- A warning system and machine room ventilation to force the air/ammonia gas into the water tank in case of emergency need to be incorporated;
- The ammonia mixture can be diluted with water after an emergency. The mixture can then be disposed of in the waste-water system without problems. If this is not possible, then the mixture can be flared off or used as a fertilizer;
- The chiller and all its components have to be manufactured out of stainless steel. That increases the price, but it is a quality guarantee. Ammonia chillers usually have a long life, particularly for the three main components (compressor, condenser and evaporator).

The most important advantages of ammonia are the following:

- It has very good thermodynamic characteristics, such as a low specific weight and a high critical temperature;
- The heat exchange processes in the condenser and evaporator are excellent (better than with fluorocarbon refrigerants);

- Leaks are easy to detect and have to be avoided. Thus, leakages from ammonia chillers are likely to be much lower than in case of HFC or HCFC chillers;

- Cost price is low compared to fluorocarbon options, although this is not a major aspect in the total cost of a chiller.

The most important drawbacks of ammonia are:

- Its toxicity. Nevertheless, one needs to take into account the different concentration levels of ammonia in air:

  - At around 16 ppm, it smells very pungent, and a normal person naturally runs away to try to find clean air to breathe;

  - At over 200 ppm, the first health effects will occur;

  - At over 500 ppm, serious health damage, with irreversible lesions, are likely;

- At between 16% and 25% (concentration in the air), the ammonia mixture may explode.

Ammonia could be an attractive option for chillers, as it is already used in industrial processing equipment as a refrigerant (and also increasingly as a substitute). Furthermore, it could be used in the building sector if appropriate safety precautions were taken. The additional costs incurred, compared to other refrigeration systems with refrigerants R-22, R-123, R-134a or R-407C, could be offset by the savings in operating costs.

Energy efficiency is the primary environmental consideration for non-CFC chillers. While each refrigerant has a global warming potential, refrigerants do not contribute to global warming unless they are released into the atmosphere. Properly maintained chillers of modern design emit less than 1-4% of their refrigerant charge each year. The dominant global warming effect caused by chiller operation is the CO_2 emitted in the combustion of fossil fuels for generating the electricity to drive them. Thus, increased chiller efficiencies reduce the impact on global warming proportionally.

The higher efficiency of currently manufactured chillers is mostly a result of the improved new control of the chiller unit and the whole chiller plant, including optimized pumps, fans and cooling-tower operation. For new chillers, there is the option of control with inbuilt variable speed drive, which controls the chiller capacity by varying the compressor speed and, in the case of centrifugal types, by fine-tuning the use of inlet vanes to maintain the optimum compressor efficiency at all loads. The compressor speed is controlled by frequency control of the electrical supply to the motor.

In a chiller plant with two or more compressor units, it could be desirable to equip one of them with a variable speed drive control, leaving the other compressor for baseline chilled water production. Such a system would be operated with the standard chiller working at full load (at higher efficiency) and the chiller equipped with variable speed drive working at partial load, thus achieving a higher total system efficiency. The variable speed drive control could also be implemented at the pumps for the chilled water and the condenser water, and at the fan for the cooling tower, if the water flow varied during the day (for example if it should be proportional to the outside temperature). The payback of investment in variable speed drive control ranges from one to five years.

The chiller performance can be specified using full-load or partial-load efficiency (kW/ton) depending upon the application. Partial-load efficiency (integrated part load value) is preferred for more variable loads accompanying variable ambient temperature and humidity, which is the more common situation. Full-load is appropriate where the chiller load is high and ambient temperature and humidity are relatively constant (e.g., for baseline chillers). In Table 2, recommended and best available chiller efficiencies are provided[1].

Table 2: Load efficiency for chillers

Compressor type and capacity	**Partial load efficiency IPLV (kW/TR)** Recommended	Best available
Centrifugal, 150-299 tons	0.52 or less	0.47
Centrifugal, 300-2,000 tons	0.45 or less	0.38
Rotary screw, 150 tons	0.49 or less	0.46

Compressor type and capacity	**Full load efficiency (kW/TR)** Recommended	Best available
Centrifugal, 150-299 tons	0.59 or less	0.50
Centrifugal, 300-2,000 tons	0.56 or less	0.47
Rotary screw, 150 tons	0.64 or less	0.58

Overall, selecting a high-efficiency chiller does not guarantee high performance. It is cost effective to combine chiller replacement with other measures that reduce cooling load, permitting installation of smaller equipment. An integrated chiller plant retrofit can provide enormous energy savings. It combines the chiller replacement with other energy conservation measures that reduce the cooling load or increase the efficiency of the cooling system itself. Examples of cooling system efficiency improvements are control system upgrades, replacement of old with new more efficient pumps and fans equipped with variable speed drive control and increase in cooling tower capacity. The replacement of old cooling towers with new ones can also decrease the condenser pressure (temperature), and permit electricity savings (2 to 3% lower compressor energy consumption per °C reduction in temperature). Cooling load reduction measures include tightening the building envelope, applying window treatments and updating lighting systems. The additional cost of these and other load reduction measures can be significantly offset by the savings realized from downsizing the chiller. The first step in

[1]Published in 2004 by the US Department of Energy - Federal Energy Management Program.

implementing an integrated chiller plant retrofit is a preliminary energy audit to assess the savings potential of various efficiency measures.

Chiller replacement projects should entail replacement of chillers operated using CFC-11 and CFC-12 with energy-efficient chillers using refrigerants having a zero-ozone-depleting potential. In addition to providing direct assistance to the end-user in selecting the best alternative technology and assessing the technical and economic feasibility of the chiller replacement, such projects should also comprise a component for training of the owner's technical staff. Training would cover the operation and maintenance of the new chiller to ensure efficient functioning and a technical performance guarantee.

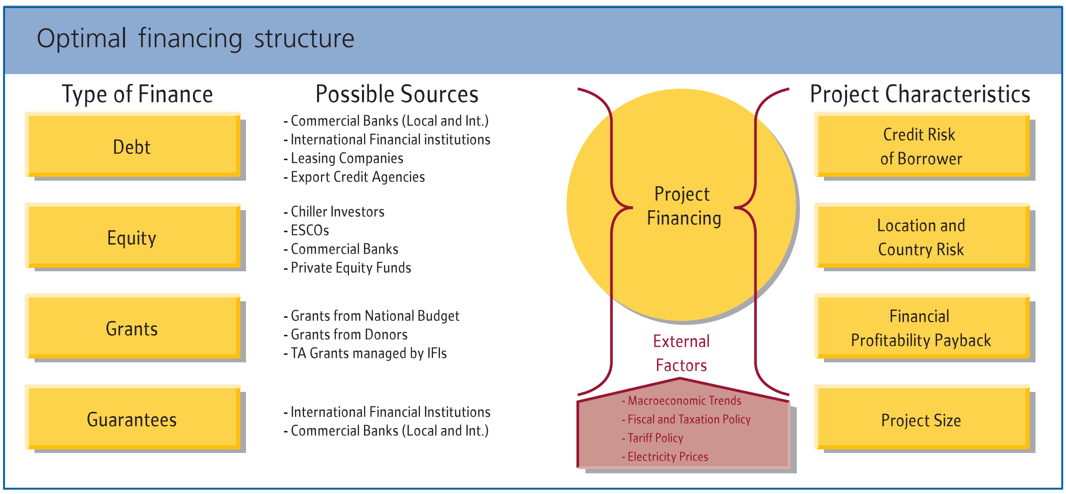
4.2. Avenues of finance

4.2.1. Sources of finance

Identification of the optimal sources of financing and determination of the financing mix are crucial to the successful implementation of any investment project. The final choice of sources of financing depends above all on the following factors:

- Availability;
- Attached conditionalities (e.g., procurement from specific countries);
- Terms, conditions and risk (currency, financing costs, maturity, repayment schedule, fees, etc.);
- Co-financing requirements (especially important in the case of loans from international financial institutions).

However, as can be seen from the diagram below, making the choice is no easy matter, as it depends not only on the available sources of funding, but also on the project character-



istics and the unique legal/regulatory/fiscal environment in the specific country. Therefore, the choice of the optimal financing structure is an iterative process, which has to take these factors into account.

(a) Debt

Debt in its most basic form consists of borrowing and repaying money (with interest), and is provided only for a predetermined period of time. Lenders are usually banks (both private commercial banks and international financial institutions) and leasing companies (providing the leasing of equipment, which is a special form of debt). Debts from international financial institutions are more favourable in terms of credit margins and maturities (due to the relative refinancing advantage of such institutions compared to commercial banks), but in most cases require a high degree of governance and transparency. Furthermore, international financial institutions finance only part of the investment costs and require further co-financing.

(b) Equity

Equity is simply a share in or claim on the assets of an enterprise and is provided for an indefinite period of time. The remuneration of the equity does not consist of interest payments, as in the case of debt, but of profit distributions (dividends). A limiting factor for the use of equity in energy-efficiency projects is the high return expected, which may not be in line with the overall profitability of typical energy-efficiency projects.

(c) Grants

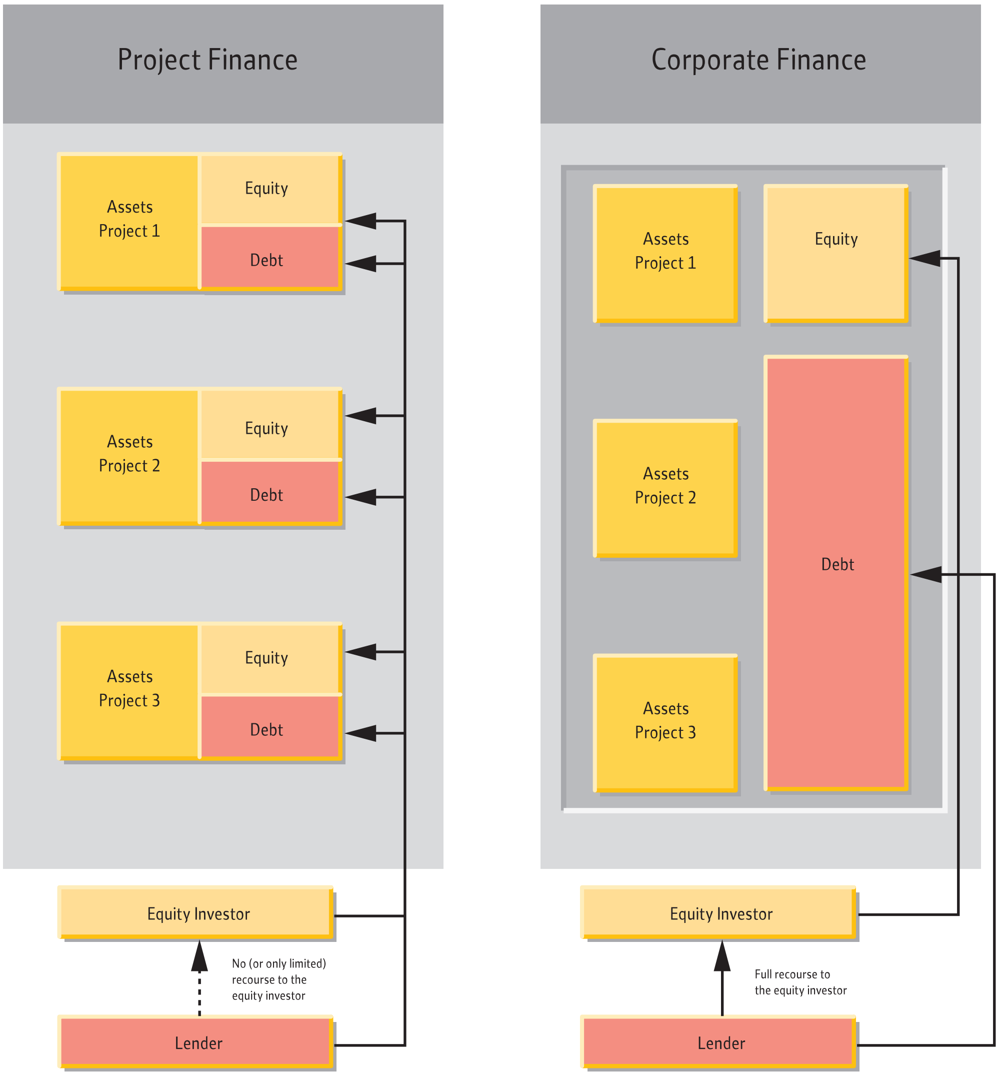
Non-repayable grants are disbursed during project implementation (capital grants) and thus reduce the amount of (external) financing of the project required. Alternatively, grants could also be used as interest rate subsidies (but from the financial point of view they have the same effect as capital grants). In most cases grants are provided by bilateral or multilateral donors (e.g., Global Environment Facility, USAID, European Union, etc.).

