UNITED NATIONS

EP

United Nations Environment Programme

Distr.
GENERAL

UNEP/OzL.Pro/ExCom/80/9
24 October 2017

ORIGINAL: ENGLISH

EXECUTIVE COMMITTEE OF
THE MULTILATERAL FUND FOR THE
IMPLEMENTATION OF THE MONTREAL PROTOCOL
Eightieth Meeting
Montreal, 13-17 November 2017

FINAL REPORT ON THE EVALUATION OF CHILLER PROJECTS WITH CO-FUNDING MODALITIES

Background

1. At its 77th meeting, the Executive Committee approved the second stage of the evaluation of chiller projects with co-funding modalities and the related terms of reference (decision 77/7). The evaluation follows up on a desk study presented at the 68th meeting,[1] which analyzed demonstration projects, four of which were at the country level, three of which were covering more than one country in a region and one of which was global covering several countries in different geographical regions. The demonstration projects experienced major delays in commencing and progress reporting was limited when the desk study was undertaken. Therefore, the second stage of the evaluation, which included field visits, was postponed until the projects reached a more mature stage of implementation.

Methodology

2. Projects in the following eight countries were selected for field visits: Argentina, Brazil, Colombia, Cuba, Jordan, the Philippines, Sudan and Thailand. Several consultants were selected to undertake country reports (one or two countries per consultant) and travelled to the countries, collected data and drafted country reports. Each consultant then prepared a synthesis report summarizing, analyzing and comparing the main findings of the country reports, and issuing lessons learnt to help enhance project implementation.

3. The evaluations at the country level assessed progress achieved by project activities towards objectives and in areas pertinent to institutional, legislative, funding and implementation according to the terms of reference. It analysed information related to the functioning of projects with various financial mechanisms in both the public and private sector; it assessed whether sufficient incentives were in place to catalyze chiller replacements without the Multilateral Fund's resources, and problems in the private as well as in the public sector in countries where funds for chiller replacements were scarce.

[1] UNEP/OzL.Pro/ExCom/68/10 and Add.1

4. Based on the findings of country case studies, the final report summarizes the lessons learned and provide recommendations, which could contribute to future policy development concerning HCFC phase-out activities in Article 5 countries.

Scope of the document

5. The present document presents key conclusions of the country reports; the results of each of the specific issues and questions identified in the terms of reference of the study, namely: national chiller context; institutional and legislative issues; funding-related issues; implementation issues; and a recommendation.

6. The document also contains the following annexes:

Annex I Terms of reference of the evaluation of chiller projects with co-funding modalities

Annex II Chiller demonstration projects and evaluation case studies

Key findings

7. The chiller population survey and respective database need periodical updating due to dynamic changes in the number of chillers and the composition of the chiller population, which might also help in determining ODS demand in the country. A large number of conversions might occur outside the scope of the project. Therefore, it would be advisable that National Ozone Units (NOUs) in countries with chiller replacement projects develop an inventory of ODS chillers still in use making the most of information that has already been collected, and assess the result of the initial survey when determining the scope of a future project and funding level. NOUs would also need to establish and maintain relationships with local chiller suppliers, as that would facilitate conducting the survey and maintaining the database.

8. Energy efficiency and energy savings are important drivers in taking decisions on chiller replacement by chiller owners. Cost of electricity and its dynamics as well as geographical location and climate conditions are important parameters in assessment energy savings. However, a chiller accounts for only part of the electricity consumption of the whole air-conditioning (AC) system, and thus, several other factors are important to be addressed when the decision to replace chillers is made. Retro-commissioning, as a more comprehensive approach, could be considered by building owners.

9. Clear policies need to be in place when replacing HCFC chillers and the early involvement of local energy departments and Energy Service Companies (ESCOs) will facilitate the implementation of chiller replacement. Potential difficulties in coordinating and involving local ministries and departments while developing complex and multi-faceted projects should be given due consideration. In one country, the involvement of energy-efficiency bank credits and ESCO was not successful; it did however, help with the development of financial mechanisms by a private/public bank and was then offered to others banks, to end-users and ESCOS. In addition, this financial scheme created some instruments, such as an insurance policy to avoid the risk of non-compliance with the envisaged energy savings.

10. Subsidies of 20 per cent have not been sufficient to convince chiller owners to replace their equipment in some countries. Availability of soft loans would be appealing for them to consider replacement CFC chillers. Accordingly, relevant Government entities would need to advertise more broadly the energy-efficiency benefits and cost-recovery aspects of replacing old energy-inefficient chillers with modern equipment.

11. When leveraging relevant energy efficiency operations with Multilateral Fund (MLF) funding and the Global Environment Facility (GEF), the Montreal Protocol compliance schedule should be taken into consideration and develop project timelines accordingly. The combination of resources from the MLF and

the GEF in the global chiller project has led to heavy implementation structures and procedures, with requirements for separate progress reporting and accounting for relatively small amounts of grant financing. These procedures need to be streamlined and simplified. There is evidence that carbon finance led to overburdening the projects with monitoring and verification procedures, which were unattractive to chillers owners.

12. Chiller replacement projects should take into account recovery and recycling capabilities in the country when establishing the overall project budget. NOUs need to be more actively involved in the accounting of recovered and reused refrigerant in chiller replacement operations. The establishment of a district cooling/heating facility in one country resulted in decommissioning three CFC chillers and made it possible to reduce energy consumption in buildings connected to the central facility. The facility, installed far away from residential areas, demonstrated the opportunities for the safe use of a natural refrigerant (ammonia).

13. It would be advisable that UNEP compiles and disseminates the valuable information on the experiences related to CFC chiller replacement, including on energy efficiency and potential energy savings for chillers, the toolkits developed (Philippines), as well as the regression analysis and investment analysis worksheets. This would help chiller owners assess the efficiency of their existing chiller units as well as the internal rate of return should they decide to replace their existing chillers.

14. The results of each of the specific issues and questions identified in the terms of reference of the study are presented below.

Review of chiller projects

15. The results of the implementation of chiller demonstration projects cover: the number of chillers replaced, ODS recovered, improved energy efficiency in replaced chillers, and project duration. The overall target established by the Executive Committee in six demonstration projects under review was at least 216 CFC-based chillers to be replaced with non-CFC and more energy-efficient alternatives. The implementing agencies (IAs) raised this target to 496 units through co-financing from other sources in projects implemented in the eight countries considered in this document. However, the total number of chillers replaced was 135 units (i.e., 27 per cent of the target). This included 57 HCFC and seven HFC-based chillers replaced with more energy efficient HFC-134a-based units in the Philippines.

