BRIEFING

Experiences and Case Studies on Energy Efficiency in the Refrigeration and Air Conditioning Sector

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Introduction

UNDP has been working actively to support Article 5 countries to phase-out ozone depleting substances (ODSs) under the Montreal Protocol on Substances that Deplete the Ozone Layer and deliver energy efficient smart solutions. In this regard, such solutions, combined with multiple sources of funding, could also overlap the use of hydrofluorocarbons (HFCs) and increase the efficiency of cooling systems, helping parties to meet the future commitments under the Kigali Amendment and also delivering important contributions towards the reduction of indirect greenhouse gases (GHGs) emissions.

Objective

The objective of this document is to compile the experiences and case studies that work on enhancing energy efficiency in the cooling sector, particularly those linked to the Montreal Protocol initiatives, in order to provide tangible examples of activities that can be replicated under the future framework of implementation of the Kigali Amendment.

Providing highly efficient cooling through District Cooling Systems…

Chillers are commonly used central-type air conditioning systems what work removing the heat from the water to a refrigerant, in a closed loop system. The chilled water is then circulated throughout the building in order to cool it's the inside temperature, and the refrigerant is pumped to a location where the waste heat is transferred to the atmosphere. This technological approach requires each building to have its own "cooling system", composed by the chiller, cooling tower, operational and maintenance teams, etc.

The conventional chiller system is subject to a continuous operation environment subject to extreme heat, saline humidity, windborne sand... Over time, performance, energy/cooling efficiency and reliability suffer, leading to significant maintenance costs and ultimately to equipment replacement. **But what if the chilled water could be directly delivered to these buildings and then used to lower the temperature of air passing through the building's air conditioning system?**

This is what a District Cooling System (DCS) does: chilled water is produced in a centralized manner and distributed to many buildings (in a district, for example). In this manner, the output of one cooling plant is enough to meet the cooling demand of many buildings in a more energy efficient way, with reduced charges of refrigerant fluids, and in some cases, by using not-in-kind (NIK) technologies, phasing-out the use of halogenated refrigerants. DCS can reach up to 90% of energy efficiency if compared to conventional chillers. Along with electricity and water, district cooling constitutes a new form of energy service.

District Cooling in "La Alpujarra", Colombia:

At its the 47th Meeting, the Executive Committee (ExCom) approved USD 1 million for a Demonstration Project in Colombia with the objective to grant co-funding and technical support to promote the reconversion/replacement of old and inefficient CFCs-based in the country assisted by UNDP. The Project was designed to manage the stock of 63 CFC-based chillers still running in Colombia by the year 2005. By that time, the lack of investment and other issues have caused power shortages and resulted in forced rationing. As the Colombian electricity sector is made up of a mix of public and privately-owned companies, and the electricity demand in Colombia has grown steadily over the past years, the future demand projected to grow was about 4.4 per cent per year through 2020, and the cost of electricity perceived as high by end-users (US $500/Kw/hour) resulted in subsidies offered to low-incomes population, which comprises around 85 per cent of the population.

During 2013, after an evaluation of the implantation performance of the demonstration project and identified that although it was successfully to manage the CFC-based chillers retirement, the penetration of low-GWP and highly efficient technologies was still lacking. In this sense, the Government of Colombia and the Public Utility joined forces signed an agreement (between the National Ozone Unit (NOU) and Medellin's Public Utility Company EPM - *Empresas Publicas de Medellin*) in order to finance a study on the design and implementation of a cooling district.

EPM has identified specific cooling needs for their clients at the Administrative Complex of "La Alpujarra", which is composed by many buildings (such as the Antioquia Province City Hall, The City Council, The Province Assembly, the Tax Revenue Authority, the Customs Authority, and the Tigo-UNE Telecommunications Utility, among others) that were using individualized chillers-cooling systems, which were very energy intensive cooling equipment.

Based in this study, the EPM, the NOU, the SECO (Colombian´s State Secretariat for Economic Affairs) and the APC (Presidential Agency for Cooperation) had established and inter-agency cooperation agreement and managed to mobilize USD 2.5 million from the Swiss Cooperation Agency, added to the USD 500,000 from the MLF demonstration project and USD 11 million from EPM to co-finance the District Cooling project, in the total value of USD 14 million.