(d) Guarantees

Credit guarantees are provided in favour of a lender to an energy-efficiency project, whereby the instrument provides assurance of repayment of the amount covered by the guarantee in the case of default of the borrower. The underlying rationale for this type of instrument is that commercial lenders will be encouraged to provide loans to energy-efficiency borrowers.

A crucial distinction is also to be drawn between project finance and corporate finance. In a project finance transaction, the borrower is a “special purpose company” (which implements only one specific project) and thus the lender fully relies on the expected future cash flows resulting from the project’s energy savings. When these do not materialize, a default may be the worst-case scenario. In a corporate finance transaction, the borrower is a company which has several business activities (not only the specific energy-efficiency investment project as in the case of a special-purpose company) and the lender has recourse to all the borrower’s assets.

Project finance vs. corporate finance



Pure project finance deals are normally not applicable to chiller replacements, since the minimum size for project finance deals is around USD 20 million.

4.2.2. Energy service companies (ESCOs)

In many countries, energy service companies are used to implement, operate and finance energy-efficiency investment in the framework of a public-private partnership (PPP). From the point of view of financing, energy service companies use a mixture of their own financial resources (equity) and external debt from banks. Their unique role is to assume and manage the performance risk in order to achieve the estimated energy savings. See the box below for more information on energy service companies:

The energy service company first identifies potential savings and then signs an **energy performance contract,** with the owners (its client). Under the contract, the energy service company agrees to reduce energy use, and the client agrees to pay it a certain amount of the savings from the project. The energy service company then implements the project, recoups its investment (and realizes some profits) from the savings, and the client continues to save energy after the contract has been concluded.

To be called an energy service company, a company must be able to do two things:

- Identify and carry out energy-saving projects;
- Finance its investments.

The financing component is what makes an energy service company different from a contractor or energy auditor. In most cases, however, the energy service company itself does not have the equity to invest in a series of large energy-efficiency projects. Therefore, it needs **third-party financing** to realize the project. Large equipment vendors may use an energy service company as a means of selling their equipment while keeping risks and debt on that company's books, rather than on the books of the parent company.

Energy service companies are a very good source of financing for energy efficiency for their clients, because facilities pay no money up front. However, the ESCO approach relies upon two elements in any country: (1) rule of law; and (2) access to financing. A strong legal environment is necessary to protect the energy service company from the risks it assumes by financing the projects.

Energy service companies differ in terms of the services they offer. A list is given below, reflecting the range from full-service to low-service contracts:

Full-service energy service company: The energy service company designs, finances and implements the project, verifies energy savings and shares an agreed percentage of the actual energy savings over a fixed period with the customer. This is also referred to in the USA as the "shared savings" approach.

End-use outsourcing: The energy service company takes over operation and maintenance of the equipment and sells the output (e.g., steam, heating/cooling, lighting) to the customer at an agreed price. Costs for all equipment upgrades, repairs, etc. are borne by the energy service company, but ownership typically remains with the customer. This model is also sometimes referred to as chauffage or contract energy management.

ESCO third-party financing: The energy service company designs and implements the project, but does not finance it, although it may arrange for or facilitate financing. The energy service company guarantees that the energy savings will be sufficient to cover debt servicing payments. This is also referred to in the USA as guaranteed savings.

ESCO variable-term contract: This is similar to the full-service energy service company, except that the term of the contract can vary based on actual savings. If actual savings are less than expected, the contract can be extended to allow the energy service company to recover its agreed payment. A variation is the "first-out" model, where the energy service company takes all the energy savings benefits until it has received its agreed payment.

Equipment supplier credit: The equipment supplier designs and commissions the project, verifying that the performance/energy savings match expectations. Payment can either be made on a lump-sum basis after commissioning or over time (typically from the estimated energy savings). Ownership of the equipment is transferred to the customer immediately.

Equipment leasing: Similar to supplier credit, the supplier receives fixed payments from the estimated energy savings. However, in this case, the supplier owns the equipment until all the lease payments, and any transfer payments, are completed.

Technical consultant (with performance-based payments): The energy service company conducts an audit and assists with project implementation. The energy service company and customer agree on a performance-based fee, which can include penalties for lower energy savings and bonuses for higher savings.

Technical consultant (with fixed payments): The energy service company conducts an audit, designs the project and either assists the customer to implement the project or simply advises the customer for a fixed, lump-sum fee.

4.2.3. The wider context of energy efficiency

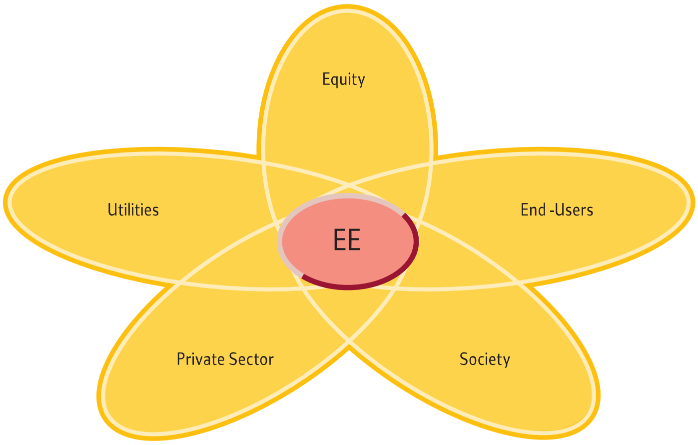
From the financial point of view, chiller replacements belong to the energy-efficiency sector, which has specific characteristics and barriers that must be taken into account.

Such financial barriers mainly arise from restricted access to loans from commercial banks at competitive rates and/or maturities. This is mainly due to relatively small individual project sizes (and thus loan amounts) and below-average creditworthiness of potential borrowers (which are often small and medium-sized enterprises without any credit rating).

Furthermore, many commercial banks lack know-how and experience in financial and credit analysis of energy-efficiency investments. Energy-efficiency investments – unlike other investment projects – derive their economic value, not from additional cash flows (as in "traditional" investment projects), but rather from energy cost savings.

Energy-efficiency (EE) investments are at the interface between many interests (government, utilities, private sector, society and end-users) and thus cannot be compared to "traditional" purely commercial investments.

Energy-Efficiency Investments



Due to the unique characteristics of energy-efficiency investments, the project development phase and the associated audit costs are a major barrier. Such audits comprise technical and financial studies, which verify the feasibility of a proposed project. In most developed countries the investor himself or an interested energy service company will perform such audits. But for less developed countries, this approach is not practical. Therefore in recent international financial institution projects, the following options have been tested to overcome the audit cost barrier:

ESCO/customer pays: In developed markets, the energy service company pays up front for the audit. If no project is identified, the company absorbs the audit cost. If a viable project is identified but the customer does not invest, then the customer reimburses the company for the full cost of the audit. If viable measures are identified and the project proceeds, then the cost of the audit is included in the total financing package. (USA, Canada)

Contingent loans: Under this arrangement, the Global Environment Facility grant administrator would lend funds to cover the audit costs. If the project leads to an investment, then the audit loan is included in the project-financing package. If the audit does not lead to a project, then the audit loan is converted into a grant. (Croatia, Uruguay)

Audit grants: Full or partial grants for energy audits can help identify a pipeline of energy-efficiency projects. This option is particularly useful in the early stages of market development, as it allows energy service companies to gain hands-on experience without risk to themselves or their customers. (Vietnam, Tunisia, Thailand, Poland)

4.2.4. Chiller replacements under Clean Development Mechanisms (CDMs)

This section analyzes the eligibility of chiller replacements under CDM and the potential financial income that may be generated through CDM. The potential for implementing chiller replacement projects under CDM is already being evaluated in the context of various project activities. The most concrete project is the "Accelerated Chiller Replacement Programme" prepared by the International Bank for Reconstruction and Development. The project is designed to secure the early replacement of energy-inefficient, large-sized chillers (capacity 100 tons refrigeration or more) in India. In line with the development of the project development document, a specific methodology – AM0060 "Power saving through replacement by energy efficient chillers" was approved by the UNFCCC CDM Executive Board on 30 November 2007.

The methodology is applicable to project activities that replace an existing chiller with a new, more energy efficient chiller. The methodology applies to two configurations: one where prior to the implementation of the project activity the cooling system was served by only one single existing chiller, for which the rated output capacity of the new chiller is not significantly larger (maximum +5%) than the rated output capacity of the existing chiller; and another where prior to the implementation of the project activity the cooling system is served by several chillers for which the rated output capacity of the new chiller is not significantly larger or smaller (maximum ±5%) than the rated output capacity of the existing chiller. In the latter case, the procedures stipulated in the approved methodology should be applied for each chiller separately.

The methodology does not apply to existing chillers or new chillers that directly use the refrigerant for process cooling or air conditioning, as is the case for direct expansion systems. The methodology also does not apply if the identified baseline scenario is not the continuation of use of the existing chiller.

There is a set of conditions that apply to this methodology including, among others, the requirement to recover and destroy or store the refrigerant contained in the existing chiller in suitable containers within suitable premises to ensure that the recovered, destroyed refrigerant gases can be monitored and tracked. Another is the requirement to destroy the chiller being replaced under the project activity in accordance with an established monitoring and certification protocol.

Further details on the approved baseline and monitoring methodology – AM0060 "Power Saving Through Replacement by Energy Efficient Chillers" can be found on the UNFCCC website, http://cdm.unfccc.int/methodologies/PAmethodologies/approved.html

The utilization of a Clean Development Mechanism (CDM) for a country-specific chiller replacement programme may play an important role. Thus, the CDM component has to focus on the potential energy savings arising from the replacement of existing chiller equipment with new, more efficient chillers. One appropriate way to use the CDM potential of chiller replacements in a country may be through a programme of activities. On the contrary, due to high initial development and transaction costs, a CDM project based on a single chiller replacement seems not to be feasible. Chiller replacement would be eligible as a small-scale CDM project under the Kyoto Protocol. The energy-efficiency gains achieved result in Certified Emission Reductions (CERs) that can be sold to contribute to the financing of the chiller replacement. To achieve this contribution, a chiller operator must use the services of a competent firm to prepare the necessary documents for the CDM Executive Board of the Kyoto Protocol, and the respective Designated National Authority in each country. Such an approach would result in a transaction cost based on each single project, and would consist of the cost of developing the project document, the validation and verification cost as well as the share of proceeds as required by the Executive Board for project registration and the cost of CER issuance. Transaction costs calculated on the basis of a single project could easily minimize the economic feasibility of an average chiller project. Furthermore, the volume of Certified Emission Reductions achieved by the chiller under typical energy-efficiency gains would not be marketable.

Below, the CDM Executive Board guidance on the registration of project activities under a programme of activities as a single CDM project activity is analysed.

Eligibility criteria:

1. A programme of activities is a voluntary coordinated action by a private or public entity which coordinates and implements any policy/measure or stated goal (i.e. incentive schemes and voluntary programmes) that will lead to reductions in greenhouse gas emissions or will increase net greenhouse gas removals by sinks that are additional to any that would occur in the absence of the programme of activities, through an unlimited number of CDM programme activities (CPAs);

   A first methodology (AM0046 – Distribution of efficient light bulbs to households) for a programme of activities in Ghana has been registered. However, procedures for registering a programme of activities as a single CDM project have not as yet been published. The project development document for the programme of activities, as well as the project development document for each CDM programme activity, are currently being developed and will be adopted at the thirty-second meeting of the Executive Board.

2. The physical boundary of a programme of activities may extend to more than one country, provided that each participating non-Annex I host party provides confirmation that the programme of activities, and thereby all CDM programme activities, assist in achieving sustainable development;

   Accordingly, one single programme of activities for chiller replacement projects on a national or regional basis could be implemented on the basis of the confirmations of the Designated National Authority of the host party.