16. The duration of the project implementation varied from 56 to 145 months with, on average, an implementation delay of almost three years against the approved target. The replacement of chillers started in several countries two or three years after CFCs were phased out and the bulk of CFC-based chillers had already been replaced by owners and occurred due to the obsolescence of the equipment, the availability of more energy-efficient alternatives, a shortage of spare parts, the high cost of maintenance and an anticipated or real scarcity of CFCs for servicing and without external funding.

17. For instance, the targets to phase out CFC consumption in the Philippines and Thailand were 22 ODP tonnes and 13.2 ODP tonnes, respectively. The planned objectives to support the fulfilment of CFC phase-out obligations under the Montreal Protocol were not achieved, except partially in Thailand, where the project resulted in the reduction of CFC consumption of 3.460 ODP tonnes or 26 per cent of the target. The replacement of CFC chillers in Colombia, India, the Philippines, and Sudan occurred beyond the 2010 phase-out target. The replacement of CFC chillers took place before 2010 in Cuba and Jordan, and could have had an effect on reducing CFC consumption.

18. In 2001, Brazil carried out a survey in 12 states with 700 CFC chillers, and then extrapolated the data to the other 14 states, thus obtaining a total population of 1,250 units of CFC centrifugal chillers. The majority of the existing chillers were installed between the 1970s and early 1990s with a remaining economic life of up to 10 years. The next survey was conducted in 2014, and showed that the number of

remaining CFC chillers was only 18 very old units with the total refrigeration capacity of 9,000 tonnes of refrigeration, which could not be qualified for replacement. Subsequently, the chiller replacement component was excluded from the project. The objectives of the project were reoriented to assess overall building energy efficiency (retro-commissioning).

19. The objective of reducing post-2010 CFC refrigerant demand with recycled CFCs recovered from de-commissioned CFC chillers was only partially met. No specific obligations have been reported on the amount of recovered and reused refrigerants. In total, 23 ODP tonnes of CFC and HCFC refrigerant have been recovered in the eight countries of the sample. Most of this amount has been stored and is awaiting destruction.

20. The energy efficiency of new chillers was an important parameter for the replacement of CFC-based chillers, which eventually determined the investment pay-back period. In the majority of projects, the specific energy consumption ratio of the new chiller had to be equal to or lower than 0.63 kW/tonnes of refrigerant (TR) and have a difference of at least 0.3 kW/TR between the efficiency of old and new chiller. This parameter was used as the most important criteria for selection of candidates for replacement in all projects. Suppliers guaranteed the energy efficiency of new non-ODS chillers. The efficiency of old chillers could not be determined in Sudan since they had been out of operation for a long period by the time they were replaced.

21. The calculation of energy saved requires measuring and monitoring data related to the power output of the chiller to be replaced, the electricity consumption of the new chiller, and the cooling output. It necessitates the installation of data loggers connected, in some cases, to the database to keep track of all the data generated by the individual replacement activities. In the Philippines, the data-monitoring centre collected and analyzed data generated by the data loggers of 41 chillers connected; the system automatically generates reports, which are electronically transmitted to the project beneficiaries and concerned Government offices (includes: average efficiency, energy savings and CO_2 emission reduction). The total energy savings as a result of the project were 34.95 GWh/year, and the cumulative carbon emission reduction as a direct project benefit was 151.4 CO_2 kilo tonnes.

22. In Thailand, the installation of data loggers on each individual replaced chiller was a requirement. The verification of chiller efficiency was the responsibility of site owners. The equipment suppliers provided assistance in handling the data loggers. The evaluation of energy efficiency was based on four data records collected for that purpose, and reported energy data for the remaining locations. The energy savings from 17 replaced chillers was 15.6 GWh/year and the emission reduction was 53 kilo tonnes CO_2 equivalent.

23. The information on energy savings and emission reduction was not provided for the remaining projects. There has been a relative improvement in the average energy efficiency (kW/TR) percentage between old and new chillers. In Cuba, an attempt was made to take the measurement of all parameters to determine the energy efficiency of newly installed chillers. The results have not been recognized as satisfactory since the chiller was running on partial load. The relative energy efficiency was estimated within 15 to 50 per cent, based only on the comparison of electricity consumption. In the absence of installed measurement system such as data loggers, Colombia and Jordan reported a relative improvement in average energy efficiency (kW/TR) in per cent between old and new chillers. In Argentina, the old chillers have been replaced with units that are more efficient but no measurements of the specific parameters were made. The energy efficiency in Sudan could not be determined since old chillers were not operating for a long time.

National chiller context

Chiller surveys

24. There was no up-to-date inventory of CFC chillers available at the time of preparation of the chiller replacement projects. The eight evaluated projects were in countries with surveys of the chiller sector carried out prior to or in 2005 for projects approved at the 47th and 48th meetings. The survey in Thailand was done in 1998. Therefore, it was not easy to obtain full and accurate data on the chiller population in the country. The chiller suppliers' databases were considered a good source of data. However, they were frequently reluctant to share this information with IAs because of the competition on the market. Special confidentiality agreements were signed in some cases to get things moving.

25. The identified chillers went through a screening process using eligibility criteria based on the chiller age, remaining lifetime, cooling capacity and energy efficiency. As a result, the number of chillers qualified for funding might represent a fraction of the total chillers identified. The country case studies pointed out that the survey should be updated within a relatively short period following the dynamics of changes in a chiller population.

26. The 2013 inventory disclosed the existence of approximately 130,000 chillers in Brazil with a cumulative capacity about 3.2 million TR. According to recent estimates, HCFC-based chillers represent approximately seven per cent of the total chiller population. In the last ten years, the use of HCFC-based chillers in new systems had been decreasing significantly due to the aggressive penetration of HFC-based equipment into the market. It is estimated that HCFC chillers will be replaced by alternatives by 2025 due to the expected shortage of HCFC-22 supply.

27. Currently, virtually no CFC-based chillers remain in operation in countries covered by the evaluation except Argentina and possibly the Philippines. There is no demand for CFC recovered from replaced chillers and stored by chiller owners and reclaiming centres, except in Argentina. Countries are facing a problem with the collection, containment and destruction of stored CFC refrigerants.