***Result*:** the "La Alpujarra" DCS was implemented started to operate in late 2016, providing 3,600 tons of refrigeration (TRs) of capacity for the above-mentioned clients. The cooled water is produced using climate friendly technologies (Ammonia and absorption chillers) and it is distributed by a system of tubes throughout 1,5 km in the neighborhood. The energy supplied to the Ammonia and absorption chillers is generated from natural gas and the waste combustion which is captured by a turbine that reduces the energy consumption. The combination of co-

generation of electricity plus an ice bank to storage cold connected buildings in the district making the system very efficient. The cooling plant has extra capacity for future expansion and also the chilled water distribution piping circuit is prepared to permit new future connections to other buildings. This project is helping EPM to reduce about 30% if its CO_2-equivalent emissions.

***Lessons Learned*:** DCS start-up required relative high investment that currently traditional financing entities are not available to provide due to lack of knowledge about its functioning. Initial business studies on DCS development, implementation and payback estimates can support decision makers in this process. Additional support may be required to assure the financial warranty and insurance that will enable the installation of DCS. There is also a need to improve awareness and capacitation about the installation and operation of DCS. It is recommended that DCS are implemented gradually to assure a larger coverage that can meet the needs of the end-users.

District Cooling in Dominican Republic, Punta Cana:

The feasibility study aimed to develop a business model for district cooling in the Dominican Republic by determining the technical and financial viability of the proposal. The feasibility study commissioned by UNDP and funded by the MLF was developed within the areas owned by The Punta Cana Foundation Group (Grupo Puntacana) which includes hotels, an international airport, a new shopping mall and a new hospital; taking into account future expansion of the area (meaning, future growth of cooling and energy demand). The feasibility study was performed using a cost-minimizing perspective, and with a focus on bankability and financial performance of the District Cooling Project. The objective was to create a viable, reliable District Cooling product that is in line with international and local market expectations, energy efficiency improvements and refrigerant (HFC and HCFC) phase-out.

Result: The client situation was assessed and a complete business case study was delivered. The suggested DCS aims to use waste heat of the exhaust gases from the electricity generation plant. The waste heat would move the centralized large-scale absorption chillers to generate the chilled water that would be distributed in a chilled water loop to each client within the scoped area. This would potentially lead to a reduction in CO_2 emissions in the range of 80-90%. The technology is proven and has been used in Sweden, Denmark, and other countries for over 10 years. The final decision regarding the investment is still to be taken by the developer, but the technical and financial perspectives are very promising.

***Lessons Learned*:** DCS start-up required relative high investment and it complexity can increase if not properly designed since the beginning of the surroundings developments. Initial business studies on DCS development, implementation and payback estimates can support decision makers in this process. Additional support may be required to assure the financial warranty and insurance that will enable the installation of DCS. There is also a need to improve awareness and capacitation about the installation and operation of DCS.

District Cooling in Costa Rica:

Costa Rica is a tropical country where Air Conditioning (AC) systems are extensively used. According to the Energy Directorate (DSE) of the MINAE, commercial buildings are responsible for roughly 25% of the countries' electricity consumption, while the residential sector (households) are responsible for almost 40% of it. While the National Electricity Utility (CNFL) has launched, in 2004, a Guide to promote a smarter use of electricity in commercial buildings, it is estimated that the continuous growth of the AC installed based (particularly split types) will increase the energy demand of the sector, and in this sense, a sector Action Plan that can address both the current AC consumption basis and the future growth is of urgent need. Currently, three (3) different AC technologies are mainly being used in Costa Rica, namely: centralized systems (electric chillers for stand-alone cooling supply); split systems; and VRV/VRF systems.

Results and Lessons Learned: In May 2017, the Government of Costa Rica, the Chamber of Industry and UNDP organized a workshop in San Jose to raise awareness on the potential to introduce the concept of district cooling in the country. A technical team has initially assessed eight (8) potential sites that could receive DC systems, and the initial conclusion is that there is demand and a good potential to the adoption of these systems, since these sites hold an estimated installed capacity estimated in 14,000 tons of refrigeration (TRs) (roughly 6,500 kg of HCFCs/HFCs charged). It is also likely that funding for these large-scale projects can be obtained and the adoption of DC systems could eliminate the use of large charges of HCFCs/HFCs in these sites, contributing significantly to increase the EE of these clients and, also, to introduce early actions on the implementation of the Kigali Agreement in Costa Rica.