3. A programme of activities must comply with all current guidance by the Board concerning the treatment of local/regional/national policies and regulations.

Programmes of activities addressing mandatory local/regional/national policies and regulations are permissible, provided it is demonstrated that these policies and regulations are not being enforced as envisaged. If they are being enforced, the effect of the programme of activities is to increase the enforcement beyond the mandatory level required;

This refers to compliance in respect of the specific country regulatory status.

4. A programme of activities must be proposed by any entity, which may be a public or private entity, which shall be identified in the modalities of communication as the entity that communicates with the Executive Board. Project participants under the programme of activities shall make arrangements with the coordinator or the managing entity relating to communications and distribution of certified emission reductions;

   The implementing entity should be in charge of (i) monitoring and verification of certified emission reductions from the single projects; (ii) identification and negotiations with potential buyers; (iii) contract management and transfer of certified emission reductions; (iv) acting as sole project participant and project counterpart towards the UNFCCC EB. Participants of the programme of activities (project investors) enter into an arrangement with the managing entity to assign their rights in respect of certified emission reductions to the managing entity. Thus, the project investor is obliged to set up and run his project in accordance with special monitoring rules, as laid down by the managing entity.

5. The coordinating entity of the programme of activities must identify measures to ensure that all CDM programme activities under the programme of activities are neither registered as an individual CDM project activity nor included in another registered programme of activities;

   This has to be assured in close liaison with the local Designated National Authorities. CDM projects require letters of approval from the host country in which the project activity is located. Consequently, Designated National Authorities may easily ensure that all single project activities are not registered as individual CDM project

6. A programme of activities must apply one approved baseline and monitoring methodology, involving one type of technology or measure applicable to all CDM programme activities;

   A specific methodology – AM0060 "Power saving through replacement by energy efficient chillers" for India – Accelerated Chiller Replacement Programme has been approved, and conditions outlined within the methodology are to be considered.

7. The programme of activities must demonstrate that net reductions (removals) in anthropogenic emissions for each CDM programme activity under the programme of activities are real and measurable, that they are an accurate

reflection of what has occurred within the project boundary, and that they are uniquely attributable to the programme of activities. At the time of registration, the programme of activities must therefore define the type of information which is to be provided for each CDM programme activity to ensure that leakage, additionality, establishment of the baseline, baseline emissions, eligibility and double counting are unambiguously defined for each CDM programme activity within the programme of activities;

Firstly, such information has to be part of the project development document of each CDM programme activity and has to be in line with the monitoring requirements as set out in the methodology that will be applied. Secondly, such information has to be provided by the project sponsor if he intends to participate in the national chiller replacement scheme.

8. Each CDM programme activity must be uniquely identified, defined and localized in an unambiguous manner, including a statement of the exact starting and ending date of the crediting period, by providing, when it is added to the registered programme of activities, the information which is required for the purpose in the registered programme of activities;

   Such project identification and definition should be collected and made available by the implementing entity identified.

9. The duration of the programme of activities, not exceeding 30 years, must be defined by the entity at the time of request for its registration. Any CDM programme activity can be added to the programme of activities at any time during the duration of the programme of activities by a coordinating/managing entity. The entity must inform the CDM Executive Board of any addition(s), giving details of the programme activity(ies) in a format predefined for submitting such information. The crediting period of a CDM programme activity will be either a maximum of seven years, which may be renewed at most twice, or a maximum of 10 years with no option of renewal. However, the duration of the crediting period of any CDM programme activity shall be limited to the ending date of the programme of activities;

   Chiller replacements generally should be conducted until 2010. Accordingly, the settings under the chiller replacement programme well fit the timelines of a programme of activities.

10. The emission reductions of each CDM programme activity must be monitored as per the registered monitoring plan according to the methodology applied to the registered programme of activities. The method or approach used to verify emission reductions (that may include random sampling) shall ensure the accuracy of these emission reductions.

Such information has to be provided by the project sponsor based on monitoring guidelines in a country.

Financial contribution from the CDM:

The potential financial contribution from the CDM may be analyzed taking into account the following factors:

- The amount of certified emission reductions generated depends on the energy savings achieved, as well as on the corresponding reduction in emissions based on the grid energy substituted;
- Certified emission reductions may be generated from 2008 to 2012 according to the implementation schedule;
- Prices for certified emission reductions are very volatile over time;
- Transaction costs have to be estimated based on Executive Board rules, as well as on the market cost for CDM project development.

Considering such assumptions, it is clear that the CO_2 volumes and the revenues from their sale will become more attractive as the number of chiller replacements implemented increases.

The following conclusions may be drawn from the above:

- Due to high initial transaction costs, chiller replacement projects may only contribute financially if a significant number of single projects are realized under a programme of activities;
- The financial incentive gained from the CDM is relatively low compared to incentives otherwise provided under a financial scheme;
- There would be a clear awareness-raising for CDM projects if chiller replacement projects were to be implemented as CDM projects.

4.3. Regulatory recommendations

4.3.1. Institutional setup

Preparing the terrain for successful chiller replacement implementation involves raising the awareness of the public and that of chiller owners, building sufficient capacity in local engineering and financial institutions to assess the techno-economic feasibility of chiller replacement and providing policy assistance to the government to create an environment supportive of chiller replacement. Sufficient investor capacity is required in respect of the technical analysis and modifications required to achieve the highest efficiency gains from chiller replacement. Advice to investors is also required on obtaining an attractive financing package by increasing access to capital from financial institutions, import/export banks, energy service companies and chiller suppliers. If the CFC phase-out target of 2010 is to be met, an appropriate organizational framework, such as a National Ozone Unit, has to be set up, either within the ministry of the environment, or in an environmental agency, or as an interdisciplinary group comprising representatives of each party involved. Such well-structured organizations for chiller replacement in the various countries can also be interpreted as a clear signal that the governments take their commitment to chiller replacement seriously.

At the national level, the average energy-saving potential for chillers may vary depending on country-specific characteristics, but will generally be around 30% of the existing energy consumption. Energy savings have a major economic potential. However, this economic development cannot be achieved on a sustainable basis without an adequate government policy and without legislation on energy-efficiency standards and targets. The government has an essential role to play in implementing an energy policy oriented towards energy savings, and in the creation of a legal framework for the development of the energy market.

The institutional setup should also take into account that roles and responsibilities of the stakeholders have to be assigned clearly, so that every group involved knows exactly what it can do to help reach the phase-out goal.

All national priorities concerning chiller replacement have to be coordinated in such a way that the environmental issues will be mainstreamed in the context of national strategies for sustainable development.

4.3.2. Legislation

While most countries have defined phase-out dates for CFCs and other ozone-depleting substances, these need to be supported by subsidiary legislative provisions. Governments need to amend the necessary regulations to include measures that would motivate the chiller owner to invest in chiller replacements. Such measures include: (1) a compulsory energy audit, (2) obligation of chiller users who consume electricity above a minimum annual threshold to develop their own programmes for chiller replacement and energy efficiency, (3) promotion of a tariff policy for electricity so as to stimulate the efficient use of energy, and finally (4) the reimbursement of a portion of the taxes paid by users that invested in the efficient use of energy.

In countries where there is no appropriate regulation in place concerning mandatory maintenance of chiller equipment, it should be taken into account that such a law would, on the one hand, help to reduce the environmental impact of the existing chillers, and on the other hand, would also greatly help to raise the awareness of the chiller owners concerning the need for replacement. This is because the external maintenance suppliers would keep the owners informed about actual discussions and other framework conditions.

Generally, countries have regulations controlling the import/export of ozone-depleting substances and equipment containing them in order to ensure their compliance with the total CFC phase-out target of 2010. In contrast, few countries have specific tax-incentive schemes that are enforced to benefit the institutions and individuals that invest in clean technologies.

A fundamental precondition for the replacement of chillers is the establishment of a scheme for recovery, recycling, reclamation and destruction of CFCs. Otherwise, chiller replacement activities might give rise to uncontrolled situations in which there would be the danger that CFCs recovered would be released into the atmosphere or handled insecurely in other ways.

Another aspect of legislation would be that, depending on the national circumstances, chillers should not only be retrofitted by using another less harmful refrigerant, but should also be replaced using innovative and energy-efficient technologies. Therefore, it could be useful to stipulate emission performance standards, and also to establish energy-efficiency standards by enacting new regulations.

Since one major barrier to chiller replacement is the lack of regulatory provisions embodying financial incentives to stimulate new investments, governments should consider establishing an appropriate range of economic instruments, such as taxes and/or environmental grant schemes.

4.3.3. Implementation and execution of regulation

The enactment of laws is a very important precondition for a targeted chiller replacement programme in a country. But if countries do not have effective authorities in charge of implementing and executing the regulations, the laws would just be so much paperwork, and the CFC phase-out target of 2010 would not be met. Inadequacy of enforcement of existing national legal provisions, including a lack of appropriate penalties and/or sanctions, seems to be a major constraint, which could be addressed by empowering and training relevant inspection authorities.

To ensure successful chiller replacements, it is necessary to develop the capacity of national institutes that conduct training on refrigeration and air conditioning. In addition, Refrigerant Management Plan (RMP) projects should aim at establishing a recovery and recycling scheme for refrigerants at the national level. Therefore, workshops should be arranged that familiarize the participants with servicing tools and recovery units, in order to make possible the sustainable implementation of such good practices. Moreover, the establishment of central recovery and recycling centres that collect CFCs and recycle them for reuse to service other equipment should be promoted. Such recovery and recycling centres have already been established in various developing countries. Refrigerant Management Plans should give specific attention to the small proportion of the CFCs that is contaminated and cannot be recycled. Given the lack of destruction facilities in developing countries, particularly in Africa, it has been a common practice to supply those countries with cylinders in which to store the contaminated CFCs until they can be destroyed. Alternatively, countries may choose to export the volumes of CFCs recovered to countries that possess reclamation facilities, which could process them to a higher grade and then destroy the residuals.

At the very beginning of a national chiller replacement programme, an inventory of existing CFC (and other) chillers has to be established, and this must be updated regularly.

The refrigerant contained in chillers, be it CFCs, HFCs or natural refrigerants, should be specifically dealt with if a chiller breaks down or requires maintenance. It is only then that the refrigerant could be emitted into the atmosphere and would pose a threat to the ozone layer and could also contribute to climate change. It has therefore been the practice of the Montreal Protocol and its Multilateral Fund to fund "Refrigerant Management Plan" projects to train and certify the technicians working on the maintenance of refrigeration and air conditioning in good maintenance practices. These projects focus on training of technicians, as well as on institutionalization of proper maintenance procedures, thus guaranteeing the sustainability of these Refrigerant Management Plans after completion. To ensure that such plans are in place, appropriate laws or ordinances should be enacted to make them a legal requirement for chiller owners.

5. Guidance for chiller replacements

5. Guidance for chiller replacements

5.1. General recommendations

Successful implementation of a chiller replacement project involves various fields, such as awareness-raising among the public and chiller owners, capacity-building in engineering and financial institutions and policy assistance to relevant government institutions. Countries that intend to introduce an initiative for the replacement of CFC chillers must consider the following questions:

1. What is the country's problem regarding the inventory and the use of CFCs in chillers?

2. What can the country do in the short term to design a strategy for annually replacing part of the CFC chiller base and for dealing with the remaining centrifugal chillers, even if they have to be operated after 2010-2015 (stockpiling recycled material)?

3. What can agencies do overall, together with governments, to raise awareness regarding the savings that can be realized through the replacement of old chillers with new ones?

4. What is the infrastructure and how can regulatory instruments, including incentives by electricity companies and other entities, promote the replacement of chillers?

5. How can the general population of chiller owners be made aware of financing or financial incentives and possibilities in order to stimulate chiller replacements?

