MULTILATERAL FUND FOR THE IMPLEMENTATION OF THE MONTREAL PROTOCOL ON SUBSTANCES THAT DEPLETE THE OZONE LAYER

PROJECT COVER SHEET

COUNTRY: COLOMBIA **IMPLEMENTING AGENCY:** UNDP

PROJECT TITLE: Demonstration project for integrated management of the centrifugal chiller sub-sector in Colombia, focusing on application of energy-efficient CFC-free technologies for replacement of CFC-based chillers

PROJECT IN CURRENT BUSINESS PLAN: Yes

SECTOR: Refrigeration & Air Conditioning
SUB-SECTOR: Chillers

ODS USE IN SUB-SECTOR: Current (2004) 4 MT ODP

PROJECT IMPACT: Reflecting the net ODP value not applicable MT ODP (* demonstration)

PROJECT DURATION: 3 years (2006 – 2008)

		MLF	Counterpart	Total
PROJECT COSTS & FUNDING:	US$	1,000,000	1,000,000 GEF MSP (GEF 3)	2,000,000
AGENCY SUPPORT COSTS:	US$	75,000	90,000	165,000
TOTAL COSTS:	US$	1,075,000	1,090,000	2,165,000

LOCAL OWNERSHIP: 100%
EXPORT COMPONENT: 0%

STATUS OF COUNTERPART FUNDING: As described above
PROJECT MONITORING MILESTONES: Included
NATIONAL COORDINATING BODY: Ozone Technical Unit (UTO), Ministry of Environment, Housing and Territorial Development (MVADT)

PROJECT SUMMARY

This project aims at developing and demonstration of sustainable institutional and financial mechanisms to facilitate integrated management of the centrifugal chiller sub-sector in Colombia, through application of environmentally sound and energy-efficient alternative technologies for replacement of CFC-based centrifugal chillers. Upon completion, the project will have the following primary outcomes: (a) creating conditions favorable for removal of technological, financial and regulatory barriers to early replacement of CFC-based chillers (b) elimination of the residual consumption of Annex-A, Group-I substances (CFCs) in servicing of CFC-based centrifugal chillers Colombia; (c) creation of a stockpile of CFCs recovered from replaced chillers to be used for servicing of those CFC-based chillers, for which replacement is not immediately viable (d) demonstration of energy savings through application of energy-efficient replacement technologies and (e) demonstration of reductions in greenhouse gas emissions through application of energy-efficient replacement technologies. From a sample numbering 58 chiller installations, representing the priorities of the Government of Colombia in terms of ownership and end-use profiles, a representative sample of 13 chillers will be selected for replacement demonstration.

The secondary outcomes of this demonstration project would be: (a) Compilation of a national inventory and conversion priority list of CFC-based chillers; (b) Compilation of a range of cost-effective replacement technology options and (c) Capacity-building of national expertise in implementation of chiller replacement technologies. It is expected that the primary and secondary outcomes of the project would be critically useful in developing a strategy for country-wide replacement of CFC-based chillers through leveraging a combination of funding sources such as commercial finance, carbon finance and other multilateral and bilateral funding sources.

PREPARED BY: UNDP jointly with UTO/MVADT and chiller task force national team **DATE:** 3 October 2005

COLOMBIA

DEMONSTRATION PROJECT
FOR INTEGRATED MANAGEMENT OF THE CENTRIFUGAL CHILLER SUB-SECTOR IN COLOMBIA, WITH FOCUS ON APPLICATION OF ENERGY-EFFICIENT CFC-FREE TECHNOLOGIES FOR REPLACEMENT OF CFC-BASED CHILLERS

Prepared jointly by

UTO/MVADT
United Nations Development Programme
3 October 2005

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LIST OF ABBREVIATIONS

ARI	American Refrigeration Institute
ANSI	American National Standards Institute
ASHRAE	American Society of Heating, Refrigeration and Air-conditioning Engineers
BTU	British Thermal Unit
C	Carbon
CDM	Clean Development Mechanism
CFC	Chlorofluorocarbons
CO_2	Carbon dioxide
COP	Coefficient of Performance
DSM	Demand Side Management
EER	Energy Efficiency Ratio
EFLH	Equivalent Full Load Hours
ExCom	Executive Committee of the Multilateral Fund for the Montreal Protocol
GDP	Gross Domestic Product
GEF	Global Environment Facility
GHG	Greenhouse Gases
GWP	Global Warming Potential
HCFC	Hydrochlorofluorocarbons
HFC	Hydrofluorocarbons
Hr	Hour
ISO	International Standards Organization
Kcal	Kilocalories
Kg	Kilogram
Kg-C	Kilogram Carbon equivalent emissions
Kw	Kilowatts
Kwh	Kilowatt-hours
Kwh/TR	Kilowatt-hours per ton of refrigeration
MLF	Multilateral Fund for the Implementation of the Montreal Protocol
MP	Montreal Protocol on Substances that deplete the ozone layer
MT	Metric Ton (1,000 kilogram)
ODP	Ozone Depleting Potential
ODS	Ozone Depleting Substances
TEWI	Total Equivalent Warming Impact
TR	Tons of Refrigeration (12,000 BTU/hr or 3,024 kcal/hr)

PROJECT OF THE GOVERNMENT OF COLOMBIA

Demonstration Project for Integrated Management of the Centrifugal Chillers Sub-sector in Colombia, focusing on Application of Energy-efficient CFC-free technologies for Replacement of CFC-based chillers

1. SITUATION ANALYSIS – MOP and ExCOM GUIDANCE

Decision XVI/13 of the Meeting of the Parties to the Montreal Protocol (November 2004) requested the Executive Committee of the Multilateral Fund for the Implementation of the Montreal Protocol (MLF) to consider funding additional demonstration projects[1] in the chillers sub-sector to help demonstrate the value of replacement of CFC-based chillers, as well as to increase awareness of users of the impending phase-out and options that may be available for dealing with their chillers. Decision XVI/13 also requested countries preparing or implementing Refrigerant Management Plans (RMPs) to consider developing measures for the effective use of the ozone-depleting substances recovered from the chillers to meet servicing needs in the sector.

Further to this Decision, the Executive Committee of the Multilateral Fund (ExCom) adopted Decision 45/4 (d) in April 2005, requesting that criteria and modalities for chiller demonstration projects be developed. At the same time, the ExCom set aside a funding window of US $15.2 million dollars for funding in this sub-sector in response to the MOP decision.

At its 46th Meeting (July 2005), the ExCom adopted criteria and modalities for chiller demonstration projects under Decision 46/33. The main aim of the decision is to allow for utilization of the US $15.2 million funding window for additional demonstration projects in the chiller sub-sector, with an understanding that no further funding for chiller replacement would be approved by the ExCom, as per the following guidelines (paraphrased):

(i) That the MLF agencies, as well as interested bilateral agencies, submit project proposals to ExCom 47 (November 2005) that demonstrate replicability and scale-up potential (feasibility of, and modalities for) for replacing centrifugal chillers in the future through use of resources external to the MLF. Agencies were encouraged to submit such projects on a regional basis to allow as many countries as possible to be included;

(ii) To agree to the following conditions for such investment demonstration projects:

1. Countries participating in the demonstration should have enacted and were enforcing legislation to phase out ODS (refer to Section 3.3);
2. As the project is intended to use financial resources outside the Multilateral Fund, the credibility of those financial resources should be indicated at time of submission to the Fund, on the understanding that such financial resources should be secured before disbursement of funds approved under the Fund commences (refer to Section 3.5);
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 (refer to Section 5.4);
4. The maximum Multilateral Fund grant for a particular country is US $1,000,000; for regional

[1] There are 4 ongoing demo programmes for replacement of CFC chillers at present – Côte d'Ivoire, funded by France; Mexico (managed by the World Bank using UK MLF bilateral contribution + private sector input), Thailand (managed by the World Bank with joint financing through MLF and GEF) and Turkey (managed by the World Bank with MLF funding – CFC chiller phase-out as part of Refrigerant Mgmt Plan)

projects, approval of additional funding on a revolving fund basis could be decided on a case-by-case basis (refer to Section 6.2); 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 (refer to Annex 3).

2. PROJECT OBJECTIVES – Aims and Outcomes

This project aims to develop and demonstrate sustainable institutional and financial mechanisms to facilitate integrated management of the centrifugal chiller sub-sector in Colombia, through application of environmentally sound and energy-efficient alternative technologies for replacement of CFC-based centrifugal chillers.

2.1. a. The project will have the following primary outcomes:

a) Creating conditions favorable for removal of technological, financial and regulatory/fiscal barriers to conversion to of non-CFC energy efficient chillers;
b) Based on the above, establish a business model for market transformation;
c) Reduction/elimination of the residual consumption of Annex-A, Group-I substances (CFCs) in servicing of CFC-based centrifugal chillers Colombia;
d) In coordination with the ongoing activities being implemented under the National Phase Out Plan, creation of a stockpile of CFCs recovered from replaced chillers to be used for servicing of those CFC-based chillers, for which replacement is not viable;
e) Demonstration of energy cost savings through application of energy-efficient replacement technologies; and,
f) Demonstration of reductions in greenhouse gas emissions through application of energy-efficient replacement technologies, a component that will satisfy the requirements for the associated GEF co-financing request.

2.1.b. The secondary outcomes of this demonstration project would be:

a) Compilation of a national inventory and conversion priority list of CFC-based chillers;
b) Compilation of a range of cost-effective replacement technology options; and,
c) Capacity-building of national expertise in implementation of chiller replacement technologies.

It is expected that the primary and secondary outcomes of the project would be critically useful in developing a replicable strategy for country-wide replacement of all CFC-based chillers through leveraging a combination of funding sources such as commercial finance, carbon finance and other multilateral and bilateral funding sources and counterpart funding from intended recipients.

The project is intended to serve essentially as a demonstration project for funding mechanisms, for institutional and management frameworks and for energy and cost savings through adoption and application of appropriate technologies. To this end, a representative selection of chillers, drawn from a sample set of 50 nationally-owned chiller installations, representing the priorities of the Government of Colombia in terms of ownership and end-use profiles, have been selected for this replacement demonstration.

3. BACKGROUND

3.1 Introduction

Colombia, the fourth largest country in Latin America, occupies a total area of 1.2 million km2. The country is made up of 32 departments, with Bogotá being the capital district. Colombia is the third-most populous country in Latin America after Brazil and Mexico. Movement from rural to urban areas over the past five decades has been significant, increasing from 57% to 74% in the late 1990s. Thirty cities have a population of 100,000 or more.

The Colombian climate is tropical on the coast and eastern plains, with cooler temperatures predominating in the highlands. Being close to the equator, Colombia's average temperature does not change much throughout the year, although its climate does vary with its different altitudes. While most of the country enjoys relatively stable temperature ranges of an annual average of 24-28^{o}C[2], the country does have three distinct climatic zones with temperatures ranging from over 30°C on the Caribbean coast to 12°C on high mountain plateaus. Average temperature in Bogotá range from 10°C to 18°C in July to 9°C to 20°C in February.

With the advent of the Montreal Protocol on Substances that Deplete the Ozone Layer, global production of chillers using CFCs or refrigerants containing CFCs essentially came to an end. The average chiller manufactured today uses about 35% less electricity than average chillers produced just two decades ago. With the best technology available, operated on HCFC-123 or HFC-134a, new chillers can use up to 50% less electricity than an average chiller from 1976.[3] Energy efficiency savings is therefore a primary environmental consideration and potential economic incentive for conversion to non-CFC chillers.[4] Replacing CFC based chillers also contributes to reduced greenhouse gas emissions, both from an energy consumption perspective and from reduced emissions of CFCs which have high global warming potential[5]. Naturally, the choice of non-CFC refrigerants will affect the aggregate greenhouse gas emissions impact of the substitute technologies.