Cost of electricity

28. The cost of electricity is an important factor in determining the responsiveness of chiller owners to proposals to participate in the chiller replacement programmes. The cost of electricity and Government subsidies vary in the eight countries reviewed. In Argentina, electricity had been subsidized and, until recently, it had been an impediment to promoting chiller replacement. Despite its age, the equipment can still be in good condition due to the low use of the chillers in Argentina's climate, and spare parts are still available. Recovered/reclaimed CFC is still available for any top-ups needed for the systems. The 20 per cent subsidy offered by the World Bank was not attractive to the majority of chiller owners and local circumstances have not been conducive to getting funding for capital expenses. The World Bank has been negotiating an increase of the subsidy up to 33 per cent.

29. Between December 2015 and January 2017, electricity prices increased substantially in Argentina (by 400 per cent to 800 per cent depending on the tariff). A publicity campaign aimed at chiller owners, promoting the potential benefits of energy-efficient chillers is planned. The impending shortage of recovered/reclaimed CFCs will also be broadly advertised. Stocks of recovered CFC-11 and CFC-12 seem to be limited, which should also attract more chiller owners to consider replacement of their energy-inefficient chillers.

30. In Cuba, the cost of electricity, typically fuelled by gasoline-powered generators, is high and fluctuates with oil prices. Thus, the responsible use of energy is regulated and strictly controlled by the Government; an annual quota is established for users and penalties are applied if the consumption exceeds

the established quota. Energy efficiency was a main driver in the successful implementation of the project. Therefore, the project was welcome and progressed well with the government's support.

31. In Colombia, the cost of electricity is perceived as high by users (US $0.15 KWh). Subsidies are offered to low-income households,[2] but the use of AC is still perceived as a luxury item. Due to the high up-front cost of central systems based on chillers, mini splits and multi splits are being installed in new buildings and also in replacement of old central systems.

Geographical location

32. The geographical location of the country and its climate conditions have an effect on AC energy demand and subsequently on potential energy savings. Energy efficiency gains depend on the number of working hours over the year. In AC-related business, the climate is a very important factor and is typically represented through a measure known as cooling-degree-days (CDD), [3] which provides an index of the energy demand required to cool indoor spaces. In terms of the CCD, Cuba, Thailand and the Philippines are among several tropical countries with the highest AC energy demand. The CDD index determines the number of chiller operating hours, energy savings and pay-back period. The CCD index varies significantly depending on the location of the chiller replacement project.[4]

Institutional and legislative issues

Chiller replacement strategy

33. There was no specific national strategy in place for phasing out CFC chillers in countries under evaluation prior to the time when chiller replacement projects were initiated. The broader strategic objectives stem from national ODS phase-out schedules, which are either in line with the Montreal Protocol requirements or even ahead of them. This strategy typically entails banning the importation of CFC-based chillers and CFCs according to the adopted phase out schedule. Installed CFC-base chillers could continue to be used as long as there were stockpiled and recycled CFCs around to service the chillers (after CFC imports were banned).

34. Under the ODS phase-out strategy implemented by the Philippine Ozone Desk, both the public and private sectors are required to comply with the phase-out schedule. One of the adopted regulations states that by 1 January 2025, all imports of HCFC-123 as cooling agent for chillers and as a fire-extinguishing agent will be absolutely prohibited, except in the servicing sector. For HCFCs, the separate quotas for HCFC-22, HCFC-123 and HCFC-141b has been established. This will help the chiller owners who replaced their old chillers with new HCFC-123 chillers, and will allow them to operate their equipment up to the end of its useful life.

35. The energy conservation policy adopted by the Government of Thailand included funding mechanisms, which encompassed the early replacement of energy non-efficient CFC chillers nationwide by providing low-interest credits. No similar mechanisms were created in other evaluated countries. From the World Bank's perspective, however, with the proven high internal rate of return, the Government may

[2] It is estimated at 13.400.000 or 85 per cent of population, of which only 1.500.000 have an air-conditioning system.
[3] The cooling-degree-days index is calculated by subtracting 18 from the mean daily outdoor temperature in degrees Celsius and summing up only positive values over a fixed period, such as an entire year. The selection of 18 degrees as the base outdoor temperature accounts for the additional heat generated by occupants and their activities, resulting in an average indoor temperature of 21 degrees—typical room temperature—when it is 18 degrees outdoors. For an average outdoor temperature higher than 18 degrees, most buildings require cooling to maintain a 21-degree indoor temperature.
[4] Colombia: Cartagena 3805, Medellin 1581, Bogota 66; Brazil, Brasilia 1668; the Philippines, Manila 3947; Thailand, Bangkok: 5167.

not need to provide additional incentives to replace the remaining CFC chillers if the private sector receives all of the necessary information, along with a clear message from the Government.

Coordination

36. The coordination mechanism was integrated into project design. The scope of the coordination mechanism and the participation of respective Government bodies and others stakeholders therefore varied according to the project design and the financial mechanism involved. For example, Government participation in the implementation of chiller projects in the Philippines varied from project to project. The involvement of chiller suppliers and ESCOs in project implementation contributed beneficially to the development of the chiller pipeline and increased project disbursement for subsidy payments to chiller owners. The willingness of ESCOs to bear the risk related to projected energy savings was one of the major barriers to investments in energy efficiency. ESCO willingness to either invest up-front or ensure best practice maintenance in return for a contractual payment of a percentage of the energy savings achieved helped building owners buy into, and grow, the ESCO market.

37. In the case of Cuba, new and enhanced partnerships were established between Canada's bilateral assistance Fund (Technology Early Action Measures (TEAM)) executed by Environment Canada, UNDP Energy Thematic Fund (TTF), SMARDT (a Canadian enterprise), with the Government of Cuba providing counterpart funds. Several national Ministries were closely involved in the implementation of the project, namely the Ministry of Tourism, the Ministry of Health, the Scientific Council, and the Ministry for Culture. Each of the Ministries operates at least one workshop that repairs and services AC and chiller systems. They all participated in practical project implementation and awareness outreach. The demonstration projects contributed significantly to creating the required partnerships among stakeholders.