Specifically, CFC chiller replacement programmes should be designed to overcome technical barriers, regulatory barriers and financial barriers. Recommendations to tackle these barriers are grouped below according to the barrier type:

A. Technical barriers

1. There are no "real" (technologically based) technical barriers to the replacement of CFC-based chillers, since alternative technologies are available on the market;

2. The recovery and recycling of CFCs should be considered for the purpose of securing the necessary supply so that a certain number of CFC-based chillers can be kept in operation for a number of years;

3. When replacing chillers, energy efficiency is the leading factor that necessitates adequate examination of all the components of a refrigeration system;

4. The speed of CFC-based chiller replacement is determined by national and international policies and the availability of financial resources;

5. Although there is a short-term need to replace CFC-based chillers with chillers using refrigerants such as HCFCs, HFCs or ammonia, there is also a need to design a long-term strategy for the use of chillers aiming at the use of sustainable refrigerants and technologies (including renewables).

B. Financial barriers

1. Development of of country-specific approaches;

2. Promotion of integrated chiller replacements, including consideration of linkages between financial, technical and regulatory barriers, combination of chiller replacements with energy-efficiency measures, and the offering of complete financial packages;

3. Consideration of the conditionalities of various co-financing sources.

C. Regulatory barriers

1. Establishment and updating of an inventory of existing chillers;

2. Introduction of provisions for recovery, recycling, reclamation and destruction schemes;

3. Ensuring of adequate technical capacity for service operations;

4. Establishment of performance standards for emissions and energy efficiency;

5. Review and updating of existing maintenance regulations;

6. Ensuring of adequacy of capacity and mandate of inspection authorities, including customs authorities, to address enforcement issues.

Considering the main underlying recommendations, a chiller replacement programme may well be structured into: (i) the analysis phase, (ii) the design phase, (iii) the implementation phase and (iv) the monitoring phase, which have to be carried out in a degree of detail that depends on the country-specific situation in the CFC chiller sector. Details regarding each of these phases are given below.

Chiller replacement programme phases

(i) Analysis

- Preparation/updating of the chiller inventory,
- Analysis of the legal/regulatory environment,
- Definition of state-of-the-art applied technology,
- Identification of chiller investors,
- Identification of potential lenders/financial backers (e.g. energy service companies)/financing programmes.

(ii) Design

- Policy measures,
- Designation of a project implementation agency,
- Determination of the optimal technical solution - evaluation of technical aspects,
- Financial structuring,
- Awareness-raising,
- Development of a scheme for recovery, recycling, disposal and destruction of CFCs.

(iii) Implementation

- Disposal/recycling of CFCs,
- Replacement of (CFC) chillers.

(iv) Monitoring

- Monitoring.

5.2. Analysis

In the initial phase of national chiller replacement programmes, a national chiller inventory system must be established to provide specific figures and information about:

- Numbers of chillers;
- Technical data (type, refrigerant type, age, power, capacity, energy efficiency);
- Geographical data;
- Information about the chiller owners in each sector.

Such information is essential in order to tailor a country-wide replacement programme. Furthermore, the legal/regulatory environment for a chiller replacement programme needs to be screened to identify missing legal requirements that should be filled in to support the Montreal phase-out process. As the next step, governments need to be assisted in preparing a chiller replacement policy by amending necessary regulations to include, e.g.:

- Compulsory energy audit;
- Obligation of chiller users who consume electricity exceeding a minimum threshold annually to develop their own programmes for chiller replacement and energy efficiency;
- Implementation of the legal framework for management of stocks for chiller servicing needs and for CFC inventory control;
- Promotion of a tariff policy for electricity designed to stimulate the efficient use of energy;
- Reimbursement of part of the taxes paid by users who have invested in the efficient use of energy.

5.3. Design

In the design phase, development of a chiller replacement project includes preparation of the terrain for project implementation, technology transfer demonstrating energy efficiency and dissemination of lessons learned.

An awareness campaign aims at increasing the awareness of the public and end-users of the impending phase-out and the options that may be available for dealing with chillers, as well as the economic incentives of chiller replacement. The awareness campaign could capitalize on existing instruments in the country and should focus on two main elements: (1) stakeholder involvement, and (2) elaboration of a strategy for mobilizing funds for the replacement of the remaining (CFC) chillers.

A process of stakeholder consultation and involvement is necessary at an early stage. National workshops may be held with the stakeholders to consult with them and involve them directly and to ensure that they act as the promoters for chiller replacement projects and thus assure the project's sustainability. The identification of local banking partners and elaboration of a fund-mobilization strategy at the national level seems necessary in order to demonstrate sustainable and innovative mechanisms to facilitate the (early) replacement of chillers.

Capacity-building efforts are vital in order to train investors in the technical analysis and modifications required to achieve the highest efficiency gains from chiller replacement. Investors should be actively advised on how to obtain an attractive financing package by increasing their access to capital from financial institutions, import/export banks, energy service companies and chiller suppliers.

Government agencies should be assisted in implementing management of stocks for chiller servicing needs by designing specific training in good practices and refrigerant containment for the servicing of chillers. Training should also be offered as part of the technology transfer operation and to chiller owners in order to develop skills in the field of energy management.

A chiller replacement project may be eligible for the status of a CDM project under the Kyoto Protocol. The energy-efficiency gains achieved could potentially result in certified emission reductions that can be sold to contribute to the financing of the chiller replacement. To achieve this contribution, a chiller operator would need the services of a competent firm to prepare the necessary documents for the CDM Executive Board of the Kyoto Protocol and the relevant Designated National Authority in the country. Accordingly, national procedures should be established for submission of chiller projects under CDMs.

At the national level, the average energy saving potential for chillers is estimated at about 30% of the existing energy consumption. Energy savings have a major economic potential. However, this economic development cannot be achieved on a sustainable basis without an adequate government policy and legislation on energy-efficiency standards and targets. The government in a specific country has an essential role to play in the implementation of an energy policy oriented towards energy savings and the creation of a legal framework for the development of the energy market.

Accordingly, advice to government agencies on amending necessary regulations to include measures that would motivate the chiller owner to invest in chiller replacements is necessary. Such measures could include compulsory energy audits, obligation of chiller users who consume electricity exceeding a minimum threshold annually to develop their own programmes for chiller replacement and energy efficiency, promotion of a tariff policy for electricity designed to stimulate the efficient use of energy, and finally reimbursement of part of the taxes paid by users that have invested in the efficient use of energy.

Technology transfer may play an important role to ensure the introduction of adequate air-conditioning technology, which is appropriate to country-specific needs. Clearly, the environmental impacts of chillers mostly relate to energy consumption and refrigerant leakage. In terms of energy efficiency, the payback on new chillers could be three to five years (very much depending on the annual running time and electricity prices), compared to old CFC chiller technology. For the introduction of new chiller technology into a country:

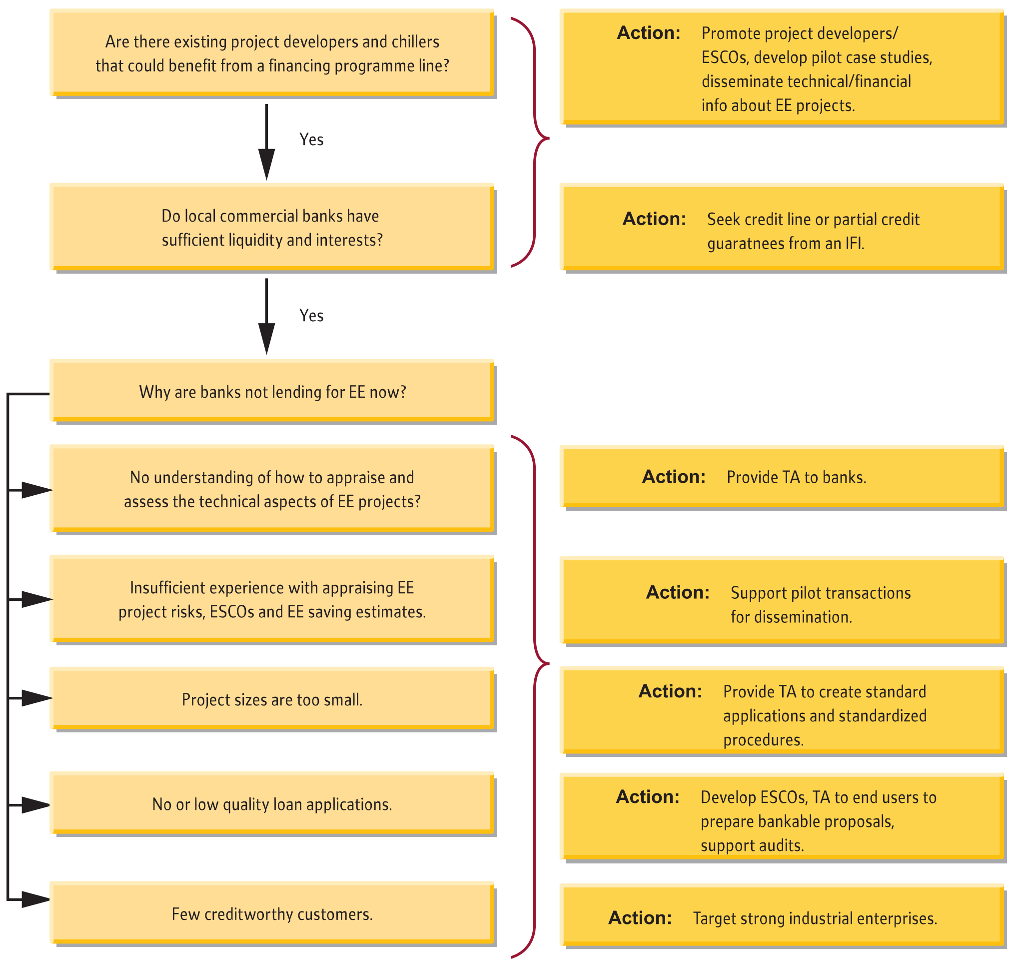
- Chiller refrigerant options are multiple;
- Options for chiller replacements include many more than only centrifugal chillers;
- Choices for replacements depend on the strategy that has been designed for the replacement, and energy efficiency should be the predominant consideration;
- Chiller replacement relates to the total design of the central system.

Old CFC chillers are mostly inefficient and have poor maintenance records, while new chiller technology offers superior economic benefits in terms of energy savings and increased reliability. Therefore, the application of innovative chiller technologies such as solar-heated drives for chillers and absorption chillers should be considered in cases where they would be appropriate for the country. For example, the introduction of heat-driven chillers is often dependent on the price structure in respect of electricity and fossil fuel in a country. This does not lend itself to generalization, but is very much country-specific. Finally, if an appropriate scheme to handle ozone-depleting substances properly has already been established, one of the most environmentally critical steps towards the phase-out target in 2010 has already been taken, and the CFC chiller replacement can be initiated directly. If not, a national CFC scheme to recover, recycle and destroy CFCs must be set up, bringing together different groups such as government authorities, suppliers of refrigerants, waste management companies and chiller owners to work together on the task.

The selection of appropriate financing instruments needs to take into acount the specific investment climate for chiller replacement in a country. It is essential to develop a systematic approach to identify the financial barriers existing in specific countries and to establish strategies to overcome them. The problem may sometimes not be a lack of finance, but a lack of access to finance. In any case, building a project pipeline and stimulating the market to create demand for financing is usually a priority.

A schematic decision tree for energy-efficiency financing is presented below, which may be useful for ensuring a structured approach:

Energy Efficiency Financing Decision Tree



In countries with small chiller populations, the need for an elaborate and complex financing scheme may be less relevant than in those with larger chiller populations. As indicated in the diagram above, the ability and willingness of commercial finance should be explored first. Based on the outcome, appropriate financing schemes must be instituted. Such financing schemes often apply a standard project cycle to identify, finance, implement and monitor individual projects.

5.4. Implementation

During the implementation phase, it is important that the project plans and the replacement programmes (from both the technical and the budgetary points of view) are performed as originally planned, taking into consideration variations or changes if they become necessary. Therefore, a committed project management structure, overseen by a programme steering committee, with sufficient technical and financial personnel resources, needs to be in place.

A precondition for successful chiller replacements is to ensure that each key milestone during implementation will be duly documented and recorded by the project manager and reported to the steering committee. In this way, successful chiller replacement will be documented at the end of the project and it can be traced back over all the various sub-phases of the implementation.

From the environmental point of view, the most relevant factor will be the recovery of the CFC refrigerant. According to existing national CFC recovery and destruction schemes, CFCs must be recovered by qualified maintenance technicians.