3.2 Colombia's Montreal Protocol Activities

Colombia acceded the Vienna Convention on 16 July 1990, and the Montreal Protocol, along with its London Amendment on 6 December 1993. It later introduced its acceptance of the Copenhagen Amendment on 5 August 1997 and ratified the Montreal Amendment on 16 June 2003. In addition, the Government of Colombia, through the law 960 of 28 June 2005, approved the Beijing Amendment and the ratification process is expected to be completed during 2005.

Colombia is classified as a country operating under Article 5 of the Montreal Protocol as its consumption per capita of Annex A, Group I chemicals is less than 0.3 kg ODP per year. Colombia does not produce any of the Annex A Group I substances (CFCs), and the demand for CFCs as of now has been met through imports, principally from Mexico, but also Venezuela and the Netherlands.

The Country Programme for the Phase out of ODS (CP) in Colombia was approved by the Executive

[2] Executive Summary from Colombia's First National Communication to the UNFCCC; December 2001.
[3] Report of the TEAP Chiller Task Force, Technical and Economic Assessment Panel of the Montreal Protocol, May 2004.
[4] Ibid. While some alternatives (HFCs) do possess Global Warming Potential (GWP), refrigerants on the whole do not contribute to global warming unless released into the atmosphere. Properly maintained chillers of modern design emit less than 1% of their refrigerant charge each year. The dominant global warming effect caused by chiller operation is therefore, the carbon dioxide emitted during combustion of fossil fuels used to generate the electricity required to drive them.
[5] CFC-11 has a GWP of 5000, while CFC-12 has a GWP of 8500

Committee of the Multilateral Fund at its 12th Meeting in March 1994. Since then, the Ozone Technical Unit (UTO) within the Ministry of Environment, Housing and Territorial Development (MVADT), co-sponsored by the Institutional Strengthening Project, has managed its implementation.

At the 41st Meeting of the Executive Committee in December 2003, Colombia received approval of its Country Programme Update and "National Phase-Out Plan for substances Annex A Groups I and II" (NPP). The NPP for Colombia had the objective of establishing the strategy and action plan for total elimination of CFC and halons consumption in Colombia, and enabling the country to maintain compliance with the 2005 Montreal Protocol CFC reduction obligation, and further comply with the 2007 and 2010 Montreal Protocol reduction obligations concerning CFCs and halons.

The implementation of the CP and the recent start of activities within the NPP in Colombia have been very successful and have enabled the country to be in compliance with all the Montreal Protocol measures, including the 1999 CFC freeze obligation, and even with the 2005 CFC reduction obligation in advance of the required date. The country has also achieve compliance with the 2002 halons freeze obligation and even with the 2005 halon reduction obligation, also in advance of the required date. Colombia has also achieved total phase out of MB and TCA and is already in compliance with the 2005 CTC reduction obligation.

Some of the crucial elements in determining the outcome of the implementation process are listed below:

- Relationship between policy adoption and industry conversions: well-designed policies depend have been to great extent the result of consultative process carried out with the industry sector that will be affected by them.
- Interaction between non-investment and investment activities: non-investment activities carried out by the Government on public and industry awareness, legal framework needed to support all other initiatives and increasing the level of technical knowledge on new technologies have been instrumental in setting off initiatives, maintaining momentum, and enabling investment actions.
- Role of implementing agencies: implementing agencies have had a foremost role in the CP implementation process through guidance, technical expertise, and invaluable feedback about specific experiences in other projects.

Baseline consumption of CFC for Montreal Protocol controls (average consumption for the years 1995 to 1998) is 2,208 ODP tonnes. Through the implementation of MLF funded activities and application of the legislation Colombia has achieved reductions for more than 50 % the baseline. Table 1 shows the CFC consumption trend in Colombia compared to the Montreal Protocol Controls.

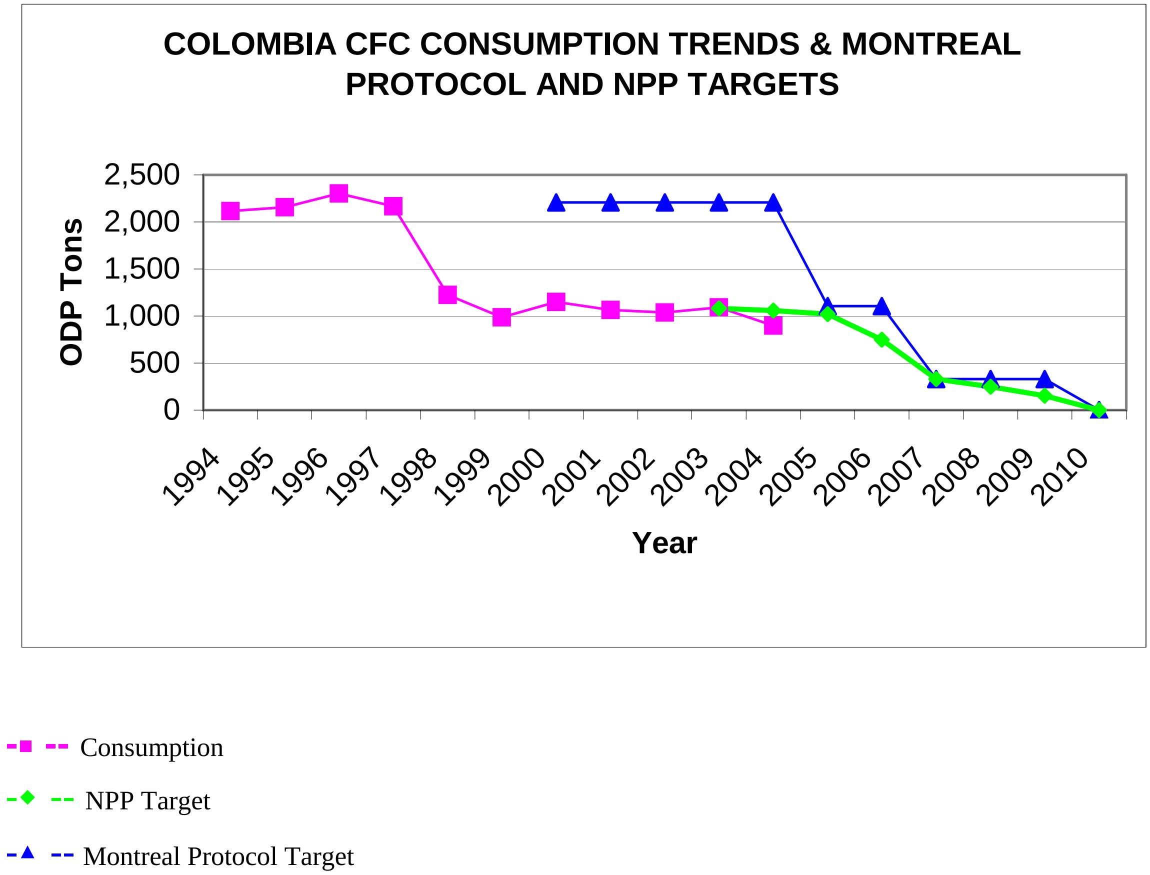


Table 2 shows latest reported level of CFC consumption per sector in Colombia. A brief description of the status of consumption per refrigeration sub-sector is presented below:

Table 2: Consumption 2004 per Sector. Annex A Group I substances

	Consumption per Sector (Metric Tonnes)						
			Refrigeration				
Substance	**Aerosols**	**Foams**	**Manufacturing**	**Service**	**Solvents**	**Process Agent**	**TOTAL**
CFC-11	2.80	41.88	10.00	40.32			95.00
CFC-12	5.28	16.33	25.00	754.25			800.86
CFC-113					2.19	0.00	2.19
CFC-114			0.00	0.00			0.00
CFC-115			0.00	1.48			1.48
Subtotal	8.08	58.21	35.00	796.05	2.19	0.00	899.53

The country has achieved the elimination of the CFCs described above through the implementation of different projects approved and financed by the Multilateral Fund (MLF) – among them the NPP. The situation associated with each of the CFC consuming sectors is briefly presented below:

i) REFRIGERATION AND AIR CONDITIONING SECTOR

Manufacturing

The ***domestic*** refrigeration manufacturing sector was reconverted through a project approved by the Multilateral Fund. This process terminated in 1997.

The ***commercial*** and industrial refrigeration manufacturing sector has worked with the large and mid-size companies, which also have been reconverted through MLF projects. One umbrella project is expected to end in December 2005 and the NPP includes a sub-project on the elimination of CFCs in other, smaller commercial refrigeration companies is also expected to be completed in December 2005.

During 2004 the ***air conditioning*** conversion projects were also completed.

Maintenance

The refrigeration and air conditioning maintenance sector has been covered previously by an R&R project and another project on Training in Good Practices of Servicing in Refrigeration, both of them concluded. In the Good Practices Programme, the National Apprenticeship Service (SENA) has reported the training of approximately 2,670 technicians during 2003 and 2004. They have received instruction in R&R techniques, MP implementation, basic environmental ecology, and the handling of refrigerants. Under this model approximately 4000 refrigeration technicians have received instruction.

The R&R project is focused on CFC 12 and does not include equipment to recover CFC 11. As of now, conservations activities addressed to the chillers sector have not been programmed and they will be subject and tailored to the strategy of chiller replacement. The present demonstration project will help to establish the needs for implementing the strategy to ensure that CFC from chillers is not released to the atmosphere and can be re-used in maintenance (CFC 12) when feasible.

ii) FOAMS SECTOR

Colombia is implementing the Terminal Phase-Out project for polyurethane foams, which should be finalized technically at the end of 2005. With the consolidation of this project and the completion of the commercial refrigeration sector, it is expected that CFC-11-based foams will be prohibited beginning in 2006.

iii) AEROSOLS SECTOR

Colombia has prohibited the use of CFC as an aerosol propellant for commercial use since 1989. Regarding medical use in Measured Dose Inhalers (MDI), one laboratory was identified using around 8 ODP tonnes in 2004. The laboratory is conducting research in preparation for the propellant transition.

iv) SOLVENTS SECTOR

During 2004 Colombia terminated a project aimed at substituting CFC113 for HFCF141b.

3.3 Colombia's Montreal Protocol Institutional Framework

Once the Country Programme was approved, the Ozone Technical Unit (UTO) was created within the Ministry of Environment and funded under the Multilateral Fund to promote, execute and disseminate all activities related to the implementation of the Montreal Protocol.

In 2003, the Ministry of Environment absorbed some of the functions of the Ministry of Economic Development thus becoming the Ministry of Environment, Housing and Territorial Development (MAVDT, by its initials in Spanish), through Decrees 216 and 217 of February 2003. Two Vice Ministries were also created, one for Environment and one for Housing and Territorial Development. The Ozone Technical Unit did not suffer any changes and continued under the direction of the Vice Ministry of Environment.

Currently, through the NPP the UTO has regional presence in the regions with the highest concentration of ODS consumption. This has proven instrumental in achieving better coverage with the projects and better understanding of the consumer sectors.

The policy under which the Government of Colombia has approached the implementation of the Montreal Protocol has been one of assisting the industry in its efforts to eliminate the use of ODSs, and encouraging industry's agreement and cooperation, while at the same time promoting awareness both of industry and the general public about the threat of the ozone layer depletion, and the efforts being carried out by the Government and the private industry to address this threat.

Existing legal framework

To date, the following instruments form the legal framework that supports such efforts:

- Law 30 of year 1990, by which the Vienna Convention was adopted.
- Law 29 of year 1992, by which the Montreal Protocol and its London Amendment were adopted.
- Resolution 0528 of year 1997, by the Ministry of Environment, prohibiting the production of domestic refrigeration equipment that contains CFCs, and establishing the requisites for their import.
- Resolution 0304 of year 2000, by the Ministry of Foreign Affairs, which establishes annual quotas for CFC imports, a system of import licenses, and sanctions for non-compliance.

Among many other complementary legal instruments in place, the most relevant for the purpose of this project are:

- Decree 1753 of year 1994 and Decree 1180 of year 2003 that regulate the environmental licensing for the different productive sectors in the country. In the case of ODSs, the license to produce or import ODSs is required only for those that started activities after 1993, that is, the non-traditional importers.
- Law 223 of year 1998, which establishes exemptions 1) on import taxes for equipment used for recycling or processing of contaminant residual waste or emissions, and 2) on Added Value Tax for elements necessary to assemble, install or operate monitoring equipment necessary to comply with environmental regulations.