38. In Colombia, successful partnership took place between the NOU and Medellin Public Company in decommissioning three CFC chillers located in the Provincial Government Building and the local custom office. The CFC AC systems have been replaced by a district cooling/heating installation utilizing ammonia and absorption chillers. The implementation of this comprehensive project required close coordination with the Swiss system supplier and local authorities.[5] The collaboration with and co-funding by Switzerland SECO (Switzerland Secretaria de Estado para Asuntos Economicos) has been essential for the development of the La Alpujarra district cooling project, as well as the collaboration and dedication of MADS (Ministerio de Ambiente y Desarrollo Sostenible), UTO (National Ozone Unit) and APC (Agencia Presidencial de Cooperacion Internacional). Also the agreement signed for the "Colombia Thermal Districts" project will permit the replication of similar projects. Similar projects are currently being considered in Bogota, Cali, Cartagena and Barranquilla.

39. In Brazil, UNDP brought in the chiller replacement project as a component of a much larger undertaking "Market Transformation for Energy Efficiency in Brazil". The objective of this large project was to increase energy-efficiency investments in private and public buildings. Emphasis was placed on demonstrating the energy-efficiency potential of retro-commissioning buildings, including the installation of non-CFC-based chillers, by addressing the technical and financial barriers that exist in the country. This encompassed capacity-building as well as improved access to financing for energy-efficiency initiatives in order to "influence, transform, and develop the market for energy-efficient building operations in Brazil and move towards a less carbon-intensive and more sustainable energy consumption path in the country."

40. The implementation of this ambitious project required the participation of UNDP, GEF, MLF, International Development Bank (IDB) and a number of Brazilian authorities.[6] Negotiations between the

[5] Government of Antioquia Province, Provincial Customs Council, Ministry of Environment and Sustainable Development, and Presidential Office on International Cooperation

[6] Energy Research Company, Ministry of Mines and Energy, Brazilian Electricity Regulatory Agency, Ministry of Planning, Brazilian Development Bank, Ministry of Finance and National Program for the Conservation of Electric Energy.

GEF and the IDB on financing and guarantee terms took about five years. Nevertheless, there was zero disbursement under the chiller component and eventually, the number of CFC chillers became negligible in the country. The mid-term evaluation recommended restructuring the project.

41. The main problems in project implementation were related to the absence of an energy policy to promote energy efficiency in building operations and the absence of a regulatory framework. The chiller replacement component was withdrawn and placed in a new UNDP/MLF project addressing the integration of chiller replacement in the improvement of energy efficiency in buildings through technical assistance and training for servicing personnel and the owners of building. A dedicated component of the project provides technical assistance to owners of four selected buildings in chiller replacement as part of the retro-commissioning process.

Public and private sectors

42. Typically, the project designs did not differentiate between public and private sector chillers because it is not possible to determine in advance which chiller owner may apply for assistance. The issues they have to face are different. The public sector is dependent on budget appropriations for its capital expenditure, and is therefore unlikely to have up-front capital for chiller replacement. Strict legislation and bureaucracy are other barriers to access funds. In the private sector, economic instability, lack of finance, insufficient warranty and high interest rates caused the postponement of capital-intensive projects.

43. UNDP reported on the Colombia project, which was in its initial phase, and covers work with both private and public owners. It appears that working with private owners may be easier, as the system for receiving savings from the energy gains is simpler: the owner invests in the conversion and the owner saves in the energy bill. Budgets are less simple in the public sector. For instance, in some cases the process required to obtain approval for the investment is long, and in other cases the monetary savings from the energy gains are not necessarily received by the same department that decides to undertake the investment on the chiller, making the process potentially more complex. On the other hand, the Colombia example shows that the public sector can invest significant resources (US $6.6 million) to construct a district cooling installation. In Cuba, the Government successfully invested in chiller replacements in a crucially important sector (hospitals). Significant co-financing by the public sector for purchasing ancillary equipment was observed in Argentina and Sudan.

44. The Electricity Generating Authority of Thailand (EGAT) was running its own chiller programme, which was complementary to the GEF/MLF project because its primary target was the public sector. The EGAT programme did not offer a technical shortfall guarantee or independent verification of results, and did not issue detailed case studies.

Dissemination of information

45. The demonstration projects played an important role in designing and implementing chiller phase-out strategies and activities. The complete operational procedures developed under the pilot project in Thailand, which included a methodology for *inter alia* baseline power performance measurements and service contract requirements, were adopted by the private sector (i.e., chiller suppliers). These procedures were applied outside the project, supporting the market-driven and the Government-promoted chiller replacement programme. The project results and the effect of the dissemination activities contributed to the Thailand Green Leaf Programs that were created by the Thai Hotel Association to green the tourism industry. This included avoiding the use of CFC-based chillers. This program is still in place.

46. The Thailand Building Chiller Replacement Project was the basis for further study on chiller replacement, namely the India Chiller Study that determined that the barrier to chiller replacement could be overcome by an incentive of about 20-30 per cent of the cost of a new chiller. The global chiller replacement project followed, which drew a number of lessons learned and experiences from the Thailand

project in its design, such as the need for monitoring systems, which were replicated in the India and Philippines projects. The financing models built on the co-benefits derived from the synergy between improving energy efficiency and replacing refrigerant was used in all evaluated projects except Sudan. While actual programme design and implementation varied according to local circumstances, the technical materials developed as part of the appraisal process in Thailand were adapted for use in other countries. A series of workshops and seminars have been organized internationally on the dissemination of information and experience gained during the implementation of the Thai project.

47. Activities on the dissemination of information related to the replacement of chillers with energy-efficient alternatives continued as part of demonstration projects approved at 47th and 48th meetings. In the Philippines, 26 training seminars were organized for personnel participating in the chiller replacement programme. The information, education and communication materials were developed as part of project activities, particularly the documentary video. In October 2016, a workshop was held to develop a blueprint for the sustainability of the project after the funding from the World Bank was terminated. The strategies have been developed and communicated to the government authorities concerned.