CFCs can be:

- Reused for the maintenance of existing chillers which continue to be operated using CFCs; the part of the CFCs recovered that cannot be reused must be stored in storage cylinders until they can be destroyed in the country concerned;
- Handed over to the supplier of the new chiller unit, with the obligation to treat them in accordance with international "state-of-the-art" destruction standards;
- Exported to countries with existing recycling or destruction facilities for recovered CFCs; or
- Recycled or destroyed in the country concerned.

Whatever the CFC treatment opportunities in a country are, a complete record always has to be kept of the amount of CFC that has been recovered and, if relevant, how it was disposed of (reuse, storage until destruction, storage and export via supplier or directly, and in countries with destruction facilities, destruction in the country). All records should be verifiable by accompanying documentation.

From a technical point of view, it should also be mandatory in chiller replacement projects to list all the dismantled components of a replaced CFC chiller in an "equipment destruction report". Such a report is important to prevent used and possibly unsuitable equipment from being installed in facilities elsewhere.

The record regarding CFC recovery and the equipment destruction report are to be sent to the national ozone officers, national co-ordinators and all other organizations that are responsible for the replacement of chillers in the context of the Montreal Protocol implementation programmes.

From the financial point of view, the project management unit must ensure that the project is implemented on time and within budget, using appropriate instruments for project management and cost control. This also involves constant monitoring of the performance of the suppliers or service providers involved.

After completion of a chiller replacement project, an independent external verification of the project must take place. Therefore, internationally accredited organizations or national ozone officers or national co-ordinators should visit the chiller replacement site, verify the various reports and evaluate the conformity of the project completion with applicable national and international standards. Such a final evaluation and verification may also be relevant to certain financial schemes, where the disbursement of funds is linked to a positive verification of the completion of the work.

5.5. Monitoring

National governments through their ozone offices, in line with their obligations under the Montreal Protocol, should:

- Develop a robust monitoring and reporting mechanism to identify CFC usage in the chiller sector, which includes, among other things, constantly updating chiller inventories to determine the remaining CFC chiller population;
- Create an incentive programme for CFC chiller owners to reveal the factors providing an incentive for replacement;
- Provide regular reports showing progress in the phase-out process.

Thus, countries should continue activities and should endorse chiller replacement projects through their institutional support over longer periods of time in order to guarantee the success of such country-specific activities. Depending on the legal framework in a country, the National Ozone Office could well monitor the steps in the phase-out of all CFC centrifugal chillers in a country, for example, by means of regional teams. Possible measures could be inspections at reconverted companies to ensure that CFC-based chillers are not used once a CFC chiller replacement project has been completed. A licensing system could be a tool to monitor and ensure compliance of control measures.

The information that needs to be provided periodically by the project owner could be agreed as part of a project-monitoring plan pre-agreed with the National Ozone Office. An efficient way of doing this would be to collect the information through a stand-alone report summarizing the energy savings that have occurred.

Among other issues, the terms for monitoring should take into account the fulfilment of existing legal requirements established by environmental regulations and authorities. For example, the following conditions have to be fulfilled:

- The forecast reduction of electricity consumption of the chiller equalling an amount of … MWh per year must be achieved each year (continuously);
- The electricity consumption of the chiller project must be recorded by a specifically installed electricity monitoring apparatus (which could be an electricity meter);
- For a period of at least five years after implementation of the measure, the annual consumption of electricity (kWh/y) and refrigerant (in kg/y), as well as the hours of operation and all incidents that have occurred must be recorded.

In this way, special emphasis should be placed on the collection of data about actual energy savings and greenhouse gas emissions.

Appendices

APPENDICES

A. Executive Committee Guidelines for Approval of Chiller Demonstration Projects

The forty-sixth meeting of the Executive Committee of the Multilateral Fund for the Implementation of the Montreal Protocol agreed on the following conditions for chiller investment demonstration projects:

1. The relevant countries should have enacted and have been enforcing legislation to phase out ozone-depleting substances;

2. The project is intended to use financial resources outside the Multilateral Fund, such as national programmes, Global Environment Facility (GEF) funding or other sources. Accordingly, the credibility of those financial resources should be indicated when the project is submitted for approval under the Multilateral Fund. Such financial resources should be secured before disbursement of funds approved under the Multilateral Fund commences;

3. The total funding per investment will be determined using an accessible mathematical and/or business model, taking into account relevant decisions of the Executive Committee;

4. The maximum Multilateral Fund grant for a particular country is USD 1 million; for regional projects, approval of additional funding on a revolving fund basis could be decided on a case-by-case basis; and

5. The project proposal includes a general strategy for managing the entire CFC chiller sub-sector, including the cost-effective use and/or disposal of CFCs recovered from chillers in the countries concerned;

The project submissions to the Executive Committee were prioritized using the following criteria:

1. Fulfilment of the requirements under the list of conditions above;

2. Cost justification;

3. Interlinkage with the existing phase-out plan (where relevant);

4 Regional balance of projects according to the main regions: East Asia and South Asia, West Asia and Central Asia and Eastern Europe, Africa, as well as Latin America and the Caribbean;

5. The total funding per chiller, taking into account relevant national and local conditions, could be determined by an accessible mathematical and business model and the annual return on investment;

6. CFC consumption for the servicing of chillers as a share of total 2004 CFC consumption in the country; and

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

The forty-seventh meeting of the Executive Committee adopted further criteria for funding the demonstration projects as follows:

1. The non-investment component would be capped at a level of 10 per cent of the project costs for projects relating to one country and at a level of 15 per cent for regional projects;

2. The submission of project proposals for the funding of chiller retrofits was allowed, provided that the existing compressor was being replaced with a compressor of greater efficiency and the chiller to be retrofitted was less than 15 years old, the total investment including counterpart funding remained below USD 45,000 per retrofit, and the savings were calculated on the basis of the application of the established discount rate for 2.5 years;

3. The project proposals should make use of external resources such as national programmes, Global Environment Facility funding or other sources to the extent possible and should as a minimum provide external resources for 5 per cent of the project costs.

B. Draft initial project proposal

General information about the project sponsor

Sector (please tick relevant box(es) and specify)

Public sector
Hospital Specify:
Public building Specify:
Other Specify:
Private sector
Office Specify:
Shopping centre Specify:
Industry Specify:
Other Specify:

Legal name of firm and contact details of a person authorized to act on behalf of the firm and explain details of the project.

Name:		
Address:		
Tel.:	Fax:	Mail:
VAT Number		
Contact person Tel. :	 Fax :	 Mail :

Legal status of incorporation

( ) Public company
( ) Private company (please specify type)
( ) NGO
( ) Other (please specify)

Brief description of the firm's/organization's business profile and core activities

Description of the market and the firm's market position (market size, market share, main competitors, etc.) – in case of a private firm

Project partners

Name:

Address:

Tel.: Fax: Mail:

Rationale for involvement:

Project description

Description and current status of the project

Rationale and justification of the project

Legal status of the building where the new chiller will be installed

Technological data sheet for chillers

A1 Planned Measure (brief description)

- refrigerant change/retrofit
- chiller substitution
- new chiller and system

A2 Description of Plant

A2.1 Existing Chiller

	Plant 1	Plant 2	Plant 3
Name			
Cooling power [kW]			
Cooling capacity [TR]			
Electric power [kW]			
COP			
Energy consumption [kWh]			
Operating hours [hours/day]			
Operating days [days/month]			
Refrigerant			
Global Warming Potential of Refrigerant			
Amount of refrigerant [kg]			
Average leakage rate [kg/a]			

A2.2 New Chiller

	Plant 1	Plant 2	Plant 3
Name			
Cooling power [kW]			
Cooling capacity [TR]			
Electric power [kW]			
COP			
Energy consumption [kWh]			
Operating hours [hours/day]			
Operating days [days/month]			
Refrigerant			
Global Warming Potential of Refrigerant			
Amount of refrigerant [kg]			
Average leakage rate [kg/a]			

A3 Energy Efficiency

Energy reduction [MWh/a] annual forecast	
Energy costs [US$/kWh/a]	
Cost reduction [US$/a] annual forecast	

A4 General Data

No. months with AVG >20° C [month/year]	
National emissions factor [CO_2equ./MWh	

Location of the project

Time schedule for project implementation (commencement of the project, construction and installation, completion and acceptance, start of operations)

Project economics

Estimated total project costs

Item	Currency	% of total
Project preparation (feasibility study, technical studies, etc.)		
Equipment		
Construction and installation works		
Legal fees (if any)		
Pre-financing costs (if any)		
Other (please specify)		
Total		100%

Ensured financing commitments and financing requirement

Total project costs:	
Financing already committed:	Financing secured, as % of total project costs:
Financing requirement:	Financing requirement, as % of total project costs:

C. Detailed project description/project appraisal

General information about the project sponsor

Legal name of firm and contact details of a person authorized to act on behalf of the firm and explain details of the project.

Name:		
Address:		
Tel.:	Fax:	Mail:
VAT Number		
Contact person Tel. :	 Fax :	 Mail :

Legal status of incorporation

( ) Public company

( ) Private company (please specify type)

( ) NGO

( ) Other (please specify)

Brief description of the firm's business profile and core activities

Description of the firm's products and services and proportion each product contributes to the total turnover

Description of the market and the firm's market position (market size, market share, main competitors, etc.)

Description of major customers (please specify names, % of total sales, absolute sales)

Description of major suppliers (please specify names, % of total supplies, absolute value of supplies, type of products)

Detailed information about the current project sponsor's operation before implementation of the proposed project

Ownership structure

Number of permanent employees

Details of the organization and management structure of the firm

Financial information (based on audited financial statements and future projections)

Figures in EUR	*Historical*			*Budget*	*Projected*		
Item	*2004*	*2005*	*2006*	*2007*	*2008*	*2009*	*2010*
Sales revenue							
Gross profit							
Earnings before interest and taxes (EBIT)							
Net finance costs							
Profit from ordinary activities							
Net income							

Fixed assets and working capital

Figures in EUR	*Historical*			*Budget*	*Projected*		
Item	*2004*	*2005*	*2006*	*2007*	*2008*	*2009*	*2010*
Fixed assets							
Inventory							
Receivables							
Payables							

Debt details

Figures in EUR	*Historical*			*Budget*	*Projected*		
Item	*2004*	*2005*	*2006*	*2007*	*2008*	*2009*	*2010*
Long-term debt (> 1 year)							
Short-term debt (< 1 year)							

Ratios							
Figures in EUR	*Historical*			*Budget*	*Projected*		
Item	*2004*	*2005*	*2006*	*2007*	*2008*	*2009*	*2010*
Gross profit margin, in %							
Net profit margin, in %							
Current ratio, in %							
Return on equity (ROE), in %							
Return on average capital employed (ROACE), in %							
Debt/equity ratio							

Description of the proposed project

Description and current status of the project

Rationale and justification of the project

Technical details of the project (type of technology used, equipment details, installation specifications, etc.)

Project implementation partners (energy service companies, consultants, leasing companies, etc.) and reasons for their involvement

Name:

Address:

Tel.: Fax: Mail:

Reason(s) for involvement

Details of preliminary agreements

Location of the project

Time schedule for project implementation (commencement of the project, construction and installation, completion and acceptance, start of operations)

Project economics

Estimated total project costs

Item	EUR	% of total
Project preparation (feasibility study, technical studies, etc.)		
Equipment		
Construction and installation works		
Legal fees (if any)		
Pre-financing costs (if any)		
Other (please specify)		
Total		100%

Estimated annual operation and maintenance costs

Technical description of the existing technology, equipment and facilities to be used in the project

Name and description	Condition (new, good, fair, poor)	Age in years

Chronological timetable of project implementation and planned cash outflows necessary in order to complete the project

Date of purchase or cost incurred	Brief description of item purchased	Amount in EUR

Performance contract details (major terms and conditions, duration, payment schedule, penalties, etc.)