Replicability: Follow up work is already planned in the context of a Project with assistance from the Kigali Cooling Efficiency Programme (K-CEP), where funding has been approved for the development of a national District Cooling Strategy combined with the full development of feasibility studies for the most suitable sites with the aim to introduce the first real District Cooling project in the country. The project is expected to be completed by late 2019.

District Cooling in Maldives:

Maldives is implementing its HPMP and targets to complete the phase-out of HCFC use by 2020. HCFCs in the Maldives are used primarily for air-conditioning and secondly for refrigeration. A feasibility study was done by UNDP and the Government of Maldives, funded by CCAC, to evaluate options for district cooling that would negate the need for HCFCs and HFCs in future.

Results: It was found that planned developments in Hulhumale would generate a very large demand for cooling. Based on masterplan data of the development real state, potential demand has been estimated at 300 MW for cooling capacity and 1.8 million MWh of cooling energy every year. The feasibility study looked at several production technologies and found that a Seawater A/C system (SWAC) with a minimum installed chiller capacity can provide feasible and

competitive district cooling in Hulhumale. Further from shore, the water temperature would be sufficient for a very efficient SWAC system. Closer to shore a hybrid system was recommended where sea water is used in combination with chiller to provide the desired temperature and capacity for the district cooling system.

Lessons Learned: Since the Hulhumale developments will be brought on stream over several years, a 3-phase approach of 100 MW for each phase was recommended. When fully implemented, CO2 savings of 426,000 tonnnes/annum could be achieved. The final decision regarding the investment is still to be taken, but the technical and financial perspectives seem promising. "It is believed that this project is of particular importance to the Maldives and other Small Island Developing States (SIDS) dependent on imported fossil fuels, because it helps us gain energy security and pave the path for a sustainable economy" said Mr. Mauman Abdul Rasheed of the Government of the Maldives.

Demonstrating feasible low-GWP and energy efficient technologies with support from the MLF…

At the 75th meeting, the Executive Committee considered the demonstration projects and feasibility studies for district cooling. At the 76th meeting, the Executive Committee approved 15 projects to demonstrate low-GWP technologies consisting of seven projects in the RAC and assembly sub-sector, five in the foam sector and three in the refrigeration servicing sector. At the extent possible, UNDP also looked into demonstrate innovative technologies that could, at the same time, replace the HCFCs and deliver the best energy consumption performance possible, also looking at the refrigeration system as a whole in order to assure that the best performance and lower energy consumption could be maintained over time.

Costa Rica, demonstration of replacement of HCFC-22 for Ammonia/CO_2 in Refrigeration Systems;

The project was developed by Costa Rica and UNDP to demonstrate that Ammonia/CO_2 technologies can be safely deployed in the field in Latin America. These systems can result in better solutions for countries with limitations in the use of supercritical CO_2 in direct expansion or in countries were barriers prevented the adoption of CO_2 subcritical installations (cascade systems mostly using the R-404a with reduced charges as a secondary fluid).

This project will allow the partner company *PreMezclas Industriales* to eliminate its HCFC usage and thus achieve another step required for the public plan of carbon neutrality and help the country reduce its HCFC consumption, also managing and reducing the current energy demand of the refrigeration system which is 136,031 kwh/month, responding for 18% of the total energy consumption of the facility.

Results: the project is at its final stages of implementation, but it uses a two stage Ammonia/CO_2 system where a reduced charge of ammonia is loaded in the primary cooling circuit. Liquid CO_2 is circulated as secondary cooling, but at subcritical pressure, reducing the costs of installation and almost eliminating the associated risk with pressure. The two stage Ammonia/CO_2 system

is supported by the of tighter controls, monitoring and maintenance practices for both refrigerants, in order to avoid leakage and maintain the good operation and achieve the intended energy efficiency overtime. Due to the efficiency of the new refrigeration system, the new thermal load is calculated in 75.8 TR, against 150 TR of the obsolete HCFC-22 based system.