- Law 488 of year 1998, issued by the Congress, related to the reform of the national tax system, which in its articles 32, 33, 34 and 35 establishes tax exemptions for donations coming from the MF, and allowed to establish tax exemptions on occasional profit generated by the transfer of ownership of equipment to enterprises converted to non-CFC technology and beneficiary of MF funded projects.

Through the implementation of the NPP major results in controlling ODS commerce were achieved during the period of 2004-2005. Details of these could be consulted in the NPP report submitted to the 47th Executive Committee Meeting.

3.4 Colombia's Energy Demand Scenario

The Colombian electricity sector is made up of a mix of public- and privately-owned companies, the result of deregulation launched in the 1990s which opened the sector to private investment and established a wholesale electricity market.[6] Hydroelectric power dominates in electricity generation in Colombia, with conventional thermal, principally coal and natural gas, as well as other renewables, making up the difference. In 1990, electricity accounted for 11.4% of final energy consumption.[7] Colombia has historically been greatly dependent on hydroelectric power for its electricity needs. Indeed, over the past decade, its generating capacity has increased by approximately 50%, reflecting the burgeoning demand for power in the country. Severe droughts, compounded by lack of investment and security issues, have caused power shortages and resulted in forced rationing. As a result, Colombia has encouraged development of more non-hydroelectric electricity generation capacity, with a goal of at least 20% shares for both coal-fueled and gas-fueled power generation in the near future. In addition, the country plans to increase its thermal generation capacity to 50% of its total capacity by 2010. [8]

On the whole, electricity demand in Colombia has grown steadily over the last 15 years, and future demand is projected to grow at about 4.4% per year through 2020. A number of institutions in Colombia are actively working on energy efficiency. These include, but are not limited to: the Instituto Colombiano de Energia Electrica (ICEL), Empresa Nacional De Electricidad S.A. (ENDE) and, the Comision Nacional de Energia.

4. THE CHILLER SECTOR – Replacement Technology Options and Costs

Traditionally, central air conditioning systems used fluorocarbon refrigerants to chill water in a cooling loop. The chilled water produced in a chiller is then circulated throughout the building to air handling units located in various parts of the building, for cooling the air. There are four basic types of water chillers, typically of over 100 tons capacity, used for central air conditioning of buildings:

a) Reciprocating compressor-based (open or semi-hermetic): Capacity up to 200 TR
b) Rotary compressor-based (open or semi-hermetic): Capacity typically up to 400 TR
c) Centrifugal compressor-based (open or semi-hermetic): Capacity typically 200 TR and above
d) Absorption systems (do not use either compressors or fluorocarbon refrigerants): Capacities typically 150 TR and above.

[6] EIA, DOE; Country Analysis Briefs, Colombia, 2002.
[7] Executive Summary from Colombia's First National Communication to the UNFCCC; December 2001.
[8] US DOE; An Energy Overview of Colombia.

The present discussion and analysis will limit itself to centrifugal chillers (and absorption chillers in context of replacement).

Large-capacity central air conditioning systems, especially those installed in the 1970s to the early 1990s, were predominantly designed with centrifugal compressors and used CFCs as refrigerants. The commonly used refrigerants in centrifugal chillers were CFC-11 (predominant), CFC-12, CFC-500 and HCFC-22 until the initiation of controls of CFCs. Centrifugal Chillers are typically electric motor-driven, but in some applications, driven by engines or turbines.

The initial refrigerant charge in centrifugal chillers is 1-2 kg per TR (ton of refrigeration) depending on the refrigerant used and the system type. Annually, the typical refrigerant loss in an open compressor centrifugal chiller ranges typically around 1-10% of the initial refrigerant charge, depending on the practices followed and the chiller technology and age. According to studies on the subject, in several countries annual charge lost per year could reach 25 % (Chillers and Refrigerant Management Training Manual, UNEP, 1994) and in some cases 30% (Report of the TEAP Chiller Task Force, UNEP, 2004).

There are three types of centrifugal chillers:

Low-pressure chillers:	CFC-11 as the refrigerant (usually up to 1,000 TR)
Medium-pressure chillers:	CFC-12 or 500 as the refrigerant (300 - 1,500 TR)
High-pressure chillers:	HCFC-22 as the refrigerants (usually from 300 - 8,500 TR)

Centrifugal chillers are also classified as open type (where the compressor and the drive motor are separately mounted) or semi-hermetic (where the compressor and drive motor are encased in a common housing).

4.1 Chiller Energy Efficiency Developments

Energy efficiency of centrifugal chillers is delineated in total energy consumption per ton of refrigeration. The average energy efficiency of centrifugal chillers has evolved as below:

Age of chiller (Years)	Energy Efficiency Range (Kw/ton)
20 or more	0.70 – 1.00
10 – 20	0.65 – 0.80
10 to new	0.49 – 0.65

The above-mentioned figures are based on ARI standard conditions.

The energy efficiency of chillers is not constant, but tends to degrade over its lifetime. It is also a function of the extent of full load and part load operation. The progressively increased energy efficiency of centrifugal chillers is due to several factors, some of which are mentioned below:

a) Mechanical design improvements in the basic chiller components (eg. more efficient impeller design, better heat exchangers, better materials, improved designs of other components, etc.)
b) Improvements in controls and instrumentation (eg. variable speed drives for the drive motor that improve part-load performance)
c) Improvements in auxiliary equipment in the chiller (eg. improved designs of the OAM - Oil, Air and Moisture - Purge Units, expansion devices, etc)

The single most significant contribution to energy efficiency has been the marked improvement in part-load operation of the chillers. Most centrifugal chillers from the 1970s to the early 1990s were designed and selected for peak-load operation based on calculation of building air conditioning loads incorporating considerable safety margins. Typically, buildings experience peak-load conditions only about 25% of the overall operating time. For 50-75% of the time the operating load is typically only 50-75% of the peak load. Thus, from the early 1990s onwards, devices such as variable speed drives in conjunction with other mechanical improvements in the chiller design led to significant increases in energy efficiencies of centrifugal chillers.

In addition to the above, additional energy efficiency gains were obtained through system optimizations as below:

a) Improved designs of peripheral equipment such as cooling towers, chilled water pumps, air handling units, etc.
b) Improved instrumentation and controls in buildings (motion sensors, variable air flow, enthalpy controllers, etc).
c) Demand-side Management (rationalizing of building air conditioning load calculations, improved building designs such as insulation, window treatments)

4.2 Economic Life of Chillers

Centrifugal chillers are rugged and reliable equipment, containing mostly rotating parts. Being large and heavy, their installation, operation and maintenance is challenging. However, centrifugal chillers are a preferred technology for large applications due to their efficiency and reliability.

In developed countries, due to pressures of emerging technologies as well as those of more stringent energy-efficiency standards, the life of centrifugal chillers was considered to be around 20 years. However, the economic life of centrifugal chillers in developing countries is considered by the owners as much more, sometimes exceeding 30 years, in view of their high initial costs.

4.3 CFC Phase-out in servicing of Chillers

There are three actions for reducing or eliminating CFC usage in servicing of centrifugal chillers:

a) Conservation (no action, continue to operate the chiller until the end of its economic life, ensuring that CFC usage in servicing follows regulatory norms)
b) Retrofitting for use with an approved substitute refrigerant
c) Replacement

The following table summarizes the technical criteria for retrofit or replacement of chillers, based on balance economic life considerations:

Type of Chillers	Balance Economic Life		
	0 – 5 years	5 – 10 years	Over 10 years
CFC-11 based	Replace	Retrofit or Replace	Retrofit or Replace
CFC-12/500 based	Replace	Retrofit or Replace	Retrofit or Replace
HCFC-22 based	No action needed	No action needed	No action needed

Conservation (no action)

Conservation may not be viable in countries or situations where adequate availability of CFCs for servicing is not assured until the end of the economic life. It could however be an option in LVCCs.

Retrofitting

CFC-11 based chillers can be retrofitted with HCFC-123 technology. HCFC-123 properties are not very dissimilar from those of CFC-11. HCFC-123 has an ODP of 0.02, GWP of 93 and time-weighted OEL of 50 ppm (in practice, emissions are less than 5 ppm in worst-case scenarios). The availability of HCFC-123 is expected until 2030. However, this is not considered a real drop-in technology due to the aggressive solvent action of HCFC-123. All gaskets, seals, motor winding insulation, etc. need to be replaced with compatible materials in addition to overhauling and other required modifications.

CFC-12/500 based chillers can be retrofitted with HFC-134a technology. HFC-134a has zero ODP, a GWP of 1,300 and low toxicity. HFC-134a is not controlled yet for production closure, thus availability is not an issue. Retrofitting to HFC-134a technology requires gear drive changes to obtain near-original performance. In addition, replacement of lubricants and other mechanical and electrical modifications would be needed.

Noteworthy points:

- Irrespective of the technology, a non-optimized retrofit or the cheapest option, would lead to reduction in capacity and energy efficiency by up to 10-15%
- Retrofit costs could be up to 40-80% of the replacement costs
- In order to maintain energy efficiency after retrofit, additional costs are inevitable. In most cases, non-optimized retrofits are unlikely to improve energy efficiency.
- Depending on the mechanical condition of the chiller, retrofitting <u>may not extend</u> the economic life of the chiller significantly, unless it involves replacement of the compressor and motor.

Energy efficiency gains are a critical consideration in the context of climate performance. Significant energy savings may not be available through retrofitting, unless:

a) The retrofitting involves replacement of the compressor and motor
b) Optimization of other chiller components and also of the overall air conditioning system is undertaken

Thus from an energy efficiency standpoint, retrofitting would provide overall environmental benefits only with significant additional investments.

Replacement

The two main alternative technologies for replacement of CFC-based centrifugal chillers with new non-CFC based centrifugal chillers, which are currently commercially viable, are as below:

HCFC-123: HCFC-123 has an ODP of 0.016, GWP of 93 and atmospheric lifetime of 1.4 years. HCFC-123 is non-flammable and considered to be moderately toxic with a WEEL limit of 50 ppm. The physical and thermodynamic properties of HCFC-123 are similar to those of CFC-11 therefore the operating temperatures and pressures in chiller applications are in a similar range. HCFC-123 provides comparable or better COP and IPLV than CFC-based chillers. HCFC-123 technology for chillers is stable, well-researched, and commercially available for low-pressure applications. Thus, HCFC-123 technology as a replacement for CFC-based chillers is considered techno-economically viable and efficient. HCFC-123 being classified as an Annex-C Group-I controlled substance under the Montreal Protocol, will need to be phased-out in developing countries by 2040. Manufacturing of new equipment with HCFC-123 is allowed in the USA until 2020. Thus, regulations on HCFC-123 use may impact its availability in the long-term.

HFC-134a: HFC-134a has zero ODS, a GWP of 1,300 and an atmospheric lifetime of 14 years. HFC-134a has no flammable limits in air and is considered non-toxic with a WEEL limit of 1,000 ppm. The physical and thermodynamic properties of HFC-134a make it a suitable alternative for medium-pressure applications. The energy-efficiency performance of HFC-134a-based chillers based on COP and IPLV levels, is about 5-10% lower than equivalent HCFC-123-based chillers however, the technology is established and commercially available. HFC-134a is not controlled under the Montreal Protocol, but is classified as a GHG under the Kyoto Protocol.

In addition to the above, potential commercially viable technologies or "third generation" technologies are as below:

HFC-152a: HFC-152a has zero ODP, a GWP of 140 and an atmospheric lifetime of 2 years. HFC-152a is flammable but considered non-toxic. The physical and thermodynamic properties of HFC-152a make it a suitable alternative for medium-pressure applications. It provides theoretical energy efficiency performance of about 5% better than HFC-134a. HFC-152a is not controlled under the Montreal Protocol, but is considered a GHG under the Kyoto Protocol. HFC-152a technology is not commercially available due to its flammability classification, however, it is considered technically feasible.