Summary of estimated project cash flows

Year	0	1	2	3	4	…	Total in EUR
Investment costs							
Energy savings							
Other net benefits (savings, incremental revenue, etc.)							
Net reduction or increase in operation and maintenance costs							
Depreciation of project assets							

Details of funding requirement

Proposed financing structure of the project

Financing source	Amount in EUR	% of total
Borrower's own funds (please specify)		
Supplier credits		
Amount of leased equipment		
Equity participation of other parties (if applicable)		
Grants or subsidized loans (if applicable)		
Bank loan		
Other (please specify)		
Total project costs		100%

Financing commitments ensured and financing requirement

Total project costs:	
Financing already committed, in EUR:	Financing secured, as a % of total project costs:
Financing requirement, in EUR:	Financing requirement, as a % of total project costs:

Details of collateral provided (if any) for the financing

Description of item	Estimated value in EUR
Total	

Specification of any available valuations used in the estimation of the collateral value (if any)

Name:

Address:

Tel.: Fax: Mail:

Description of (preliminary) agreements signed with financing partners

D. Example - Environmental and economic assessment of a chiller-replacement project

On the basis of a case study, below, a way of evaluating chiller replacement projects ecologically and economically in order to define a standardized procedure for calculating the amount of grant and the ecological effect is described.

Case Study

A shoe factory plans to retrofit the existing R-22 chiller into an indirectly operated chiller system using R-407C as the refrigerant, and it therefore applies for an environmental grant.

Application

The application should consist of following documents:

- Application form;
- Technical data sheet;
- Brief technical description;
- Diagram of the chiller system;
- Three different cost estimates to evaluate the project's economic viability;
- Some formal documents, such as permits, licences, credit rating report, etc.

Technical Appraisal

Technical consultants will evaluate the application by using a data analysis sheet, as shown below.

In this data analysis sheet, all the relevant technical facts must be supplied. Energy efficiency, CO_2 emissions or equivalents and operating/investing costs of the existing "old" plant and the planned "new" chiller system should be compared. The results will deliver the basis for quantification of the environmental effect of the measure.

The environmentally relevant costs of the new chiller system can be derived from the cost analysis sheet.

The size of the grant can be 30% of the environmentally relevant costs, in the case of use of a technology which has a two-circuit system and works without using any ozone-depleting substance. The grant percentage will decline to 25% if the technology only uses a significantly reduced amount of ozone-depleting substance. In the case study, only 12 kg/year of R-407C are used in a two-circuit system. So the grant percentage will be 25%.

Case Study: Shoe Factory

	Operations					
	Power		Opera-ting Hours	Amount of Refrigerant Leakage		Usable Energy
	kWel	kWth	h/a	kg	kg/a	kWh/a
Exisiting Plant						
R22	30.0	34.0	4,114	120	35	123,420
Subtotal	30.0	34.0	4,114	120	35	123,420
New Plant						
R407c	17.0	37.0	4,114	12	1	69,938
Subtotal	17.0	37.0	4,114	12	1	69,938
Reduction						
					Electricity Refrig.	53,482
Total						53,482

Environmentally relevant costs (ERC)

Grant percentages:	
30%	Investments in two-cycle system with ODS-free refrigerant
25%	Investments in two-cycle system with significantly reduced amount of ODS-free refrigerant

R407c	Refrigerant
R22	Refrigerant
	Price Electricity

CO2-Equivalent GWP		CO2-Electricity		Total	Costs Operations	Costs Investment
	t/a	kg/kWh	t/a	t/a	EUR/a	EUR
1,700	59.5	0.30	37.0	96.5	10,751.36	54,720.00
1,700	59.5		37.0	96.5	10,751.36	54,720.00
1,526	1.5	0.30	21.0	22.5	5,839.75	137,180.00
	1.5		21.0	22.5	5,839.75	137,180.00
	57.97		16.04			
	57.97		16.04	74.0	4,911.61	82,460.00

34.90	EUR/kg
14.50	EUR/kg
0.083	EUR/kWh

Environmentally relevant costs (ERC)	EUR	137,180.00
Extension of capacity		100%
Basis for calculation of grant	EUR	137,180.00
Grant Percentage		25%
Grant	EUR	34,295.00
CO2-Efficiency	EUR/t	463

Analysis of Costs

Technical consultants will have to evaluate the applied costs of the measure to determine the environmental relevance of the various investment packages. This evaluation of costs could be done and documented by using the following table.

Case Study: Shoe Factory

Package	Plant	Construction	Planning	Total investment costs	%	Environmentally relevant costs	
				137,180.00		137,180.00	EUR
					%	128,500.00	excluding planning
A **Cooling Plant**							
1. Water chiller	1			28,715.04	100%	28,715.04	
2. Air cooler	1			15,591.12	100%	15,591.12	
3. Pipe installation, E-installation	1			27,277.19	100%	27,277.19	
4. Cooling tunnels, insulation	1			53,966.65	100%	53,966.65	
5. Construction measures		1		3,000.00	100%	3,000.00	
B **Planning**			1	8,680.00	100%	8,680.00	
Plant						125,500.00	
Construction						3,000.00	
Planning						8,680.00	
						137,180.00	

In this case, all the investment costs can be classified as environmentally relevant costs. Costs for planning should only be accepted up to the level of 10% of the environmentally relevant costs, which is the case in this example.

Technical and economic statement

On the basis of the technical appraisal and the cost analysis, the technical consultants should summarize the facts regarding all the different evaluation steps in a so-called technical and economic statement. This document should enable the funding institution to recommend the various projects for receiving grants.

Terms of disbursement and technical conditions

The final part of the technical and economic statement should consist of the terms of disbursement and the technical conditions, whereby both general and specific points related to the varying circumstances of the different projects will be documented.

The terms of disbursement will have to be met by the receiver of the grant; otherwise the grant will not be paid out. If the technical conditions failed to be met, the grant would have to be reimbursed.

Examples for terms of disbursement are:

- Submission of the signed declaration of acceptance;
- Submission of all the notifications of legal authorities relevant to the project application;
- Within 12 months following completion of the project, signed documents for the final account, together with all relevant documents, including a brief report about realization of the project (with a special focus on the recovering, handling, storage and treatment of the "old" refrigerant) must be submitted.

Examples of technical conditions are:

In addition to existing legal requirements of environmental regulations and authorities, the following conditions have to be maintained:

- The forecast reduction of electricity consumption of the cooling plant to the amount of 80 MWh per year must be attained steadily;
- The electricity consumption of the subsidized plant must be recorded by installing an electricity meter;
- At least for a period of five years after implementation of the measure, the yearly consumption of electricity (kWh/y) and refrigerant (in kg/y), as well as hours of operation and incidents must be recorded and be submitted, if requested.

E. Case study for a financing mechanism

In the following, a detailed process (project cycle) of project identification, grant applications, project appraisal, funds disbursement, project implementation and monitoring is described:

- Site selection;
- Project identification;
- Initial project screening;
- Comprehensive project appraisal;
- Financial project structuring;
- Project approval;
- Financial closure and disbursement;
- Project monitoring.

(a) Bulgarian Energy Efficiency Fund (BgEEF)

The Bulgarian Energy Efficiency Fund (BgEEF) can serve as an example. The Fund was established by the Energy Efficiency Act adopted by the Bulgarian parliament in February 2004 (see www.bgeef.com).

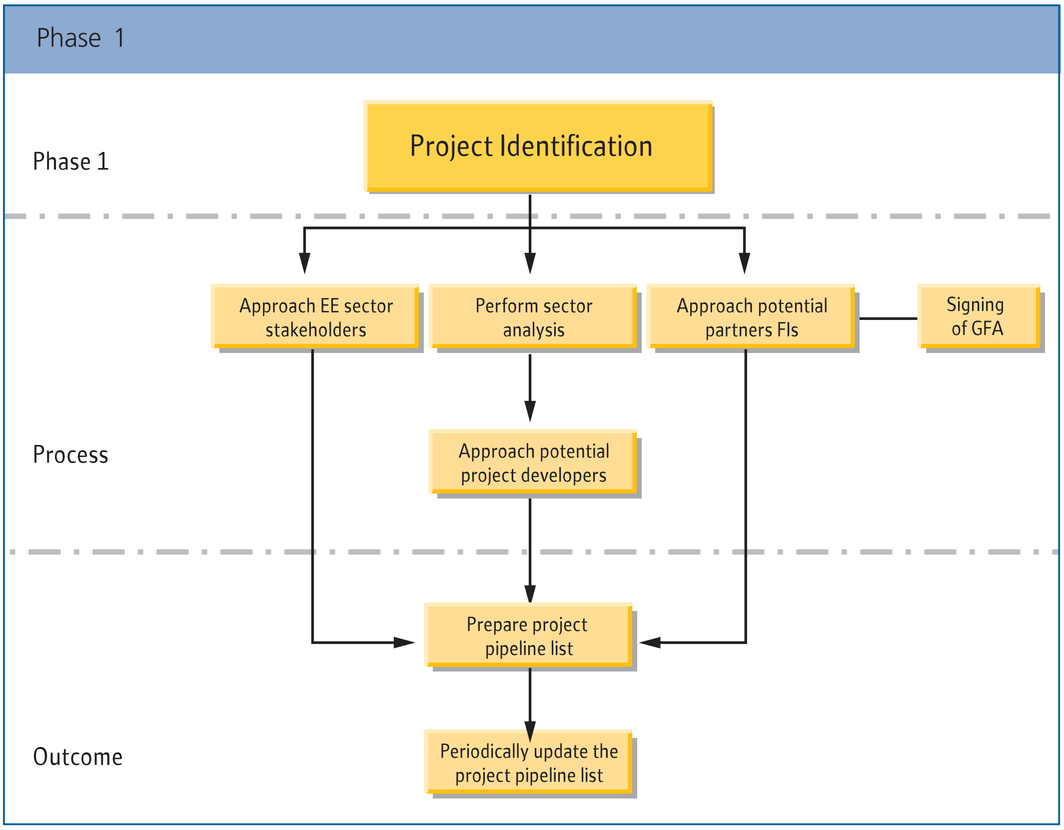
The main objective of the BgEEF is to facilitate energy-efficiency investments and to promote the development of an energy-efficiency market in Bulgaria. To this end, BgEEF will support the identification, development and financing of viable energy-efficiency projects implemented by private enterprises, municipalities and households.

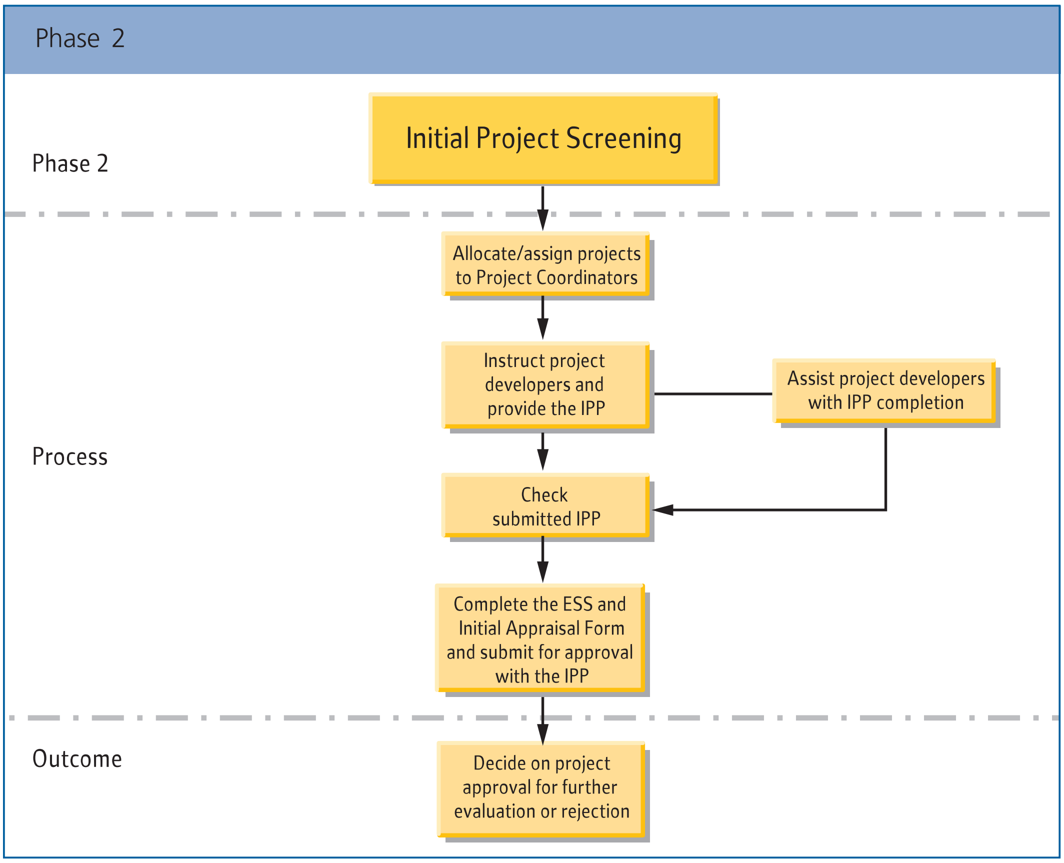
The financing instruments include long-term loans, partial credit guarantees and grants for technical assistance. The initial capital of the fund is USD 14 million.