Energy efficiency

48. In December 2013, a case study was carried out to demonstrate the energy-efficiency potential and the economic and environmental benefits obtained from the replacement of CFC-based chillers in the Ministry of Finance building located in Brasilia realized under the CFC phase-out plan. The analysis of energy consumption was conducted before and after the intervention. It turned out that the chiller replacement as such contributed insignificantly to the reduction of energy consumption. Better energy efficiency would have been achieved, however, by using a retro-commissioning approach in which the entire refrigeration system would have been under consideration, including cooling towers, water pumps, electrical and control systems, and ventilation fans as well as other building facilities. The results of this case study require more thorough economic analysis, including needed and used AC loads, as the office building located in Brasilia with a CCD index of 1668 (as previously indicated) might not have required enough operating hours to gain sufficient energy savings through the installation of energy-efficient chillers.

49. In Colombia, the work will be carried out shortly to assess the energy savings achieved through the replacement of six CFC chillers outside of the MLF/GEF project. All the parameters related to working conditions, energy efficiency and environmental impacts will be recorded and analysed, and results will be disseminated. An attempt was made to measure the energy efficiency the new installed chiller. However, the results have not been recognized as definitive since the chiller was not running under optimal conditions.

50. In Thailand, energy a ministerial order in 1995 established energy consumption standards for building AC systems (centrifugal chillers) for both existing systems and new installations. Depending on the cooling capacity, the ministerial order establishes that energy consumption shall not exceed 0.8 - 0.9 kW/TR for all existing centrifugal chillers, and 0.67 - 0.75 kW per TR for new installations. It should be recognized that the established energy consumption threshold for existing CFC-based chillers was not stringent enough to stimulate their early replacement with more energy-efficient equipment.

51. There are no specific references to existing energy-efficiency standards for chillers in the other countries under evaluation. The Philippines has the following energy-efficiency standards and labelling programs: efficiency standard and labelling program for room air-conditioners; energy labelling programme for refrigerators and freezers; fluorescent lamp ballast energy-efficiency standard; and energy-efficiency standard and labelling for compact fluorescent lamp. There are no energy-efficiency standards for chillers.

Funding-related issues

52. The interest-free loan provided by MLF and GEF was used as a financial mechanism in the implementation of the chiller replacement project in Thailand. The project demonstrated that the synergy of merging funds from different sources could be used to achieve complementary global environmental benefits: ODS phase-out and GHG emission reduction. The project also demonstrated that investments in new energy-efficient alternatives could be paid back within 3 to 5 years. Because of the market corrections following the crisis in Thailand, the commercially available interest rate dropped so low that the preferential rate provided through the GEF and the MLF grants was not competitive. Moreover, during the same period, the Ministry of Energy successfully offered several financial subsidy schemes to promote energy efficiency that were more attractive for the private sector. Under the Ministry of Energy schemes, interest rates were lower, repayment periods were longer and there was no requirement to dismantle the old CFC chiller and install a data logger for the new chiller. The project jointly funded by GEF and the MLF therefore closed one year earlier than anticipated due to the limited uptake of loans by chiller owners. By that time, 17 out of the targeted 24 chillers had been replaced, but there was significant funding remaining, with US $1.3 million being returned to the GEF and US $1.27 million being returned to the MLF.

53. Incentives in the demonstration projects under review were provided based on rate of return on investment considerations. The projects approved at the 47th and 48th meetings provided incentives to chiller owners averaging 20 per cent of the purchase cost of a new chiller as a partial guarantee fund supporting investments in CFC-free, energy-efficient chillers. This approach was aimed at directly reducing many of the real and perceived project risks, effectively ensuring a payback period of 3-5 years for building owners who replaced an old CFC chiller.

54. The MLF allocated US $1 million each to Argentina, Brazil, Colombia, the Philippines and Sudan, US $735,556 to Jordan, and US $984,553 to Cuba. All of the projects except Argentina, Jordan and Sudan eventually secured GEF co-financing. Cuba successfully received co-financing from Canada and UNDP. UNIDO, however, experienced serious difficulties in securing co-financing from the Agence Française de Développement (AFD) for the Sudan project, which caused a significant delay in implementation, but eventually the problem was resolved.

Multi-source funding for projects

55. The design of chiller energy efficiency projects in the Philippines as part of the global chiller replacement project envisaged funding through a blend of GEF and MLF grants, CDM financing and private-sector resources. The CDM financing was not provided to beneficiaries at the beginning of the project, but was to be made available only after chiller replacement had been completed, savings on CO_2 emissions had been generated and verified, and certified emission reductions had been issued. Thus, it was expected that additional chiller units would be replaced using revenue generated by carbon credits. The negotiation on CDM co-financing was difficult and very lengthy.

56. In 2012, the depressed carbon market made it necessary to terminate the emission reduction purchase agreements with potential buyers of Certified Emission Reduction (CERs). Accordingly, the Philippines project was restructured; the removal of the carbon finance component, and the decision to subsidize 15 per cent of the ex-works cost of the chillers facilitated the speedy implementation of the restructured project (i.e., elimination of the requirements for baseline power measurement, monitoring and validation of emission reductions in order to meet CDM requirements). Energy-inefficient HCFC-and HFC-based chillers have been included in the replacement programme.

57. There is evidence that carbon financing led to overburdening the projects with monitoring and verification procedures, which were unattractive to chillers owners. Furthermore, during the short period of project implementation, none of chiller owners who were consulted expressed an interest in relying on carbon payments to obtain the subsidy, even though that approach was designed to be more lucrative than

the up-front subsidy. Most chiller owners considered it to be too complex and fraught with risk of non-payment, which now appears to be the case.

58. The project design in the Philippines had issues that made implementation challenging. The project components funded by the different sources (i.e., GEF, MLF, and carbon finance) were interdependent, and therefore not immune to risks caused by other components. As a result, the collapse of the carbon market not only affected project components that were financed by carbon finance revenues but affected the project as a whole.

59. In Brazil, UNDP embarked upon enhancing energy efficiency investments in public and private buildings through access to commercial financing and ESCOs. The programme intended to encourage cross-convention synergies with the Montreal Protocol to include a chiller replacement component as an element in enhancing building energy efficiency, thus contributing to the phase-out of CFCs. With the US $1 million financing from the MLF, the co-financing from the GEF, the IDB, banks, ESCOs and end-users was anticipated to reach US $135 million. The efforts to secure co-financing, the necessary guarantees and agreements took a very long time. The implementation of the project faced overwhelming barriers and extensive delays, leading to withdrawal of the chiller-replacement component along with the MLF share of financing because the available fleet of CFC chillers virtually disappeared during the delay. UNDP decided not to embark on the replacement of HCFC-based chillers.