HFC-245ca: HFC-245ca has zero ODP, a GWP of 610 and an atmospheric lifetime of 7 years. Its physical and thermodynamic properties make it suitable as an alternative for low-pressure applications. It provides a theoretical energy efficiency performance marginally lower than HCFC-123. HFC-245ca is not flammable however it has higher vapor pressure than CFC-11 and HCFC-123, and is therefore subject to more stringent pressure vessel regulations. HFC-245ca is classified as a GHG, but is not controlled under the Montreal Protocol. This technology is not yet commercially offered.

Absorption chillers provide a non-centrifugal chiller technology alternative, for replacing CFC-based centrifugal chillers. The absorption refrigeration cycle has been well known for over 100 years. The main advantages of absorption technology are:

- Thermal compression in contrast to mechanical compression, results in much smaller moving or rotating parts, absence of lubricants and therefore lower maintenance costs as compared to centrifugal systems.
- Reliable, silent and vibration-free operation
- Significantly reduced reliance on electricity supply and infrastructure

- The technology is environmentally sound with no ODP or GWP and occupationally safe

There are two main types of absorption cycles:

Ammonia-Water:	In this system, ammonia is a refrigerant and water is the absorbent. However, since ammonia is toxic, the installations need proper ventilation and safety precautions
Lithium Bromide-Water:	In this system, water is the refrigerant and lithium bromide is the absorbent.

Both technologies are commercially available. However, since absorption technology uses thermal compression, it requires an external heating source, such as through direct combustion (oil or natural gas), indirect heating (steam or hot water) or waste heat (flue gases or waste steam).

There are two main subtypes of technologies in Absorption systems: Single-effect and Double-effect. Single-effect absorption chillers are less efficient and are economically viable only if a source of waste heat (steam or flue) is available. Double-effect absorption chillers are usually direct-fired (oil or natural gas). Double-effect absorption chillers, if provided with an additional heat exchanger, usually present an added benefit of producing a hot-water stream, which can be used for heating.

Direct comparisons between centrifugal systems and absorption systems are complex, as the apparent COP of absorption systems is lower than centrifugal systems. However, double-effect direct-fired absorption chillers can also produce hot water, which would otherwise require a separate boiler. If, instead of the normal COP, a resource COP (which takes into account the source-to-site efficiency of the fuel) is used for comparison, then absorption systems depending on application, can provide comparable energy-efficiency performance.

4.4 Selection of Replacement Technology

Taking into account the differences in capacity and operating conditions, the existing CFC-based centrifugal chillers in Colombia provide an average energy efficiency of 0.77 Kw/TR (source: World Bank/ICF – Global Overview of the Chiller Sector – World Bank Financial Agents Workshop, 2004) while commercially available high-efficiency non-CFC chillers consume 0.56 Kw/TR (ARI 550/590) or less. For selection of the replacement non-CFC chiller technology, the project will explore all available technology alternatives and support those replacement options that promise the least ODP and GWP, an energy efficiency rating of not more than 0.56 Kw/TR and the most favorable technical and economic feasibility and environmental and occupational safety. The final selection of the replacement technology would be made based on a case-by-case assessment of specific circumstances of the installations.

5. CHILLER DEMONSTRATION PROJECT DESCRIPTION

The project aims to identify the most cost effective and environmentally friendly options for transforming the market of chillers in Colombia, based on the following objectives (refer to Section 2.1.a):

a) Creating conditions favorable for removal of technological, financial and regulatory/fiscal barriers to conversion to of non-CFC energy efficient chillers;
b) Based on the above, establish a business model for market transformation;

c) Reduction/elimination of the residual consumption of Annex-A, Group-I substances (CFCs) in servicing of CFC-based centrifugal chillers Colombia;
d) In coordination with the ongoing activities being implemented under the National Phase Out Plan, creation of a stockpile of CFCs recovered from replaced chillers to be used for servicing of those CFC-based chillers, for which replacement is not viable;
e) Demonstration of energy cost savings through application of energy-efficient replacement technologies; and,
f) Demonstration of reductions in greenhouse gas emissions through application of energy-efficient replacement technologies, a component that will satisfy the requirements for the associated GEF co-financing request.

The demonstration project addresses both the objectives of the Montreal Protocol on Substances that Deplete the Ozone Layer and the UN Framework Convention on Climate Change. Focus sectors will include public buildings (hospital, university and government) as well as a number of private sector buildings (to be determined), as outlined in the demonstration budget detailed in Section 6.4 below. Some of the pre-selected institutions for the demonstration are the University of Antioquia Region, Government Building from El Valle Region, Institute of Social Security in Cucuta and a hydroelectric energy provider.

5.1 Chiller Population

Centrifugal chillers are the main component of the institutional end-user sub-sector of the Refrigeration and Air Conditioning sector (RAC). Their application is generally in hotels, large office buildings and large commercial complexes such as malls and airports. They can be based on high-pressure as well as low-pressure technology.

An initial survey, conducted by the World Bank in 2002, identified a total of 58 locations housing chillers, with a total distribution of 80 units. Further research has allowed the information to be updated, with the following consumption and distribution picture emerging:

Table 3 - Distribution of CFC chillers in Colombia

SECTOR	***CFC 11***	***CFC 12***	***TOTAL***
Private buildings	19	13	32
Office Buildings	20	1	21
Private Hotels	4	0	4
Government Hospitals	1	0	1
TOTAL	**43**	**14**	**58**

These figures may be considered low for a country the size of Colombia (~40 million inhabitants) however, the moderate climate in some of Colombia's most populated areas—such as Bogotá—makes the use of air conditioning systems in many cases unnecessary, or favors the use of individual cooling units.

The range of chillers installed in Colombia vary in size between 160 TR and 420 TR. The total charge of CFC-11/12 is **19,372** kg. They tend to have a lifetime of 25-30 years. CFC-using chillers were, for the most part, installed during the 1980s and, compared to recent installations, have proven energy-inefficient. Installations made in the 1990s were generally HCFC-123-, HCFC-22-or HCF-134a-based.

Centrifugal chillers are not manufactured in Colombia. All equipment is imported from the United States through manufacturers including Trane, Carrier and York. These manufacturers make their own service arrangements through authorized service stations. It is estimated that 25% of the refrigerant charge needs to be replaced each year.

Colombia's National Phase-out Plan (NPP) includes the following activities to phase out CFCs:

- Terminal Phase-out of CFC's in the Commercial Refrigeration Manufacturing Sector.
- Action Plan for the Refrigeration Servicing Sector
    - Technician-licensing programme for the Refrigeration and Air Conditioning Service Sector
    - R&R and Tooling to strengthen good practices and CFC conservation
- Complementary Technical Assistance on Strengthening of Legal Framework, Information and Awareness and Implementation and Monitoring

At time of submissions, the NPP included a project component to provide incentives to chiller owners for conversion, as it represented one element of the country's overall CFC phase-out strategy. However, this component of the NPP was not recommended for approval and the activity was removed from the Plan. As a result, the NPP does not include implementation of a sector strategy for chillers users. Conservation activities addressed at end-users in the chiller sector have not been planned replacement. The present demonstration project will help to establish the needs for implementing the strategy to ensure that CFC from chillers is not released to the atmosphere and can be re-used in maintenance (CFC 12) when feasible.

5.2 Energy Efficiency Analysis

An analysis was carried out for the 58 selected chiller installations representing a range of ownership profiles and end-use applications covering the following parameters:

- Estimation of direct energy savings and costs from replacement of this chillers with energy-efficient non-CFC chillers

- Indirect reductions in CO_2 emissions due to reduced energy consumption with the replacement chillers

- Reduction in direct GHG emissions due to reduced annual leakage rates with the replacement chillers

Assumptions

a) Equivalent Full Load operation Hours (EFLH) for various applications are as below:

- For Residential & Commercial Buildings: 3,000/year
- Hotels: 4,000/year
- Hospitals: 5,000/year

b) Electricity costs in Colombia are US$ 0.08/Kwh

c) Average Energy Efficiency of Chiller Installations in Colombia is 0.70 Kw/TR

(Source: ICF/WB - Global Overview of Chiller Sector - WB Financial Agents Workshop 2004)

d) Average energy efficiency for all replacement chillers is 0.56 Kw/TR
(Source: ARI Standard 550/590)

e) Carbon intensity of power sector in Colombia is 0.22 kg-C/Kwh. This is used for calculation of the indirect CO2 emission reductions due to energy efficiency gains with the selected replacement technology. *(Source: Energy Information Administration, US Department of Energy)*

f) The existing CFC-based chiller installations can continue to operate for the next 10 years.

g) For calculating direct GHG emissions reductions due to reduced leakage rates/losses with the replacement chillers, the following assumptions are made:

- In the baseline 50% chillers are CFC-11 based and 50% are CFC-12 based. For replacement, 50% chillers would be HCFC-123 based and 50% would be HFC-134a based
- Annual leakage rate in the baseline is 10% of the initial refrigerant charge. For replacement, the annual leakage rate is 2% of the initial refrigerant charge.
- The GWPs are: CFC-11 – 4,000 CFC-12 – 8,500 HCFC-123 – 93 HFC-134a – 1,320

The results of the analysis based on the above assumptions, are tabulated below:

Table 4 : Energy Efficiency Analysis for 58 selected installations

End-use Profiles/Parameters	Private Buildings	Private Hotels	Government Office Buildings	Government Hospitals	Total (or weighted averages)
Number of sample installations	32	4	21	1	**58**
Range of dates of installations	1975-1986	1970-1980	1966-1992		**1966-1992**
Carbon intensity of power (Kg-C/Kwh)	0.22	0.22	0.22	0.22	**0.22**
Baseline Scenario (CFC-based Chillers)					
Available Economic Lifetime (years)	10	10	10	10	**10**
Total Installed Capacity (TR)	9,865	1,165	6,330	250	**17,610**
Total Refrigerant Charge (Kg)	10,852	1,282	6,963	275	**19,372**
Equivalent Full Load Hours (Hrs/year)	3,000	4,000	3,000	5,000	**3,103**
Energy Costs (US$/Kwh)	0.08	0.08	0.08	0.08	**0.08**
Energy Efficiency (Kwh/TR)	0.7	0.7	0.7	0.7	**0.7**
Annual Energy Use (Kwh)	20,716,600	3,262,000	13,293,000	875,000	**38,146,600**
Annual Energy Costs (US$)	1,657,320	260,960	1,063,440	70,000	**3,051,720**
Lifetime Energy Costs (US$)	16,573,200	2,609,600	10,634,400	700,000	**30,517,200**
Lifetime Indirect CO_2 Emissions (t-C)	45,580	7,180	29,240	1,930	**83,930**
Lifetime Direct CO_2 Emissions (t-C)	67,825	8,013	43,519	1,719	**121,076**
Replacement Scenario (non-CFC Chillers)					
Comparable Economic Lifetime (years)	10	10	10	10	**10**
Total Installed Capacity (TR)	9,865	1,165	6,330	250	**17,610**
Total Refrigerant Charge (Kg)	9,865	1,165	6,330	250	**17,610**
Equivalent Full Load Hours (Hrs/year)	3,000	4,000	3,000	5,000	**3,103**
Energy Costs (US$/Kwh)	0.08	0.08	0.08	0.08	**0.08**
Energy Efficiency (Kwh/TR)	0.56	0.56	0.56	0.56	**0.56**
Annual Energy Use (Kwh)	16,573,200	2,609,600	10,634,400	700,000	**30,517,200**
Annual Energy Costs (US$)	1,325,856	208,768	850,752	56,000	**2,441,276**
Comparable Lifetime Energy Costs (US$)	13,258,560	2,087,680	8,507,520	560,000	**24,412,760**

Lifetime Indirect CO_2 Emissions (t-C)	36,460	5,740	23,400	1,540	**67,140**
Lifetime Direct CO_2 Emissions (t-C)	1,395	165	895	35	**2,490**
Energy Efficiency Savings					
Lifetime Energy Cost Savings (US$)	3,314,640	521,920	2,658,600	175,000	**6,670,160**
Lifetime CO_2 Emission Reductions (t-C)	75,550	9,288	48,464	2,074	**135,376**
Net/Weighted Average Energy Efficiency Savings per Installation					
Average installed capacity (TR)					**304**
Annual Energy Savings (Kwh)					**132,064**
Annual Energy Cost Savings (US$)					**10,565**
Lifetime (10-year) Energy Cost Savings (US$)					**105,651**
Lifetime Total CO_2 Emission Reductions (t-C)					**2,416**

This analysis does not take into account the following additional sources of efficiency gains and emission reductions:

- Impact of system optimization
- Demand-side management

5.3 Identification of Barriers to Conversion

Colombia has 60 CFC-based chillers remaining to be converted. Of these, 23 are in the public sector and 37 are owned by private sector entities.