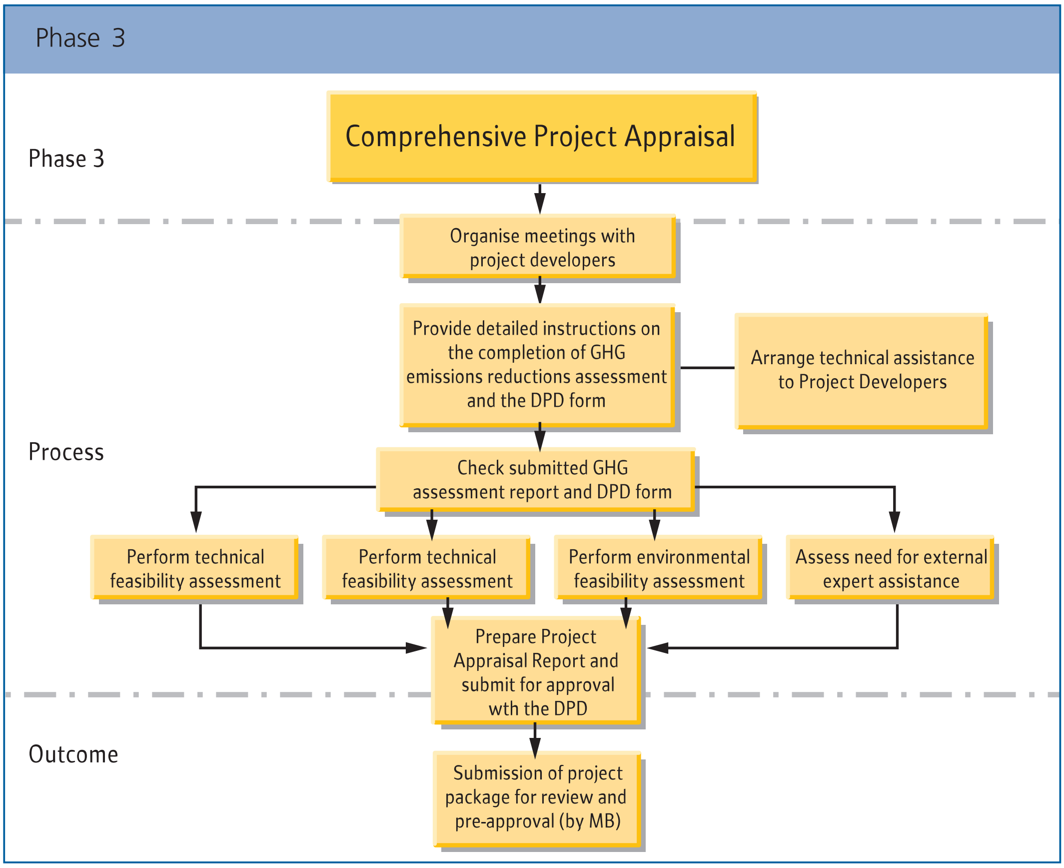
Further information can be found on the home page, including templates for application forms and business plans and case studies.

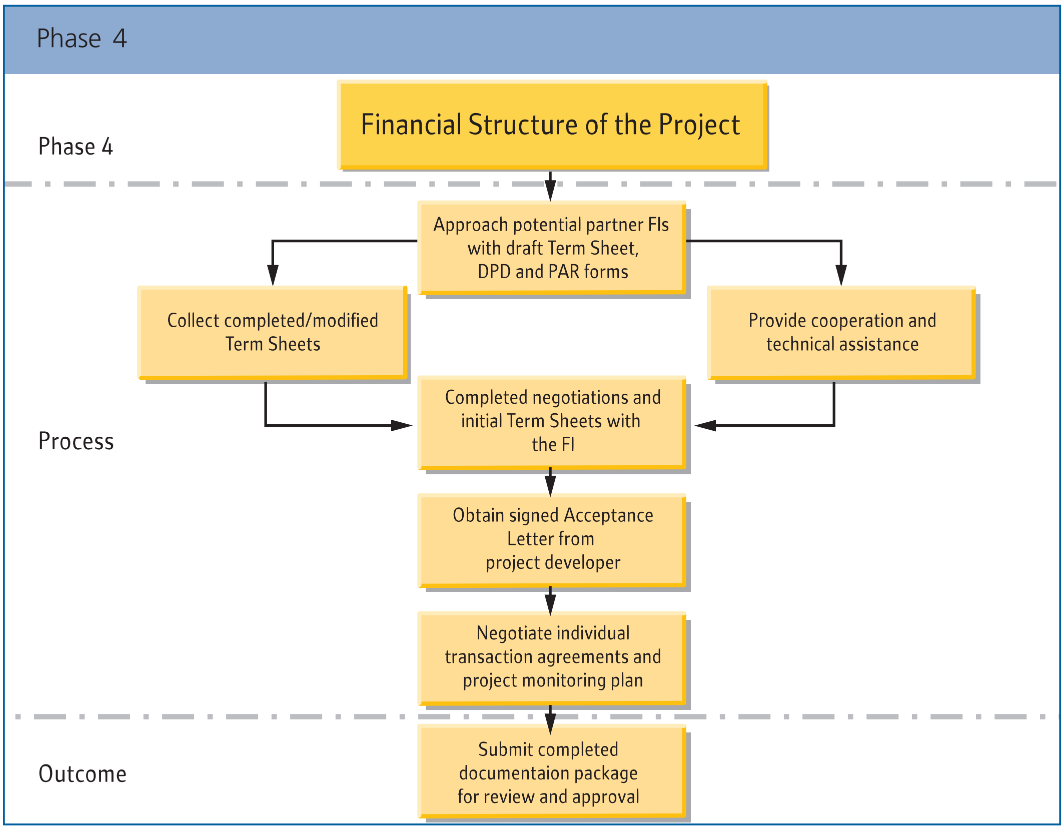
The detailed project cycle of the Fund is illustrated below[2].

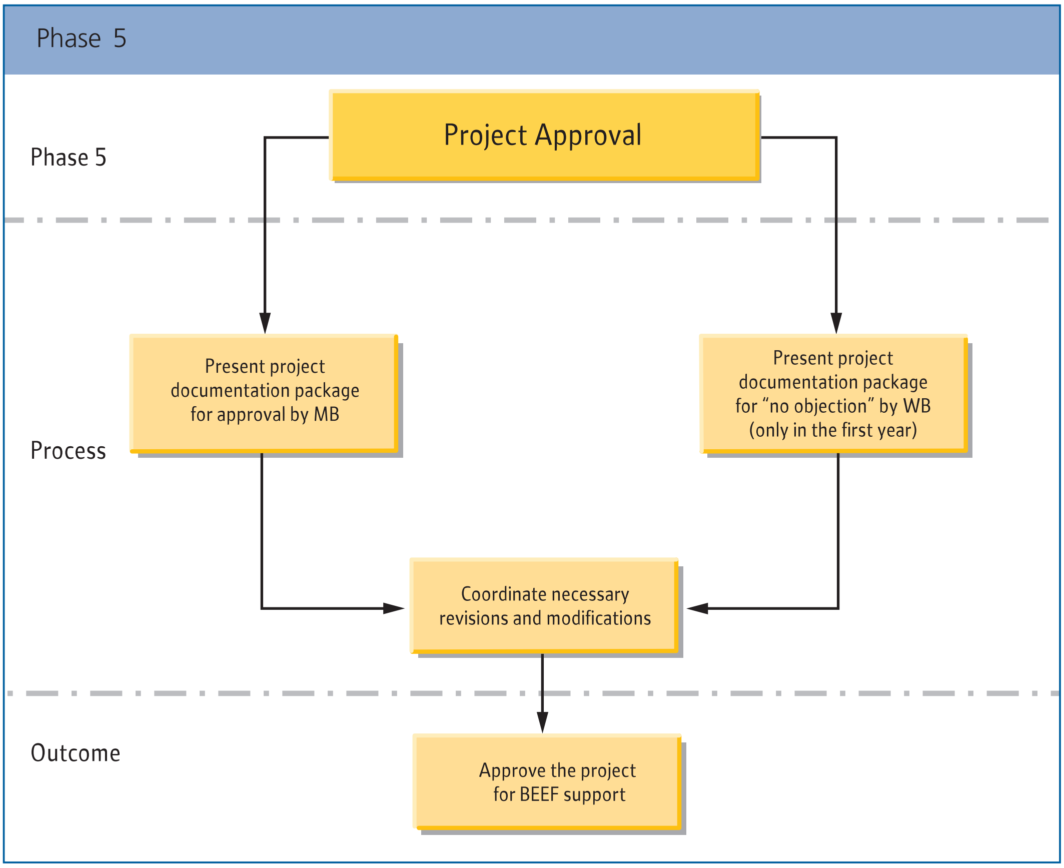
[2] World Bank, *Bulgaria: Energy Efficiency Project, Operations Manual*, Project No. E956, 2004

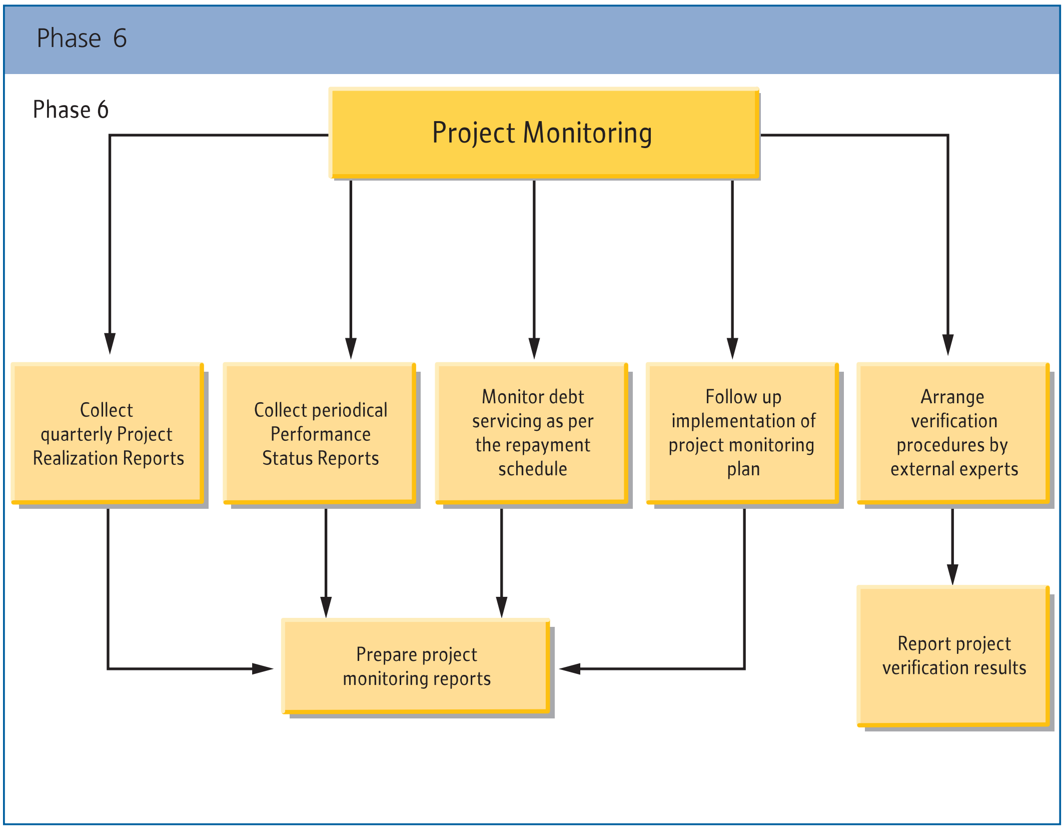

Phase 1
Phase 1
Project Identification
Process
Approach EE sector stakeholders
Perform sector analysis
Approach potential partners FIs
Signing of GFA
Approach potential project developers
Prepare project pipeline list
Outcome
Periodically update the project pipeline list