60. Experience implementing projects with co-financing from several sources has been mixed. While such projects represent a clear effort to acknowledge synergies amongst various global environmental actors and their financing mechanisms, they also revealed the complexities that can arise when several financing partners become involved. Such challenges have ranged from an inability to synchronize the timing of financing approvals, the collapse of the carbon market, the impact of the 2008 financial crisis in the case of the Thailand project, competing institutional and implementation arrangements (e.g., dual reporting under the MLF and the GEF), and issues regarding the suitability and commercial availability of alternatives in the case of the Philippines project.

61. Specifically, the blending of MLF, GEF and some third-party funding in the case of the Brazil and Philippines projects proved to be challenging. The issue for the GEF related to synchronizing opportunities for leveraging relevant energy-efficiency operations with the MLF funding and its development timeline, guided by global Montreal Protocol compliance targets. From the MLF perspective, the funding window for CFC chiller replacement was created on the basis of decision XVI/13 adopted by the Parties to the Montreal Protocol in 2004, and was tied to the fact that chiller owners in Article 5 countries were facing impending CFC phase-out in 2010. The replacement of chillers, even with energy-efficient alternatives, about ten years after the decision by the Parties to the Montreal Protocol could not be characterized as an adequate and responsible reaction to that decision.

62. With regard to carbon finance programmes in general, it had taken from three to six years to deliver actual financing in the past, and given the market situation at the time of negotiations with CDM under the global chiller project, the return on CERs was expected to be very low. As a result, the involvement of CDM created a disincentive for any project that would be dependent on carbon finance income at that time. The market for CERs had dropped to its lowest level since 2004. The strategy had to be reconsidered in a timely fashion and the project had to be restructured so that additional CFC chillers could be replaced and ODS could be phased out.

63. Adherence to the mandatory timelines of the Montreal Protocol should have priority when conducting risk assessments in the context of projects funded jointly by the MLF and the GEF.

64. Using two different sources of funds in the Thailand project led to a very lengthy preparation period. Two loan agreements and two guarantee agreements had to be entered into for total financing of less than US $5 million. The added complexity of administrating both funding amounts was not adequately

addressed at the design stage, which led to additional complications in project implementation and monitoring. For example, the financial intermediaries and enterprises had to report separately on their use of each funding amount, and the task team had to manage two budgets and report on completion twice. It was also difficult to balance the disbursement of the two loans (the MLF and the GEF), because of differences in the amounts and the costs of projects for each participant. Similar problems have been noted in the India and Philippines projects. Therefore, a single funding source or a better blend of funds should be considered when future projects are designed.

65. Blending MLF and GEF resources in the global chiller project has also lead to heavy implementation structures and procedures, with requirements for separate progress reporting and accounting of relatively small amounts of grant financing. These procedures need to be streamlined and simplified.

Implementation issues

Delays in implementation

66. Currently, all of the projects have been completed except for the projects in Brazil and Argentina. At the 79th meeting, the IAs were requested to submit project completion reports by June 2018 and return funds balances no later than December 2018. On average, project implementation was delayed by almost three years beyond the approved target. A key barrier was associated with the preparatory efforts linked to the complex design of co-funding that has reportedly delayed many projects considerably. Some projects experienced difficulties in the synchronization of project cycles, procedures and schedules among various funding and implementing partners. Funds from the GEF took up to two years to arrive after project approval. Additional obstacles resulting in significant delays have been observed in those projects that also envisaged a carbon finance (CDM) revenue stream.

67. The problems and delays in the implementation of the project in Brazil, were primarily related to securing multi-source financing. According to the World Bank, the reason for the delay in starting global chiller replacement project was the time needed by countries to decide on and request an allocation in relation to climate change under the GEF for chiller replacement. Other time consuming, but necessary steps were: the development and approval of the chiller energy-efficiency methodology under the CDM, developing a project framework at the country level (in coordination with, *inter alia*, IAs, suppliers and the Government), and review and clearance of the first component of the global chiller project by the GEF for India. In addition, the first component of the project for India coincided with the restructuring of the GEF project cycle.

68. The chiller replacement cycle generally takes at least six months to one year from the submission of the expression of interest. There were two critical activities that were time-consuming: the approval of the sub-grant agreements, a pro-forma document, had to be reviewed by the legal departments of the chiller owners, which took additional time; and the procurement and transportation process for chiller replacement was a lengthy process as chillers were procured abroad and had delivery lead times. The problem was exacerbated in some cases by port congestion, with delivery of the equipment from the port to the site becoming a major implementation issue.

69. The significant delay in the implementation of the project in Sudan from 2006 to 2012 was due to the lack of communication between UNIDO and the NOU, presumably because of political changes in the country. Communication resumed and a UNIDO mission was organized in early 2013. There was also an inter-ministerial conflict regarding the mandate for handling the Montreal Protocol, which has very recently been clarified.

70. There have been some major procedural changes and modernization, across the various Ministries and departments in Argentina, including the Ministry of Production, which was responsible for the

implementation of the World Bank chiller replacement project. This has resulted in delays in setting up the transparent procedures by which the project would be implemented. A problem with the customs clearance and tax exemption for imported equipment also caused delays. The process of enrolment of chillers for replacement was slow, in part due to chiller owners' lukewarm reaction to the 20 per cent subsidy. At a later stage, the World Bank agreed to raise the subsidy to 33 per cent.

71. The project in Cuba funded with bilateral assistance from Canada experienced a delay of about two years related to a long process of transferring implementation from Canada to UNDP.

72. The sub-grant agreements signed with private end-users of CFC chillers in Colombia proved to be a good mechanism that provided end users with the necessary flexibility. Such a mechanism was not useful in dealing with public institutions because of administrative constraints.

Choice of alternative technology

73. The use of both HFC-134a and HCFC-123 as refrigerants was allowed in chiller replacement projects. HFC-134a (zero ODP, and a high GWP) was considered a good alternative refrigerant, as it made it possible to move away from ODS technology while increasing energy efficiency. It was considered that the use of HFC-134a could be supported by the MLF because the benefits far outweighed the negative contribution, to global warming. Furthermore, the new chillers using this refrigerant are much more robust and refrigerant losses have been drastically reduced.