Lessons Learned and Replicability: Capacities needed to be built as pre-requisites to assure proper handling of the technologies. The installation is designed to reduce leakage risks. However, even with risks reduced and smaller charges, ammonia is a toxic substance, and Costa Rica will invest in the adoption of appropriate technical guidelines and standards to enable conditions for its safe application and further replication of the project. With a proper design and installation of the new system, allied to the proper operation and maintenance techniques, energy consumption is expected to decrease up to 20% in the refrigeration plant. The results of the project are expected to influence all levels of the supply chain (including support to make parts and knowledge on use available), training institutions and engineering universities in the country.

China, demonstration of replacement of HCFC-22 with Ammonia/CO_2 (cascade cycle) in Refrigeration Systems;

As a refrigerant, HCFC-22 has been widely used in refrigeration equipment and systems. Technological advancements in alternative, natural refrigerants, such as ammonia/CO_2 cascade refrigeration systems, have provided a clear solution for replacing HCFC-22 in industrial and commercial refrigeration. Ammonia/CO_2 cascade refrigeration systems are 15% more efficient than traditional HCFC-22 systems.

Results: The success of the project is due to technology acquisition, system integration, limit filling technologies, CO_2 heat transfer, oil return, safety research and enterprise commitment. Yantai Moon is the first enterprise in China to carry out CO_2 subcritical research and application. In May 2011, the company started this demonstration project with UNDP technical assistance. During implementation, three demonstration subprojects were completed and positive results achieved in environmental protection, safety, and energy conservation. The project was successfully completed in July 2013. By end-2016, MLF incremental operating costs were applied at over 100 converted cold storage units, and 180 CO_2 refrigeration systems were built, all of which are in full operation. Users include livestock meat processing industry, aquatic processing industry freezing and refrigeration, the beer industry, and the artificial environment.

The CO_2 system is environmentally friendly and saves energy. The charge amount of ammonia is effectively reduced to less than 20% compared to the conventional system, and the efficiency can be increased more than 10%. Users also benefit by saving on operating costs. The industrial temperature range of refrigeration is "-500 C~50 C. This demonstration project eliminated the use of 250 tonnes of HCFC-22 and reduced greenhouse gas (GHG) emissions equivalent to 425,000 tonnes of CO_2. It is estimated that future sales of such systems will increase by over 150 units/

year, eliminating 375 tonnes of HCFC-22 per year and reducing GHG emissions equivalent to 637,500 tons of CO_2. UNDP's partner institution was the Foreign Economic Cooperation Office (FECO), Ministry of Environment Protection, China.

China, demonstration of Ammonia-based Semi-Hermetic Frequency Convertible Screw for Refrigeration Systems;

Fujian Snowman is a company specialized in the manufacturing of integrated packaged refrigeration systems incorporating twin-screw refrigeration compressors, of open (ammonia) and semi-hermetic (HCFC-22) designs.

Results: The ammonia charge for open twin-screw compressor integrated package refrigeration system is greater than 100kg, and use of such a high ammonia charge is forbidden in densely populated areas. In this regard, the demonstration project tested a smaller system with a lower ammonia charge (under 50 kg.) with CO_2 as a secondary refrigerant. The product was redesigned and constructed to fit the small discharge semi-hermetic frequency convertible screw refrigeration compression unit. The key elements in operationalization and commercialization would be the innovations needed to make the systems efficient and reliable by integrating system components and manufacturing in a factory-controlled environment. Following construction of the test device, the next step would be the design, production, marketing and debugging of the new product. Training of personnel will be critical. As this is the first demonstration for this particular application, provision has been made for construction drawing design, detailed compilation of construction materials used, instructions for installation and construction, and instructions on debugging operation.

Lessons Learned: In order to expand the application of ammonia in SME industrial and commercial refrigeration systems, a semi-hermetic style ammonia compressor will be used. Following standards, building codes and safety requirements, CO2 will be used as the secondary refrigerant. This demonstration project will cover low-temperature applications and key project components would comprise: new compressor design, new heat exchanger design, construction of the compression unit, manufacturing of prototypes, and construction of the test device.

A work plan has also been provided for the market promotion needed for this new technology to enter the market. This project would eliminate 359 tonnes of HCFC-22, would result in GHG emissions reduction of 1.04 million tonnes of CO2 eq. and the partner institution is FECO/MEP, China.