Interviews with stakeholders and subsequent analysis reveal that a number of obstacles will need to be overcome in Colombia to facilitate the replacement of CFC chillers with non-CFC chillers:

1. *Lack of awareness of regulation and existing tax incentives*
    - End users are unaware of the increase in efficiency and energy cost savings associated with chiller replacement
    - End users are unclear about whether there will be a more attractive incentive in the future; as a result, they are often unwilling to change equipment prior to the end of a chillers economic life
    - End users are unaware of tax incentives. Currently all upfront taxes (including VAT and import tax) are waived for chiller equipment
2. *Low energy prices*
    - The price of electric power is $.08/kWh. At this price the resultant energy savings are not sufficient to repay the cost of a new chiller given the cost of capital
    - Large companies typically obtain good rates from utility companies, decreasing the economic case for chiller conversion
3. *High upfront investment*
    - The public sector uses a budget appropriation process for capital expenditure. Some poorly funded institutions do not have the appropriation for the capital costs of chiller replacement
    - Some private sector entities may not have access to financing, or be able to afford the typical down payment

4. *Limited access to capital*
    - Interest rates are median for Latin America (typically 20%). This interest rate prevents a new chiller from being able to pay for itself in reduced energy costs alone.
    - Some chiller owners may not have the financial profile needed to secure financing

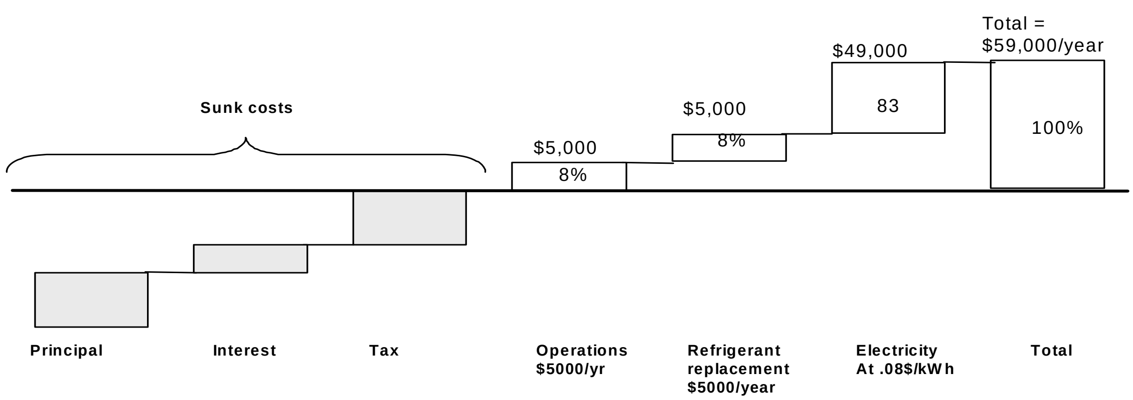
- Leasing or Performance contracting of chillers has not been tried in Colombia

All these factors compounded together (low energy prices, limited access to capital and high financing costs) create a weak economic case for conversion in Colombia. Although the replacement of CFC chillers with non-CFC chillers results in energy savings of over $10,000 and $11,000 annually for institutions in the public and private sectors, respectively, these savings are more than offset by the additional costs of the equipment, taxes and financing costs.

The total financial gap, once cost of equipment and capital is included, is vastly different for those with access to internal financing and those that must rely on external financing.

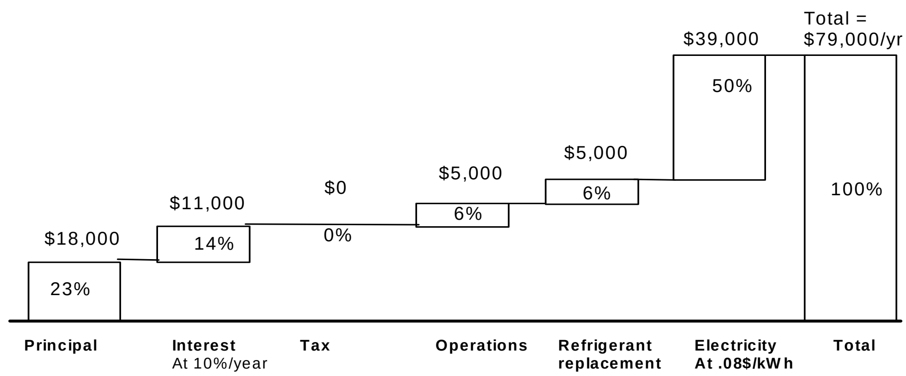
For public sector entities that have set aside budgets for conversion, there are savings of $4,000 per year to be gained. This corresponds to $11,000 for private sector entities. The case is different for public sector entities that do not have a budget for capital expenditure. These entities will face a $20,000 increase in yearly expenses if they finance a new non-CFC chiller. Using the assumption that all remaining public sector entities will need to take out loans (i.e., have not set aside budgets for) chiller replacement, the total gap for the public sector is estimated to have an NPV of $2.8 million. This analysis is explained in the following figures:

ANNUAL OPERATING EXPENSE OF CFC CHILLER IN THE PUBLIC SECTOR IS $59,000 ON AVERAGE



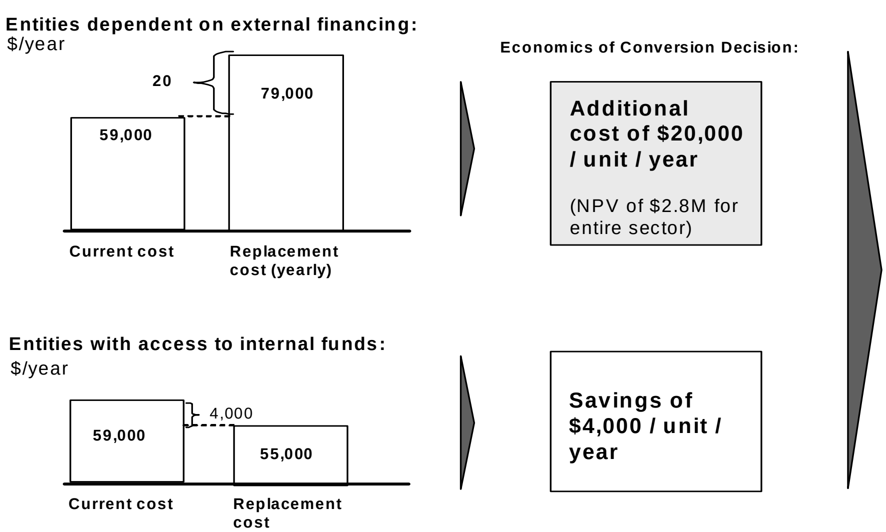
Assumptions: 300 TR chiller, .7 kW/TR power consumption, 8 hours/ day, fully paid off

ANNUAL OPERATING EXPENSE OF A NEW NON-CFC CENTRIFUGAL CHILLER IN THE PUBLIC SECTOR IS HIGHER AT $79,000



Assumptions: 300 TR chiller, .56 kW / TR power consumption, 8 hours/ day, interest rate 10%, aggregate upfront taxes exempted for public sector, down payment 0%, Loan term 10 years, Chiller price $150,000, Installation $30,000.

FINANCIAL GAP OF $20,000 PER UNIT PER YEAR IMPLIES A TOTAL GAP OF $2.8 MILLION (NPV) IN THE PUBLIC SECTOR

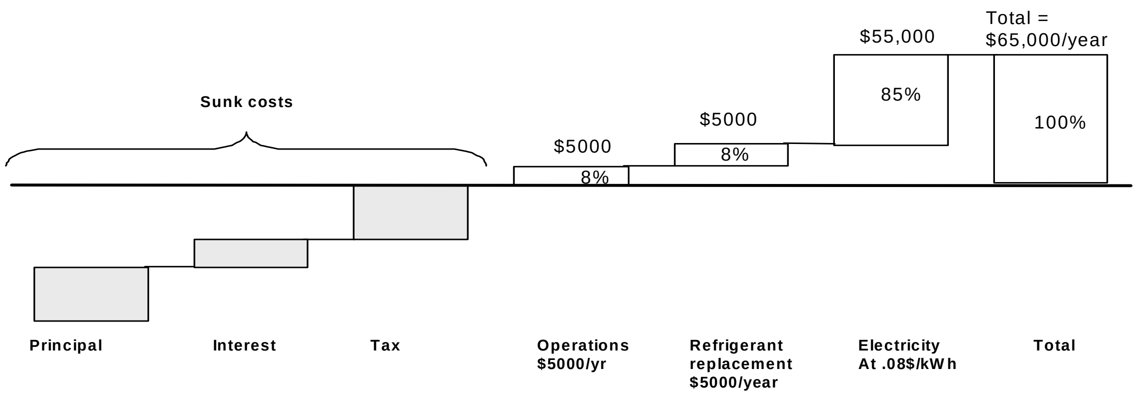


- Entities with access to internal funds have likely already converted, due to the associated cost savings
- The majority of the 23 public sector units in Colombia using CFC chillers most likely do not have access to internal funds
- For the public sector in aggregate, therefore, the financial gap can be estimated at **$2.8 M** (NPV)

Assumptions: 300 TR chiller, .56 kW / TR power consumption (replacement), .7 kW / TR power consumption (baseline), 8 hours/ day, interest rate 10%, aggregate upfront taxes exempted for public sector, down payment 0%, loan term 10 years, chiller price $150,000, installation $30,000.