74. HCFCs are controlled substances under the Montreal Protocol, and in 2007, the Meeting of the Parties decided to bring forward the phase-out schedule of HCFCs. Therefore, replacement chillers using HCFCs could be procured, and given that the useful service life of chillers is about 20-25 years, this would not incur any imminent financial hardship for chiller owners.

75. Most of the chiller owners in the evaluated projects selected HFC-134a technology. In the Philippines, prior to 2015, a number of existing HCFC-22 and HCFC-123-based chillers were replaced with more energy-efficient chillers with the same HCFC-123 refrigerant. In line with the objectives of the Montreal Protocol, the use of non-ODS refrigerant for the new chillers was included in the new eligibility criteria under the restructured project. This resulted in the disqualification of new chillers with HCFC refrigerant (e.g., HCFC-123 and HCFC-22). The implementation of this criterion in 2015 affected the list of chillers enrolled for replacement, effectively excluding chiller owners who had a standing contract with a supplier of chillers with HCFC-123 refrigerant.

76. Retrofitting of CFC chillers was included in the Cuba project. However, retrofitting chillers to HFC-134a technology requires gear-drive changes to obtain near-original performance. In addition, replacement of lubricants and other mechanical and electrical modifications are needed, and a non-optimized retrofit would lead to reduction in capacity of up to 10 to 15 per cent. Retrofit costs could be up to 40-80 per cent of the replacement costs and, depending on the mechanical condition of the chiller, retrofitting might not extend the economic life of the chiller significantly, unless it involved replacement of the compressor and motor. Thus, for these main reasons, the Government abandoned the idea of retrofitting chillers as stated in the original project and decided to replace old chillers instead.

Recovery and recycling of CFC refrigerants

77. In response to decision XVI/13, IAs included measures in their project design for the effective use of ODS substances recovered from the chillers to meet servicing needs in the sector. However, they faced problems with the practical implementation of these measures. The countries with chiller replacement projects have different recovery and recycling capabilities, which are a determining factor in providing recovered CFC refrigerant that could extend the operational lifetime of chillers.

78. The situation in Thailand was favourable for the recovery and reuse of CFC refrigerants, as a number of CFC-based chillers had been present in the country from 2002 onward. There was a requirement that only suppliers and contractors, which possessed proper refrigerant recovery and recycling equipment as per ASHRAE 15, would be eligible to participate in the project. This condition was included in the appropriate agreements. The proper management of recovery and recycling operations required additional logistics and efforts on the part of contractors. However, no funding was allocated for refrigerant management under the project. Funding was limited and targeted for chiller replacement with more energy-efficient units. As a result, the amount of CFC refrigerant recovered from the replaced chillers was lower than anticipated, with a recovery rate of about 70 per cent. Only a portion of the recovered refrigerant was reused. Most of it was too contaminated and not seen as having economic value. The amount of reused CFC refrigerant made up only about 20 per cent of the cumulative initial charge of the replaced CFC-based chillers.

79. Thirty ODP tonnes of CFC and HCFC refrigerant have been recovered in the sample of countries. ODS recovery and reclamation facilities have been established in Argentina, Brazil, Cuba and the Philippines. In Colombia, 14 centres to collect refrigerants and five refrigerant-regeneration facilities have been established, while the implementation of refrigerant destruction facilities is underway even though the country does not have equipment to recover CFC-11. Information about recovered and reused refrigerant is scarce, mainly because the population of CFC chillers had been mostly depleted in these countries at the time of CFC chiller replacement. The Cuba case study mentioned that the demand for recovery and recycling activities was high, and that recovery and immediate reuse of the refrigerant, when the refrigerant was not contaminated, was a common practice. No specific data was provided, however.

80. Up until recently, there appeared to be a sufficient stock of recovered and reclaimed CFC-11 in Argentina. The amount of 2,466 kg of recovered CFC-11 was being held at the reclaim centre and by various installers. Additionally, about 560 kg of recovered CFC-12 was held by a chiller user. Given that one chiller manufacturer representative estimated that the top-up of CFC-11 required for existing chillers is approximately 1.8 tonnes per year, it appears that stocks of recovered/reclaimed CFC-11 will soon be exhausted.

81. In the Philippines, the 31.45 metric tonnes of recovered refrigerants collected from the old chillers (including CFC-12, HCFC-22, HCFC-123 and HFC-134a) are being held by the contractors who did the recovery, and are currently being stored, either by the company that collected the refrigerants, the reclaim centre, or by the chiller facility, particularly in the case of HCFC-123, where the beneficiary still has old chillers operating on HCFC-123, or has converted to HCFC-123 chillers. The Philippines do not have any refrigerant destruction facilities. The one reclaim centre is not functioning, as the gas chromatograph does not have the standard test columns for the refrigerants. The Ozone Desk is hoping to get these during the implementation of the HPMP. There are no other recycling centres in the Philippines. Case studies in the Philippines and Colombia emphasized that the recovered refrigerants are monitored and regulated.

Recommendation

82. The Executive Committee may wish:

(a) To take note of the final report on the evaluation of chiller projects with co-funding modalities contained in document UNEP/OzL.Pro/ExCom/80/9; and

(b) To invite the bilateral and implementing agencies to apply, when appropriate, the lessons learned based on the key findings of the evaluation of chiller projects with co-funding modalities.

Annex I

TERMS OF REFERENCE FOR THE EVALUATION OF CHILLER PROJECTS WITH CO-FUNDING MODALITIES

Background

1. The desk study on the evaluation of chiller projects carried out in 2012 and submitted to the 68th meeting[7] analyzed the efficacy of the eight demonstration projects with a view to improving understanding of progress made, difficulties still being encountered, various attributes and/or shortcomings of the co-funding mechanisms and project approaches in the implementation of chiller projects.

2. The report concluded that the system of stimuli used to drive replacements has uneven results, it is not working in all countries and where it is working it is not fast enough. It includes a large variety of mechanisms, promotions and incentives which are utilized in the eight demonstration projects. However, initiation of these projects had been slow at the time the desk study was written and therefore progress reporting was limited, postponing the second stage of the evaluation, which includes field visits, until the projects reached a more mature stage of implementation. After consultations with the implementing agencies during the Inter-agency coordination meeting[8], it was agreed that the organization of the second stage of the evaluation for 2017 was opportune.