Combining various sources of funding to deploy low-GWP and energy efficient technologies…

The Multilateral Fund for the Implementation of the Montreal Protocol (MLF) offer financial and technical assistance to support Article 5 Parties achieving the phase-out goals. In a number of

cases, national funding bodies can support work related to ODS phase-out under the MLF by financing parallel programmes for replacement of RAC equipment. There is potential for bilateral funding to support A-5 Parties in specific and target activities linked to the HFCs management and, in a broader scope, a complex setting of global and regional funding mechanism that could support energy-efficiency related interventions while implementing the Montreal Protocol. In this regard, UNDP is experienced in combining different sources of funding to maximize energy efficiency gains in the RAC sector, being in position to support A-5 Parties that may wish to work with funding organisms such as the Global Environment Facility (GEF); the Global Climate Fund (GCF); Climate and Clean Air Coalition on Short-lived Air Pollutants (CCAC) and many bilateral and national donors and financing institution.

GEF/MLF supporting appliance energy efficiency in GHANA

Between 2011 and 2014, Ghana undertook a programme with UNDP support to promote appliance energy efficiency, under the leadership of the Energy Commission, in close coordination with the NOU. It quickly became a flagship programme due to strong support and coordination between stakeholders. Independent evaluation reports indicate that it delivered demonstrable sustainable market transformation for energy-efficient refrigerators and freezers.

Funding came from the GEF, MLF, and the Government. The MLF approved a demonstration project to replace CFC-based refrigerators and freezers, which was used as co-financing for the larger GEF programme. The accelerated phase-out of inefficient refrigerators was the result of the turn-in and rebate scheme, which provided incentives to consumers to return their refrigerators and obtain a discount on purchasing a new efficient model. The programme was fully financed by Ghana. The scheme partnered with retailers (who sold appliances and collected old ones still in working condition), banks (which processed the rebate vouchers and provided consumer loans) and the private sector to dismantle the old refrigerators.

Result: As of 2016, 7,257 refrigerators were replaced under the rebate scheme, with a further 25,000 illegally imported used appliances collected for safe disposal, bringing the total to around 32,000. The Energy Commission and EPA handled the recovery of ODS through an office at the dismantling facility. The scheme was launched in coordination with the ban on imports of second-hand refrigerators. A testing laboratory was set up for the monitoring and enforcement of Standards and Labelling for refrigerators and freezers. It is located at the Ghana Standards Authority. When appliances arrive in the country improperly labelled, they are tested. More than 20 retailers and importers have tested their appliances in the laboratory. Through this, Ghana managed to replace its old stock of energy-inefficient CFC-using refrigerators – thus jointly benefiting climate and the ozone layer while saving energy.

Lessons Learned: coordinated action with secured source of funding and a well-designed rebate scheme assured the buy-in of private sector stakeholders. Population has accepted well the proposed intervention which assure a great quantity of refrigerators to be replaced. However, lack

of proper recovery and disposal system did not assure that all used refrigerators were dismantled and it is estimated that around 15% of used ones were re-vamped and re-sold and are still in use.

GEF/MLF Energy Efficiency through the Development of Low-carbon RAC Technologies in TRINIDAD AND TOBAGO:

Located in the Eastern Caribbean region, Trinidad and Tobago consists of two islands with an extension of 5,128 square kilometers of land. Most political and economic activity takes place thanks to a growing economy mostly influenced by the petroleum industry where oil and gas account for about 40% of GDP and 80% of exports, This country accounts for only 0.1% of GHG emissions in the global context, but has a relatively high per-capita emission, on the order of 23.87 t/CO_2, the highest in the Caribbean region, and through its the intended Nationally Determined Contribution (iNDC) the country aim is to achieve a reduction objective in overall emissions from these three sectors of 15% by 2030 from BAU (103,000,000 tons of CO_{2eq}). Due to the country's energy-intensive industries, per capita consumption of electricity is among the highest in the Caribbean at over 6,500 kWhm strongly influenced also by the demands of Refrigeration and Air Conditioning sectors which, under the Montreal Protocol, will face the elimination of HCFCs but that, most likely, will be switched away by high-GWP of HFC refrigerants given the low penetration of natural refrigerants and other low-carbon technologies.