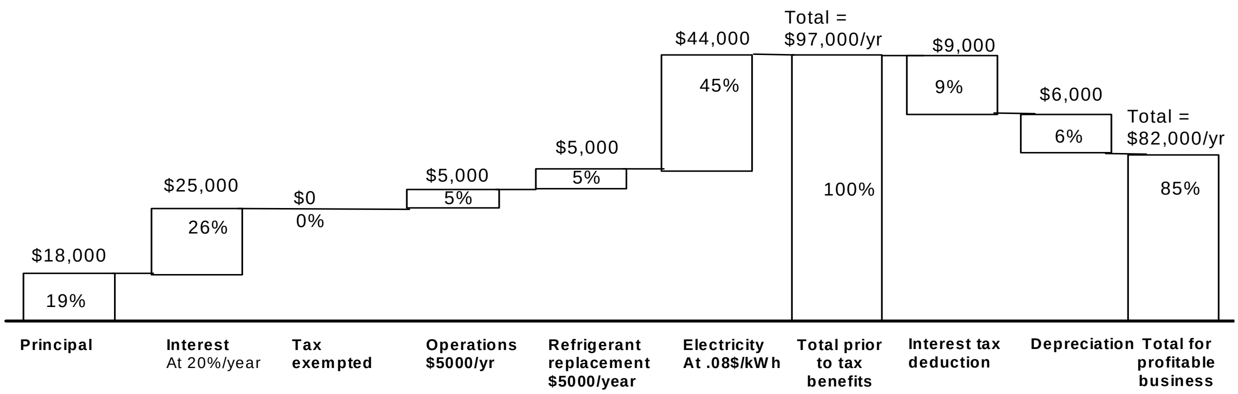
The financial gap is smaller for the private sector. While it costs approximately $65,000 each year to operate a CFC chiller, costs rise to $82,000 for a new non-CFC chiller once the costs of financing and taxes are included. When extrapolated to the entire sector, the resulting financial gap is $2.6 million for the private sector, as shown in the figures below:

ANNUAL OPERATING EXPENSE OF CFC CHILLERS IN THE PRIVATE SECTOR IS $65,000



Assumptions: 300 TR chiller, .7 kW/TR power consumption, 9 hours/ day, fully paid off

ANNUAL OPERATING EXPENSE OF NON-CFC CHILLERS IN THE PRIVATE SECTOR IS SIGNIFICANTLY HIGHER, AT $82,000

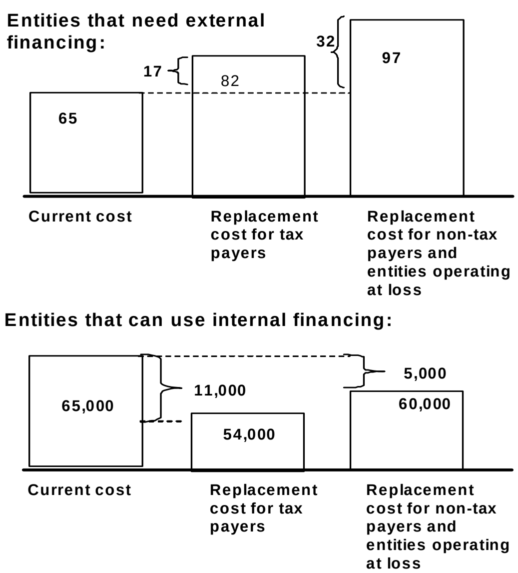


For profit making entities, a non-CFC chiller is $17,000 more expensive than the old equipment on an annual basis

Assumptions: 300 TR chiller, .56 kW / TR avg. power consumption, 9 hours/ day, interest rate 20%, aggregate upfront tax waived on chiller equipment, down payment 0%, Loan term 10 years, Chiller price $150,000, Installation $30,000., income tax rate 35%

FINANCIAL GAP OF $17,000 PER UNIT PER YEAR IMPLIES A TOTAL GAP OF $2.6 MILLION (NPV) IN THE PRIVATE SECTOR

$000s



Size of yearly gap/ unit that must be closed to enable conversion

	Tax paying entities	Non tax paying entities / entities operating at a loss
External Finance (do not have cash for replacement saved up)	**Cost of $17,000 / year / unit** ($2.6 M NPV / sector)	**Cost of $32,000 / year / unit**
Internal Finance (have cash for replacement on hand)	**Savings of $11,000 / year / unit**	**Savings of $5,000 / year / unit**

Assumptions: 300 TR chiller, .56 kW / TR power consumption (replacement), .7 kW / TR power consumption (baseline), 9 hours/ day, interest rate 20%, aggregate upfront taxes waived for chiller equipment, down payment 0%, loan term 10 years, chiller price $150,000, installation $30,000.

In summary, the financial gap is slightly smaller for the private sector than for the public sector. This is due to the greater energy savings due to longer usage hours, and the effects of being able to benefit from standard tax impacts of increased interest and depreciation expenses. The total gap for both sectors is $5.4 M which will need to be overcome for 100% of the chillers in Colombia to be converted.

5.4 Sector Wide Strategies and Funding Options

STRATEGIES AND FUNDING OPTIONS

	1 Conduct awareness-raising campaign	2 Reduce cost of equipment & financing	3 Offset risk of conversion
Purpose	Inform chiller owners of benefit of conversion and incentives available	Create time-bound incentive for chiller owners to convert, bringing owners to break-even	Offset risk associated with conversion; i.e., risk of insufficient energy savings, thereby providing non-financial incentives
Examples	*Provide information on:* ❑ Regulation ❑ Economic rationale ❑ Energy availability	*Reduce cost of equipment:* ❑ Demand-side management *Reduce cost of financing:* ❑ Interest rates	*Non-financial incentives:* ❑ Public sector loan fund ❑ Leasing

1. *CONDUCT INTEGRATED MARKETING CAMPAIGN FOR CHILLER OWNERS (benefits and consequences of their chiller conversion decision)*

Discussions with various stakeholders indicate that an effective marketing campaign is the critical first step in addressing barriers to conversion in both the public and private sectors.

This strategy will include the following components:

1. Marketing Program:
   This program will seek to educate chiller owners and stakeholders about environmental and efficiency implications of the chillers. Specifically, the information campaign directed at chiller owners should highlight:
   - Colombia's Montreal Protocol obligations and supporting legislation:
     - Impending phase out of CFCs (by 2009); diminishing supply and rising prices of CFCs as a result. CFC phase out dates set in legislation:
       - 85% of CFC imports will be phased out by 2007
       - 100% of CFC imports will be phased out by 2009
     - Energy efficiency requirements
   - High maintenance costs of old chillers

        - Leakage
        - Inefficiencies in old systems
        - Rising costs of R-11
    - Increased energy efficiency and also resulting energy savings
    - Financing options and incentives, including limited duration tax incentives.
    - Consequences of noncompliance
2. Bringing together key stakeholders to be a part of a single program. These stakeholders should include:
    - Ministry of Environment
    - Industries association (ANDI)
    - Mines and Energy Planning Unit
    - Electric Utilities
    - Major manufacturers
    - Ministry of Finance
    - The banks that will be offering loan funds (Possibly Bancoldex)
3. Identifying the catalysts to change and giving them the tools they need to make conversion happen
    - Manufacturers
    - Lease/service providers
    - Utilities/ Ministry of Energy
    - Industry association (ANDI)

Although the information/marketing campaign is a critical first step, the financial gap will also need to be addressed in order to make replacement a reality. Aside from the information campaign, the strategies needed for the public and private sectors will be tailored to address the unique challenges faced in each sector.

As discussed earlier, the type of strategy needed will depend on whether the institutions have access to internal funds or must take out loans for the financing of the equipment.

Type of institution	*Economic situation*	*Strategy needed*
Institutions that have budgeted funding for replacement chillers, i.e., that have internal financing	The ones that have budgeted will see cost savings ($4,000/year in the public sector, $11,000 in the private sector) when they replace the chillers.	This segment can likely be effectively targeted through *marketing* in the demonstration phase, and will most likely require no further strategy.
Institutions that do not have easy access to capital for replacement chillers, and must rely on external financing.	These institutions are unlikely to convert given the absence of a budget for capital investment.	In addition to marketing, the strategy for this segment is to reduce the overall cost and provide access to financing, such that the increase in yearly costs is negligible or at least manageable.

2. *REDUCE THE COST OF THE EQUIPMENT AND FINANCING*

PUBLIC SECTOR

As the figures above demonstrate, the funding needed to cover the cost gap for all of Colombia's public sector is estimated at $2.8 Million out of a total capital cost of $5.4 Million. The funding to cover the cost gap can come from a combination of sources, each of which will be negotiated during the demonstration phase of the project. Some of the major levers to be utilized are[9]:

- *Interest rates and loan term*: If the system is financed, the interest rate and loan term will play a major role in annual cost. The interest rate used in this analysis was 10% and the loan term was 10 years. Reducing the interest rate to zero and increasing the loan term to 20 years would achieve $2.8 M towards closing the funding gap. Interest rate can be reduced through a loan program created for this purpose, possibly funded by a loan guarantee from the GEF. Bancoldex may be a potential partner to manage the fund.
- *Demand-side management (DSM):* Conversion of government chillers (about 23 units) will equate to a load reduction of approximately 3GWh /year, including peak load hours. At current prices, the Ministry of Energy would avoid $.5M worth of investment in new power generation simply by facilitating this efficiency effort. Offsetting funding from the Ministry of Energy and related utilities for demand side management could therefore help fill the funding gap. Colombia faces a unique opportunity to employ DSM, due to its existing energy efficiency law and the existence of several ESCOs.
- *Absorption chillers:* For those with capital, and for whom energy self-sufficiency is critical, absorption chillers are an option; will be explored in the demonstration phase.
- *Pooled purchasing:* Here, a number of the entities looking to convert could join forces and request discounts from the manufacturers.

PRIVATE SECTOR

As with the public sector, institutions in the private sector that have put aside a capital reserve for replacement of chillers can likely be effectively targeted through *marketing* in the demonstration phase, as they will see cost savings of ~$11,000/year/installation when they replace the chillers.

The ones that have not budgeted for replacement, however, will be unlikely to convert unless the upfront cost is eliminated, and the yearly costs are made negligible or at least manageable. The funding for covering the cost gap can come from a combination of sources, each of which will be negotiated during the demonstration phase of the project:

- *Limited duration tax incentives*: Aggregate upfront taxes are waived on chiller equipment in Colombia. Creating a clear message that these taxes are of limited duration, would provide an incentive for slow-moving chiller owners to take action promptly.
- *Reduction of interest rates*: The interest rate will play a major role in annual cost. The interest rate used in this analysis was 20%. Reducing the interest rate could achieve up to $2.4 M towards closing the $2.6 M funding gap. Extending the loan term would also close the gap even further. Bancoldex may be a potential partner to manage this fund.
- *Demand-side management (DSM)*: Conversion of private sector chillers (about 37 units) will equate to a load reduction of approximately 5 GWh /year, including peak load hours. At

current prices, the Ministry of Energy would avoid $.8 M worth of investment in new power generation simply by facilitating this efficiency effort. Substitute funding from the Ministry of Energy and related utilities for demand side management could help fill the funding gap.

3. OFFSET THE RISK OF CONVERSION

PUBLIC SECTOR

This strategy is critical for institutions that do not have budgets for capital expenditure. To implement this strategy two financing vehicles are proposed:

- *Public sector loan fund*, which will be operated by a suitable entity to serve the public sector: either a development bank (possibly Bancoldex) or a special governmental facility.
- *Performance contracting* entails offering the use of the equipment for a fee to the public sector entity. The fee is based on the costs incurred by the service provider plus a 5% management fee. Performance contracting could be offered either by a manufacturer, by an ESCO or by a new entity created for this purpose.

PRIVATE SECTOR

This strategy also focuses on businesses that have not set aside a capital reserve for capital expenditure. To implement this strategy, four financing vehicles are proposed:

- Private sector loan fund (possibly incorporating GEF funding)
  - This loan fund will be operated by a suitable entity to serve the private sector, possibly Bancoldex.
- Outsourcing
  - This option entails a manufacturer offering both the equipment and services for a fee to the public sector entity. The fee is based on the costs incurred by the service provider plus a 5% management fee.
- Performance contracting
  - This option entails a manufacturer providing the equipment for an annual fee which is contingent upon the promised energy savings being met.
- Leasing
  - This option entails a manufacturer providing the equipment on a lease basis, and transferring ownership of the equipment at the end of the loan term.

DEMONSTRATION PHASE SUMMARY

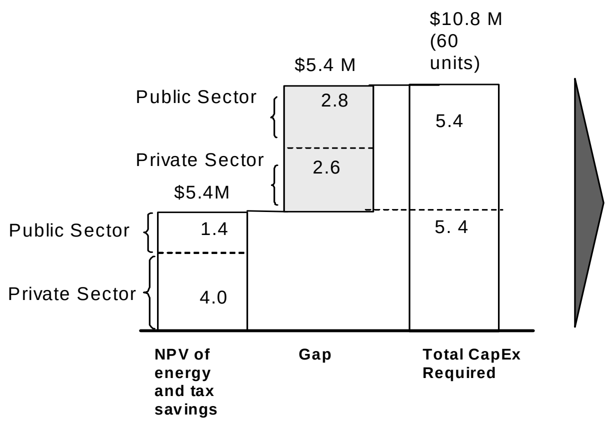
Using the strategies and funding options outlined above, the demonstration phase will leverage $1.7 million to put in place the business models, financing vehicles and educational programs such that during implementation:

- $.9 million can be used to catalyze $4.2 million of capital expenditure, converting 100% of the chillers in the public sector over the next four years; and,

- $1.5 million can be used to catalyze $6.6 million of capital expenditure, converting 100% of the chillers in the private sector over the next four years.