Objective of the evaluation

3. The objective of the evaluation is to collect and analyze information with the aim of finding an answer to the questions and issues stressed in the desk study, especially those related to the functioning of various financial mechanisms. The evaluation will examine the current demonstration projects and assess whether sufficient incentives are in place to catalyse replacements without the Multilateral Fund's resources, and the problems to be expected in the private sector chillers replacement as well as in the public sector in countries where funds for chiller replacements are scarce.

4. Based on its findings, the second phase of the evaluation will formulate lessons learned that will contribute to future policy development concerning resource mobilization. The field visits will cover eight countries with chiller demonstration projects and will ask the following questions.

National chiller context

(a) Does the country have an inventory/database of all CFC chillers remaining in operation? What is the age profile of the chillers not as yet converted or replaced? How many chillers of the total were replaced since the beginning of project implementation to date and how many remain?

(b) What is the remaining chiller-based CFC demand in the country? And if there is one, how and when is this demand expected to trail off? How is the remaining demand to be met?

(c) The impact of regional projects successes and failures on neighboring Article 5 countries.

[7] UNEP/OzL.Pro/ExCom/68/10 and Add.1
[8] Montreal, 31 August – 1 September 2016

Institutional and legislative issues

(a) Which institution(s) coordinate(s) the chiller replacement (policies and funding)? Is there a national strategy in place to phase out all CFC chillers? Are the required regulatory provisions to drive the chiller phase-out in place? If not, what is still needed?

(b) Were project designs different in approach for the public and private sector chillers? Is the private sector proceeding with replacements without assistance and if so why? Is it a fear of diminishing CFC supply or other concerns?

(c) Are all of the stakeholders (including government ministries) engaged in the conversion? Is there a coordination/communication mechanism and, if so, how is it working?

(d) If there is a dissemination strategy, how is it planned and how was the management modality working? If it is not working, what are the reasons?

(e) What role, if any, did the various demonstration projects play in designing and implementing the chiller phase-out strategies?

(f) Were there private/public sector policies and strategies in place? Were there corporate social responsibility programmes in place driving the replacement of chillers? Were there any green initiatives implemented with the projects (i.e., green buildings)?

(g) Were energy efficiency standards playing a role in the replacement of CFC chillers?

Funding-related issues

(a) How was the funding modality selected? What barriers or impediments did it encounter?

(b) Has co-funding been mobilized or is it anticipated? What were, or are, the problems associated with donor coordination in the face of different criteria, schedules and priorities? How were they overcome?

(c) What agreements are/were needed and concluded (why were they needed, with whom, and what is covered)?

(d) Are chillers replacements occurring outside the project (i.e., chiller owners and operators) are undertaking replacements on their own initiative? If so, why?

(e) What are the chiller owners' perceptions/views on the efficacy of the various funding arrangements or mechanisms (e.g., concessional loans, grants, revolving funds)?

Implementation issues

(a) With ongoing chiller conversions and replacements have there been barriers and impediments resulting in significant delays? If so, what were these and have they been resolved; and how?

(b) What are the main reasons for public and private sector chiller operators to delay replacement? To what extent, and how, have they been addressed and overcome?

(c) For the chillers that have been replaced to date, what were the actual chiller replacement costs (relative to expectations), and how were these costs met? (Who paid what share?) and what were the alternative technologies used?

(d) What was the role (or possible future role) of energy savings in both project design and implementation? Can energy service companies and utilities be used? If not, why? Are energy savings now a sufficient driver to cause replacements?

(e) Were there any CFC recovered from the chiller projects? Is there, or will there be, any monitoring of recovered CFCs? Is there a plan in place to deal with the recovered CFCs? (Re-use, disposal or destruction?)

Case study country selection

5. The following countries are proposed to be part of the sample of countries to be visited by the evaluation team:

(a) Argentina, as a country with access to financial inputs such as commercial grants, institutional grants and carbon finance credits. This would allow a more detailed evaluation of the efficacy of this approach;

(b) Brazil and Colombia, as countries that have a fully operational chiller replacement project where there are likely many additional lessons to be learned and where the expectation is that the projects underway will serve as a regional model and catalyze early replacements;

(c) Cuba, to explore project implementation in the public sector where chillers are not a luxury, but a necessity (e.g., institutions, laboratories, hospitals);

(d) Jordan, as a high-ambient temperature country and part of the global project;

(e) The Philippines, as a sizable project close to completion, part of the global project and with a co-financing mechanism with the Global Environment Facility;

(f) Sudan, as part of the strategic demonstration project for accelerated conversion of CFC chillers in African countries where progress in implementation has taken place; and

(g) Thailand, as an example in the use of savings generated by an increase in energy efficiency.

Methodology

6. A team of consultants will be recruited based on their experience and knowledge of the subject matter and of the functioning of the Montreal Protocol and the Multilateral Fund. The team will analyse the existing documents as well as the conclusions and recommendations of the desk study and collect additional information from field visits. Discussions with the Secretariat staff, the NOU and the implementing agencies will be organized as needed.

7. A synthesis report will summarize findings from both desk study and country evaluation reports and will formulate lessons learned and recommendations for consideration by the Executive Committee at the last meeting in 2017.

8. Each consultant will be in charge of elaborating the country evaluation report. The team leader, in cooperation with the other team members will draft the synthesis report. Implementing agencies will be involved in participating in the evaluation mission and in providing comments on the reports.

Annex II

CHILLER DEMONSTRATION PROJECTS AND EVALUATION CASE STUDIES

Demonstration chiller projects referred to in 2012 in desk study	Article 5 countries covered by demonstration projects	Case studies
GLO/REF/47/DEM/265	Argentina, India, Jordan, Philippines	Argentina, Jordan, Philippines
COL/REF/47/DEM/65	Colombia	Colombia
CUB/REF/47/DEM/275-	Cuba	Cuba
LAC/REF/47/DEM/36	Barbados, Dominican Republic, Jamaica, Trinidad and Tobago	
BRA/REF/47/DEM/275	Brazil	Brazil
AFR/REF/48/DEM/34, 35, 36 and 37	Cameroon, Egypt, Namibia, Nigeria, Senegal, Sudan	Sudan
EUR.REF.47.DEM.06	Croatia, Former Yugoslav Republic of Macedonia, Montenegro, Romania, Serbia	
SYR/REF/47/DEM/93	Bahrain, Syrian Arab Republic	
Early chiller project		
THA/REF/26/INV/104	Thailand	Thailand