Phase 2
Phase 2
Initial Project Screening
Process
Allocate/assign projects to Project Coordinators
Instruct project developers and provide the IPP
Assist project developers with IPP completion
Check submitted IPP
Complete the ESS and Initial Appraisal Form and submit for approval with the IPP
Outcome
Decide on project approval for further evaluation or rejection


Phase 3
Phase 3
Comprehensive Project Appraisal
Process
Organise meetings with project developers
Provide detailed instructions on the completion of GHG emissions reductions assessment and the DPD form
Arrange technical assistance to Project Developers
Check submitted GHG assessment report and DPD form
Perform technical feasibility assessment
Perform technical feasibility assessment
Perform environmental feasibility assessment
Assess need for external expert assistance
Prepare Project Appraisal Report and submit for approval wth the DPD
Outcome
Submission of project package for review and pre-approval (by MB)

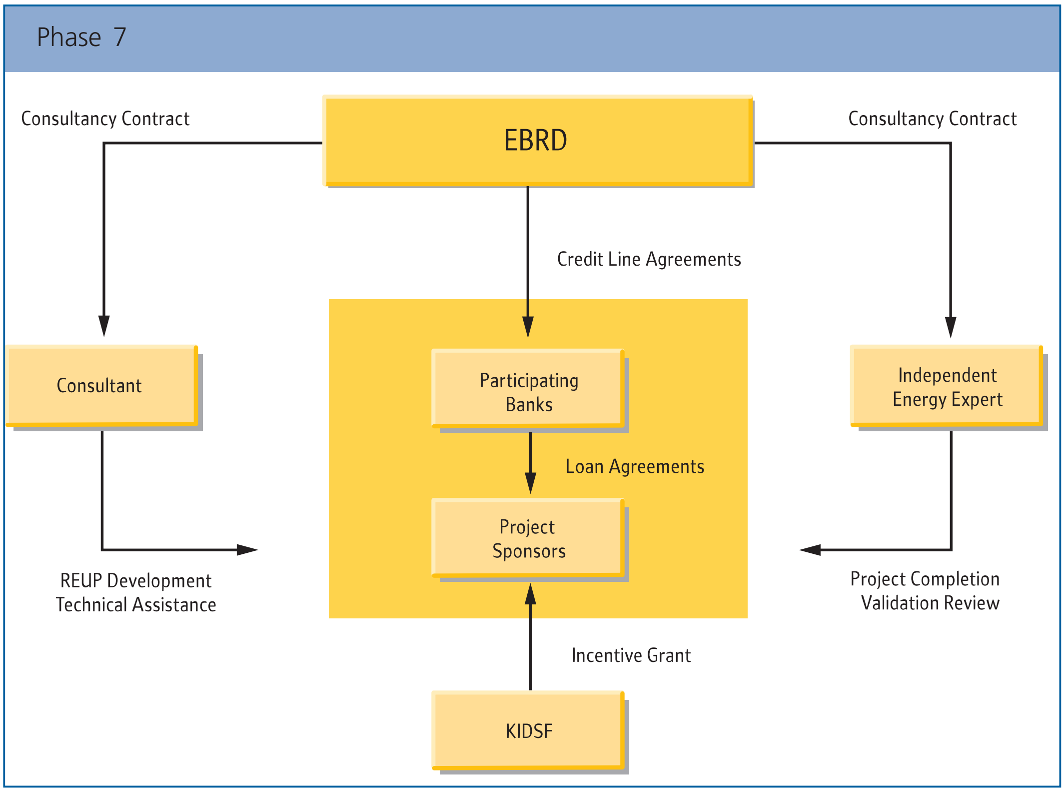

Phase 4
Phase 4
Financial Structure of the Project
Process
Approach potential partner FIs with draft Term Sheet, DPD and PAR forms
Collect completed/modified Term Sheets
Provide cooperation and technical assistance
Completed negotiations and initial Term Sheets with the FI
Obtain signed Acceptance Letter from project developer
Negotiate individual transaction agreements and project monitoring plan
Outcome
Submit completed documentaion package for review and approval


Phase 5
Phase 5
Project Approval
Process
Present project documentation package for approval by MB
Present project documentation package for “no objection” by WB (only in the first year)
Coordinate necessary revisions and modifications
Outcome
Approve the project for BEEF support


Phase 6
Phase 6
Project Monitoring
Collect quarterly Project Realization Reports
Collect periodical Performance Status Reports
Monitor debt servicing as per the repayment schedule
Follow up implementation of project monitoring plan
Arrange verification procedures by external experts
Prepare project monitoring reports
Report project verification results

(b) Bulgarian Energy Efficiency and Renewable Energy Credit Line (BEERECL)

Under the BEERECL, the EBRD extends loans to participating banks, which on-lend to private sector companies for industrial energy-efficiency projects and small renewable energy projects.



An essential component of the BEERECL is the assistance provided by DAI Europe and EnCon Services to help eligible project sponsors and participating banks develop projects. Services include energy auditing, financial analysis, risk assessment, development of bankable business plans (Rational Energy Utilisation Financing Plans–REUPs), formulation of loan applications for presentation to participating banks and deal structuring.

More information (including templates for business plans) can be found at www.beerecel.com.

Upon completion of eligible projects, as verified by an independent energy expert hired by the EBRD, the project sponsors (borrowers) receive the following incentive grant from the Kosloduy International Decommissioning Support Fund:

- Energy-efficiency projects – 7.5% of the loan principal disbursed;
- Small renewable energy projects – 20% of the loan principal disbursed.

Procedure for obtaining financing under the BEERECL.

Step 1: BEERECL application, eligibility evaluation, development of Rational Energy Utilisation Financing Plan and loan application

- The project sponsor (potential borrower) contacts (or is contacted by) the participating bank or project team and submits the application form.
- The project team determines project eligibility.
- The project sponsor signs a waiver letter releasing the EBRD from any liability.
- The participating bank performs prescreening tests of the project sponsor's creditworthiness.
- The project team performs the energy audit and project cash-flow analysis.
- The project sponsor approves the energy audit results and proposed technical measures.
- The project team, with the support of the project sponsor, develops the project business plan (Rational Energy Utilisation Financing Plan).
- The project sponsor submits the loan application and the Rational Energy Utilisation Financing Plan to the participating bank.

Step 2: Loan agreement

- The participating bank reviews the loan application and the Rational Energy Utilisation Financing Plan and makes a decision on financing.
- The project sponsor and participating bank sign a loan agreement.

Step 3: Financing disbursed and implementation

- The project sponsor receives debt financing from the participating bank, contributes its own resources and implements the project.

Step 4: Project completion and incentive grant

- The independent energy expert of the EBRD validates completion of the project.
- The project sponsor receives the incentive grant from the EBRD.

References

General literature about energy-efficiency investments and energy service companies

A. Thumann, E. Woodroof, *Handbook of Financing Energy Projects*, 2005

United Nations Development Programme (UNDP), *How-to Guide on Local Financing for Energy Efficiency*, 2005

World Bank, GEF *Energy Efficiency: Portfolio Review and Practitioners' Handbook*, 2005

World Bank, *Local Financing for Sub-Sovereign Infrastructure in Developing Countries: Case Studies of Innovative Domestic Credit Enhancement Entities and Techniques*, 2005

United Nations Environment Programme, 2006 Assessment Report of the Technology and Economic Assessment Panel, 2006
(www.ozone.unep.org/TEAP/Reports/TEAP_Reports/teap_assessment_report06.pdf)

Completed Chiller Replacement Projects

World Bank, *Mexico – Third Ozone Depleting Substances Phase out (Montreal Protocol) Project*, Implementation Completion and Results Report, Report No. ICR130, 2006

World Bank, *Thailand – Building Chiller Replacement Project*, Implementation Completion and Results Report, Report No. 36264, 2006

Examples of existing Energy Efficiency Financing Schemes

Bulgarian Energy Efficiency Fund: www.bgeef.com

Bulgarian Energy Efficiency and Renewable Energy Credit Line: www.beerecl.com

Egyptian Pollution Abatement Project: www.eeaa.gov.eg/Epap

World Bank, *Bulgaria: Energy Efficiency Project, Operations Manual*, Project No. E956, 2004

Chiller replacements under CDM

United Nations Framework Convention on Climate Change (UNFCCC):
unfccc.int/2860.php

UNFCCC: The Mechanisms under the Kyoto Protocol: The Clean Development Mechanism, Joint Implementation and Emissions Trading
unfccc.int/kyoto_protocol/mechanisms/items/1673.php

Joint Implemenation (JI): ji.unfccc.int/

Clean Development Mechanism (CDM) cdm.unfccc.int/index.html

List of Designated Operational Entities (DOE) cdm.unfccc.int/DOE/index.html

UNFCCC CDM Methodologies:
cdm.unfccc.int/methodologies/PAmethodologies/approved.html

CDM Methodology NM0197 India – Accelerated Chiller Replacement Programme:
cdm.unfccc.int/Panels/meth/MP28_Report_Ext

Designated National Authorities (DNA): cdm.unfccc.int/DNA/index.html

CER: Emission reduction credits yielded by a CDM project
www.ji-cdm-austria.at/en/portal/online_services/glossary/index.php?cid=2482

Example of Technical Guidelines

U.S. Department of Energy, Energy Efficiency and Renewable Energy, Federal Energy Management Program, How to buy an Energy-Efficient Water-Cooled Electric Chiller, 2004: www1.eere.energy.gov/femp/pdfs/wc_chillers.pdf

List of Abbreviations

BgEEF	Bulgarian Energy Efficiency Fund
CDM	Clean Development Mechanism
CER	Certified Emission Reductions
CFC	chlorofluorocarbons
CO2	carbon dioxide
COP (of absorption)	coefficient of performance
CPA	CDM programme activity
DNA	Designated National Authority
DPD	detailed project description
EB	Executive Board (UNFCCC CDM EB)
EBIT	earnings before interest and taxes
EBRD	European Bank for Reconstruction and Development
EE	energy efficiency
ERC	environmentally relevant costs
ESCOs	energy service companies
EUR	euro
FI	financial intermediary
GEF	Global Environment Facility
GFA	Grant Financial Agreement
GHG	greenhouse gases
GWP	global warming potential
HCFC	hydrochlorofluorocarbons
HFC	hydrofluorocarbons
IEE	independent energy expert
IFIs	international financial institutions
IPLV	integrated part load value
IPP	initial project proposal
KIDSF	Kozloduy International Decommissioning Support Fund
LoAs	letters of approval
MB	Managing Board
MLF	Multilateral Fund
NCPs	National Competence Partners
NOUs	National Ozone Units
ODP	ozone-depleting potential
ODS	ozone-depleting substances
PDD	project development document
PoA	programme of activities (CDM)
PPP	public-private partnership
R&R	recovery and recycling
RAC	refrigeration and air conditioning
RMP	refrigerant management plan
ROACE	return on average capital employed
ROE	return on equity
TA	technical assistance

TEAP	Technology and Economic Assessment Panel
TPF	third-party financing
TR	tons refrigeration
UNDP	United Nations Development Programme
UNEP	United Nations Environment Programme
UNFCCC	United Nations Framework Convention on Climate Change
UNIDO	United Nations Industrial Development Organization
USAID	United States Agency for International Development
VSD	variable speed drive

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UNITED NATIONS INDUSTRIAL DEVELOPMENT ORGANIZATION
Vienna International Centre, P.O. Box 300, 1400 Vienna, Austria
Telephone: (+43-1) 26026-0, Fax: (+43-1) 26926-69
E-mail: unido@unido.org, Internet: http://www.unido.org