CHILLER CONVERSION FUNDING GAP IS $2.8 M IN PUBLIC SECTOR AND $2.6 M IN PRIVATE SECTOR

NPV $M

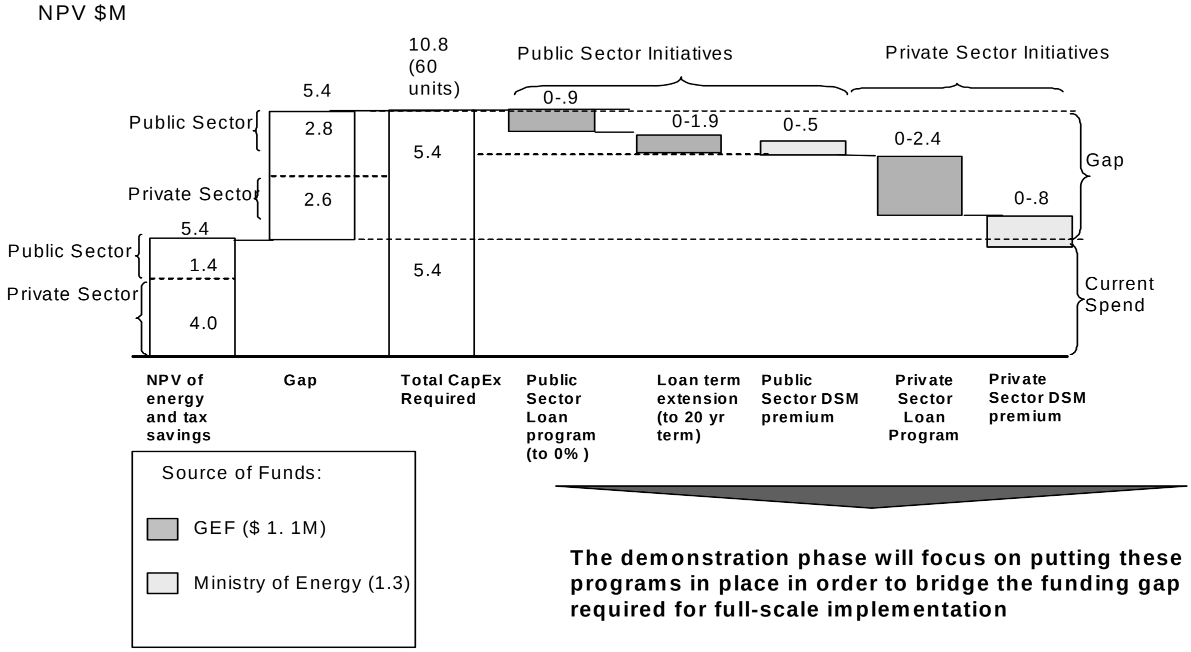


The total impediments to conversion in Colombia amount to $10.8 M. Unless this funding gap is bridged through incentives and policy changes, 100% conversion of chillers will not be likely. The demonstration phase will seek to:

- Validate the proposed business models
- Put in place the conditions needed to implement the strategies
- Conduct the marketing campaign needed for full-scale implementation

COLOMBIA IMPLEMENTATION PHASE GAPS AND INCENTIVES

NPV $M



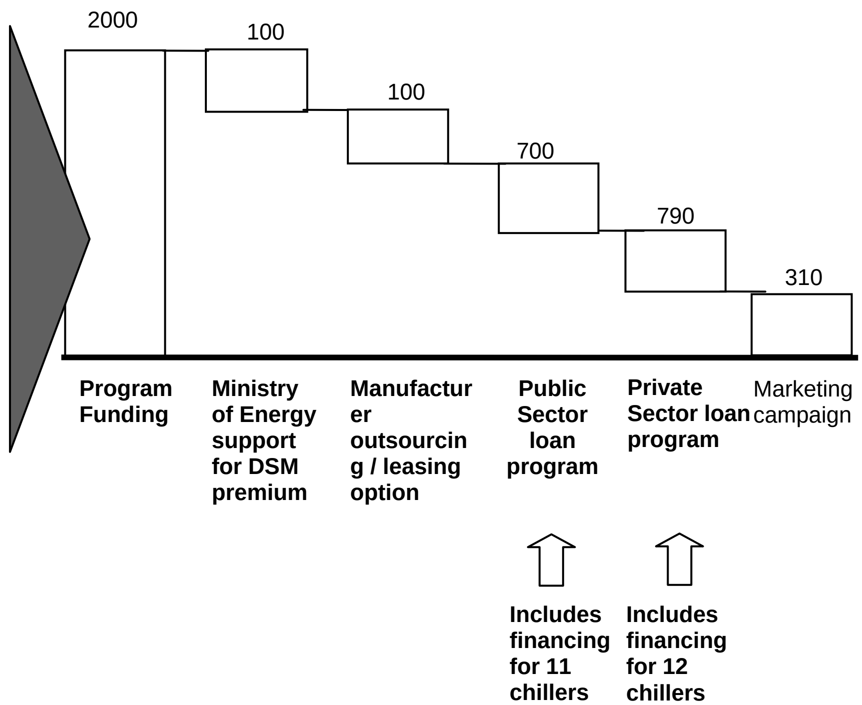
The demonstration phase will focus on putting these programs in place in order to bridge the funding gap required for full-scale implementation

COLOMBIA DEMONSTRATION PHASE COMPONENTS AND COSTS

$000s

To create the conditions for full-scale implementation, the demonstration phase will use $2 M to:

- Work with Ministry of Energy to gain support for integrated program, both financial and otherwise
- Implement a public sector loan fund vehicle (possibly GEF)
- Implement a private sector loan fund vehicle (possibly GEF)
- Work with Manufacturers to create a performance contracting and/or leasing option
- Educate Public and Private Sector about benefits and consequences of chiller decisions



5.5 Project Components and Costs

In order to ensure adequate conditions for complete conversion of chillers in the public and private sectors, several program elements will need to be put in place:

Marketing Program: The marketing/awareness-raising program will last the duration of the demonstration phase, and will include all major stakeholders and all market segments. The program is estimated to cost $310,000.

Demand Side Management: The demand side management program will carry out the tasks needed to create an energy sector subsidy for replacement chillers. The program will involve developing a business case for the Ministry of Energy, as well as providing funding for staff to work with the Ministry of Energy to develop the program. The program is expected to result in a $1.3 M backing for chiller conversion, and will cost $100,000.

Public sector loan program: This program will set up the management of a financing vehicle for the public sector, and will also finance 5 public sector demonstration projects which comprise 8 chiller units. The key components are identifying the bank partner that will manage the fund, and working with the bank to detail the loan structure including interest rate and loan term. This program will implement and demonstrate the effectiveness of a financing vehicle that could be used to channel $4 M of financing (possibly using GEF loan guarantees) and that will address the need for long-term financing in the public sector. This program will cost $700,000. The demonstration projects that will be implemented through this program will be:

- Public University I
- Public University 2

- Public Hospital
- Government Building
- Three additional institutions, TBD.

Private sector loan program: This program will set up the management of a financing vehicle for the private sector. This program will also finance 3 private sector demonstration projects which comprise 5 chiller units. This program will identify the bank-partner that will manage the fund and will work with the bank to detail the loan structure for the program including interest rate and loan term. This program will implement and demonstrate the effectiveness of a financing vehicle that could be used to channel $6 M in financing (possibly using GEF loan guarantees), and the program will cost $790,000. The demonstration projects that will be implemented through this program will be determined at a later point.

Outsourcing program: This program will set up the management of a chiller outsourcing program for both the public and the private sector, thereby addressing the financing barrier in the chiller market. In the program, we will work with each of the major equipment suppliers, and gain the participation of at least one. The plan is to work with the equipment suppliers to create a financing vehicle necessary for them to be able to offer chiller service on an outsourcing basis. This program will cost $100,000. It will provide a much-needed alternative for public sector entities with restrictions on borrowing, and will be an attractive replacement option for private sector entities that cannot take advantage of tax benefits.

6. IMPLEMENTATION of DEMONSTRATION PHASE

6.1 Management

UNDP will manage the demonstration project using its National Execution Modality (NEX), providing oversight management to the national project management coordinator and team, as well as financial oversight management services. The project, with UNDP acting as facilitator, will work at the ground level to establish the key partnerships required, across sectors, in order to create the right environment in which the long-term sustainable conversion of chillers will be enabled.

6.2 Action Plan and Indicators of Success

COMPONENTS OF DEMONSTRATION PHASE

	Identify and mitigate risks	Validate business models	Assess success	Put in place conditions for implementation	Engage in marketing campaign
Activities	• Assess risks to implementation of demonstration projects, e.g.: - Regulation - Capital • Mitigate risks - Ensure appropriate regulatory environment - Secure funds and counterpart funding	• Engage in discussions with various stakeholders to put in place necessary conditions to test business models (i.e., by demonstrating economic rationale, etc.) • Operationalize models in selected entities across public and private sectors	• Determine success of demonstration projects based on demonstrable implementation progress as well as interviews with chiller owners • Tweak models as necessary	• Work with governments and other stakeholders to put in place conditions necessary for implementation on a larger scale	• Approach various stakeholders to discuss options • Obtain agreement on program overall and specific models to implement • Develop action plan to approach and convert remaining chillder owners
Results expected	• Securing of counterpart funds	• Conditions necessary for testing of proposed models	• Critical assessment of success and replicability of demonstration projects	• Financial arrangements in place for full-implementation scale	• Strategy and action plan to convert all CFC owners • General awareness of program, particularly among chiller owners and manufacturers

The demonstration phase seeks to achieve several goals, and its success will be assessed on the following indicators:

1. Create an enabling environment for implementation
    a. Have the chiller owners in the demo phase all successfully replaced their CFC chillers with non-CFC chillers?
    b. Have the conditions for the various programs been implemented?, including:
        i. Loan structure
        ii. DSM
        iii. Outsourcing
2. Develop successful financing vehicles
    a. Are financing vehicles in place for:
        i. Public Sector Loan
        ii. Private Sector Loan
        iii. Outsourcing
    b. Do the financing vehicles eliminate 100% of the down payment?
    c. Are the annual servicing costs in line with the annual operating costs listed in this document?
    d. Are these funding programs available to all of the chillers in the sector?
3. Successfully implement demonstration projects
    a. Were all of the proposed installations, or surrogates, completed?
    b. Did the new chillers achieve the expected energy cost savings?
    c. Do the projects demonstrate an avoidance of significant increase in yearly cost?
    d. Do the projects include a diversity of sectors and applications?
4. Conduct an effective marketing campaign
    a. Have all chiller owners been reached out to?

b. Do all chiller owners understand the incentives involved with the chiller conversion program?

6.3 Counterpart Funding

The proposed demonstration project under the Multilateral Fund of the Montreal Protocol will contribute to meeting the objectives of the GEF Operational program No. 5, "Removal of Barriers to Energy Efficiency and Energy Conservation" and the GEF Strategic Priority (CC-1) "Transformation of markets for high-volume, commercial, low GHG products or processes".

Stabilizing and reducing Colombia's energy demand in the building sector through adoption of more energy efficient systems and practices is considered no longer an option but a necessity. The Colombian electricity sector is made up of a mix of public- and privately-owned companies, the result of deregulation launched in the 1990s which opened the sector to private investment and established a wholesale electricity market.[10] Hydroelectric power dominates in electricity generation in Colombia, with conventional thermal, principally coal and natural gas, as well as other renewables making up the difference. In 1990, electricity accounted for 11.4% of final energy consumption.[11] Colombia has historically been greatly dependent on hydroelectric power for its electricity needs. Indeed, over the past decade, it's generating capacity has increased by approximately 50%, reflecting the burgeoning demand for power in the country. Severe droughts, compounded by lack of investment and security issues, have caused power shortages and resulted in forced rationing. As a result, Colombia has encouraged development of more non-hydroelectric electricity generation capacity, with a goal of at least 20% shares for both coal-fueled and gas-fueled power generation in the near future. In addition, the country plans to increase its thermal generation capacity to 50% of its total capacity by 2010. [12]

On the whole, electricity demand in Colombia has grown steadily over the last 15 years, and future demand is projected to grow at about 4.4% per year through 2020. The GEF component project will contribute to mitigation of greenhouse gases, with the attendant benefit being support of cross-convention synergies.

A request for approval of a pdf A has been made to UNDP-GEF management, in order to allow for preparation of a medium size proposal (MSP) within the GEF 3 funding window (closes June 2006). The project would aim at removing barriers to energy efficiency development in Colombia, with specific emphasis on enhancing energy efficiency in building systems as a whole. Through specific actions to overcome financing barriers, through focus on capitalization of financial mechanisms and access to financing that would allow for provision of partial loan guarantees, as well as related policy, capacity building, enterprise development and awareness barriers, it is estimated that the contribution of energy efficiency to the region's energy balance can be significantly increased. As chillers form part of building systems, enhancing energy efficiency in this area, through partnership in the context of the MLF demonstration project, would form a logical first step of an overall building efficiency programme, as well as serve to build synergy between activities taken to meet the objectives of the Montreal Protocol and those of the UNFCCC. Should the submission bid be successful, MSP financing could allow for up to a 1:1: co-financing ratio with the funding request being made of the Multilateral Fund's demonstration window.

[10] EIA, DOE; Country Analysis Briefs, Colombia, 2002.
[11] Executive Summary from Colombia's First National Communication to the UNFCCC; December 2001.
[12] US DOE; An Energy Overview of Colombia.

6.4 Demonstration Project Budget

Demonstration Phase						
Total demo units installed:			23			
Total funding required ($ 000s):			2,000			
Activity			**Detailed Breakout**	**Total Req'd**	**MLF**	**GEF**
Total Project:					**1,000**	**1,000**
Pillar III: Create Enabling Conditions						
Working with manufacturers				100	50	50
Conduct feasibility assessment of performance contracting in Colombia						
Develop concept			25			
Test program on selected units			25			
Negotiate terms			50			
Working with Ministry of Mines and Energy				100	50	50
Build business case for energy savings						
Demonstrate how program offsets need for additional capacity			25			
Negotiate terms			25			
Assist Ministry with implementation of new priority theme			50			
Pillar II: Put in Place Financing Mechanisms						
Public sector				696	346	350
Conversion of selected units						
Project:	Units	Total cost	Program loan guarantee			
Government University I	2	360	120			
Government University 2	1	180	60			
Government Hospital	2	360	120			
Government Building	1	180	60			
TBD	2	360	120			
TBD	2	360	120			
TBD	1	180	60			
Transaction costs associated with creating enabling conditions			18			
Set up and manage loan guarantee (staff time)			18			
Private sector				792	442	350
Conversion of selected units						
Project:	Units	total cost	Program loan guarantee			
TBD	4	720	240			
TBD	4	720	240			
TBD	4	720	240			
Transaction costs associated with creating enabling conditions			36			
Set up loan guarantee (staff time)			36			
Pillar I: Develop Awareness						
Awareness-raising campaign (6 months)				312	112	200
Develop materials						
Staff time to develop materials (incl. cost of marketing firm)			100			
Cost of materials (publications, billboards, advertisements, etc.)			100			
Target and contact chiller owners			112			

ANNEX-1
ENERGY EFFICIENCY ANALYSIS METHODOLOGY

ENERGY EFFICIENCY ANALYSIS IN CHILLER REPLACEMENT

BASELINE SCENARIO		REPLACEMENT SCENARIO	
Installed chiller capacity (TR)	304	Replacement chiller capacity (TR)	304
Refrigerant Charge (Kg)	334	Refrigerant Charge (Kg)	304
Annual Leakage Rate (Kg/year)	33	Annual Leakage Rate (Kg/year)	6
Balance Economic Lifetime (Years)	10.00	Comparable Economic Lifetime (Years)	10.00
Energy Efficiency (Kw/TR)	0.70	Energy Efficiency (Kw/TR)	0.56
Energy Costs (US$/Kwh)	0.080	Energy Costs (US$/Kwh)	0.080
Equivalent Full Load operating Hours (EFLH/yr)	3,103	Equivalent Full Load operating Hours (EFLH/yr)	3,103
Annual Energy Use (Kwh)	660,318	Annual Energy Use (Kwh)	528,255
Annual Energy Costs (US$)	52,825	Annual Energy Costs (US$)	42,260
Lifetime Energy Costs (US$)	528,255	Lifetime Energy Costs (US$)	422,604
Annual Direct CO_2 Emissions (Tonnes-CO_2)	206	Annual Direct CO_2 Emissions (Tonnes-CO_2)	4
Annual Indirect CO_2 Emissions (Tonnes-CO_2)	198	Annual CO_2 Emissions (Tonnes-CO_2)	158
Annual Total CO_2 Emissions (Tonnes-CO_2)	404	Annual Total CO_2 Emissions (Tonnes-CO_2)	163

RESULTS	
Annual Energy Savings (Kwh)	132,064
Annual Energy Cost Savings (US$)	10,565
Lifetime Energy Cost Savings (US$)	105,651
Annual Total CO_2 Emission Reductions (Tonnes-CO_2)	242
Lifetime CO_2 Emission Reductions (Tonnes-CO_2)	2,416

Notes and assumptions:

1. In the baseline, 50% chillers are CFC-11 based and 50% are CFC-12 based.
2. In replacement, 50% chillers are replaced with HCFC-123 technology and 50% with HFC-134a technology
3. GWPs are CFC-11: 4,000 CFC-12: 8,500 HCFC-123: 93 and HFC-134a: 1,320
4. Baseline annual leakage rate is 10% of the initial refrigerant charge.
5. Annual leakage rate after replacement is 2% of initial refrigerant charge
6. The refrigerant charge in replacement chillers is estimated at 1 Kg/TR

ANNEX-2
REPLICATION OF THE STRATEGY

There is significant potential to achieve energy savings and reduce greenhouse gas emissions from the chillers market in Colombia, while at the same time contributing to the phase out of CFCs in an important emerging economy. GEF funding in the amount of $1.0 million will be requested to help remove policy, information, finance and technology barriers that are currently standing in the way of the widespread adoption of energy-efficient chillers in Colombia and to spur broader scale replication in neighboring countries.

The goal of the project will be to influence, develop, and transform the market for energy-efficient chillers in Colombia to help chart a less carbon-intensive and more sustainable path in the country, which in turn could positively influence the chillers market in Latin America as a whole. The proposed project conforms to GEF Operational Program 5: Removal of Barriers to Energy Efficiency and Energy Conservation as well as the recently adopted Strategic Objective related to Energy-Efficient Appliances.

An initial problem assessment has identified the following barriers, grouped into four categories.

I. Policy
   a) Absence of energy policy to promote energy efficiency in the chillers sector;
   b) Weakness and/or absence of regulatory framework;
   c) No lead organisation to promote energy efficiency in existing chillers;
   d) Lack of utility involvement;

II. Information
   e) Lack of awareness of energy efficiency benefits among building managers, chillers operators, building owners, national or local authorities, and energy suppliers;
   f) Absence of a strategy to educate and sensitise building managers and building owners on the benefits of energy efficient chillers;

III. Finance
   g) Absence of markets for energy efficiency services for operating chillers;
   h) High initial cost of energy efficiency equipment;

IV. Technology
   i) Lack of specialised trained personnel.

The GEF project will strive to remove all of these barriers through a comprehensive approach that will focus on creating a favorable policy environment, establishing a network between the project and key public and private actors, including chillers users, increasing awareness among key stakeholders, implementing a partial guarantee fund to reduce the risks of investing in the technology, and providing technical assistance to manufacturers. On the policy side, the project will assist the government in developing standards and certification for chillers through a national consultation process bringing together the public and private sectors, as well as civil society at large. Here, it will be important to build public-private partnerships to assist in the phase out of old chillers.

To address information barriers, the GEF intervention will support a nationwide marketing and public education program to highlight the benefits of energy efficient chillers. This program would be targeted to all of the respective stakeholders involved in chillers operation. It will also develop a range of knowledge products about the economic merits and technical options for replacing inefficient chillers that can lead to broader scale replication in other Latin American countries.

On the finance side, a partial guarantee fund will be employed as a cost-effective and market-oriented way of supporting investments in CFC-free, energy-efficient chillers. This approach would aim directly to reduce many of the real and perceived project risks and would effectively ensure a payback period of 3-5 years for building owners who retrofit or replace an old CFC chiller. In addition, the project will explore the possibility of fiscal incentives such as tax waivers to further promote the adoption of energy-efficient chillers.

Finally, technical assistance will be provided to business and industry associations, chillers manufacturers and industry participants. This could involve hands-on 'learning by doing' training and TA activities. By taking a holistic view of the market and targeting both the supply and demand side of the chillers market, the project will boost its chances of success and hence increase its potential impact on reducing greenhouse gas emissions. Replacing CFC based chillers contributes to lower greenhouse gas emissions, both from an energy consumption perspective and from the reduction of CFC emissions, which have a very high global warming potential.

One of the key lessons that has emerged from UNDP-GEF's 14 years of project-level experience is that project and regional networking play an important role in ensuring that the successful features of well-designed projects are incorporated in the design of ongoing and future projects. Through targeted meetings of project managers and country office personnel for specific types of projects, those involved with project management can discuss both technical and administrative issues, share experiences and best practices, and gain a sense of how the portfolio functions at a regional level. For instance, UNDP-GEF convened meetings for its biomass project portfolio in 2002 and 2004, and it organized a similar meeting for projects in the heat sector in 2004.

A similar chillers knowledge network could be envisaged under the auspices of the Colombia project to encourage information sharing, build awareness, and facilitate replication of project activities to other parts of the region. Additionally, the project itself will draw on the experience of, and incorporate lessons from, previous UNDP-GEF refrigerators projects in China and Tunisia, which although focused on residential appliances as opposed to commercial chillers, could still provide useful insights on how to improve awareness and replicate project results elsewhere.

Endorsement and adoption of this project would position Colombia as one of the front leaders in the area of market transformation for energy efficient (EE) technologies, with wide-ranging applications and replication potential, both to other appliances and equipment, as well as in- and outside of Colombia.

ANNEX-3
Disposal of Replaced Baseline CFC-based Chillers and CFCs

Replaced Baseline Chillers

All recipients under the chiller replacement demonstration programme shall provide a Baseline Equipment Disposal Report to UTO/MVADT in the following format upon completion of the replacement:

Name of Owner:	
Address/Location:	
Date of Commissioning of replacement chiller (s)	

Baseline Equipment Make & Model	**Qty**	**Description and type**	**Date Installed**	**Disposal Method**	**Date of Disposal**	**Verified by**

Disposal methods would be one or more of the following, but would ensure that the disposed equipment and parts are rendered unusable with CFCs:

A - Dismantled and stored (electric motors, pumps, controls, accessories)
B - Dismantled and re-used (electric motors, pumps, controls, accessories)
C - Dismantled and disposed as scrap (other parts)
D - Destruction and disposed as scrap (for compressors)

CFCs

All recipients under the chiller replacement demonstration programme shall recover the CFCs from the replaced baseline chillers, maintain a record of the inventory of these CFCs and provide a CFC Disposal Report to UTO/MVADT in the following format upon completion of the replacement:

Name of Owner:	
Address/Location:	
Date of Commissioning of replacement chiller (s)	

CFC Name	**Initial Charge (Kg)**	**Amount Recovered (Kg)**	**Amount Re-usable (Kg)**	**Amount Un-usable (Kg)**	**Storage Location of Re-usable CFCs**	**Storage Location of Un-usable CFCs**	**Verified by**

The disposal of CFC-based baseline centrifugal chillers and CFCs shall comply with the applicable national regulations and be performed in accordance with the relevant national/international standards and practices.

UTO/MVADT will periodically carry out an independent verification of the reports.

ANNEX-4
COLOMBIA NATIONAL PHASE-OUT PLAN LETTER of ENDORSEMENT

To FOLLOW.