In order to address these challenges, and building from the HCFC management interventions funded by the MLF, the Government of Trinidad and Tobago and UNDP has prepared a GEF Proposal that secured USD 5 million of co-finance, which will be instrumental to the country to Enhance national policy, regulatory and institutional frameworks for sustainable end-use of RAC technologies and to Accelerate RAC market transformation towards less energy intensive and low-carbon technologies towards energy efficient technologies, such as implementation of a District Cooling installation and the promotion of early retirement of old and inefficient RAC equipment.

Results: The project is now under its preparation phase and implementation is expected to begin by early 2019. When completed, the project is expected to have had effectively support Trinidad and Tobago to mitigate 1.5 million tons CO_{2eq} over a 20 years period.

Lessons Learned: although the project is in its preparation phase, it is being build based on lessons learned by the Government of Trinidad and Tobago about the experiences in the implementation of the Montreal Protocol and its linkages with energy efficiency, such as: Need to strengthen policy making coherence and linkages for MP and EE; Absence of public policies that can enhance and promote the introduction of low-carbon RAC technologies. Limited institutional capacity at the national level to mainstream energy efficiency measures into current actions in the RAC sector. Absence of awareness raising and technical capacities. Current use of multi-split and split systems in major buildings is a barrier for the development of EE AC systems. Lack of Public investments of low-carbon technologies in key infrastructure and large public services. And Financial institutions still consider investments in EE projects as high risk ventures.

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CCAC/MLF supporting supercritical CO_2 in the supermarkets sector of CHILE:

Chile is a partner of the Climate and Clean Air Coalition (CCAC), an initiative launched in 2012 by a group of countries, to promote collective action to reduce Short Life Climate Pollutants (SLCPs) such as black carbon, methane and HFCs and the country has received USD $482,790 grant from CCAC to conduct the demonstration project "Strengthening technical capacity for the adoption of super-critical CO_2 refrigeration system as alternatives to HFCs in the supermarket sector in Chile".

An initial assessment of national needs to adopt super-critical CO_2 in refrigeration systems was conducted, followed by training on the application of super-critical CO_2 technology in the supermarket sector. A study tour to Italy was organized to support the transfer of experiences, and the participation on technical congress in Brazilian International HVAC-R Exhibition and Congress on 2015 (Febrava/Conbrava) was organized to increase knowledge of Chilean stakeholders on this application. Furthermore, UNDP facilitated the technology transfer between foreign technology providers and local Chilean end-users in order to remove barriers to technology development.

Results: the project was able to establish an agreement with the local supermarket chain and secured co-finance that has led to the installation of the first super-critical CO_2 system in a supermarket in Chile. The project was also able to scale up its results by transferring experiences that secured the installation of the second super-critical CO_2 supermarket in Chile, funded partly by the MLF (through the HCFCs Phase-out Management Plan) and the supermarket owner.

Lessons Learned: The project was implemented by the National Ozone Unit (NOU), housed by the Ministry of Environment (MMA), with technical assistance provided by UNDP, to overcome the main barrier Chile had encountered: the very limited experience on the use of CO_2 as refrigerant fluid in RAC applications, and virtually no experience in handling super-critical CO_2 technology required special attention and exchange of experience actions to assure the success of the transfer of technology. Chile is also very dependent on HFC-based refrigerants used in the supermarket sector which has four major chains (representing 90% of the sector), requiring thorough follow up from the NOU and proper coordinated actions with the HPMP to assure that the technology could successfully replace the HCFC-22 and overlap the HFCs.

GEF Testing Low-GWP Natural Refrigerants to increase energy efficiency in BELARUS:

The private enterprise "Santa Bremor" is one of the largest producers of high-quality food products in Eastern Europe. For 20 years, it has been a leading domestic producer and a very recognized brand of fish products in Belarus and other countries. The company has about 5,000 staff and it promotes environmentally-safe production, taking measures to reduce its environmental impact. Processing of fish products requires significant use of electricity, hot water, steam and refrigeration. Climate control in production departments had utilized HCFC-22 as refrigerant.

The Ministry of Natural Resources and Environmental Protection supported the replacement of HCFC-22 through use of an absorption refrigerating machine (ARM). GEF provided $155,000 to the company through UNDP to introduce the new technology, eliminating the HCFC-22 use, and helping Belarus meet its obligations under the Montreal Protocol. The environmental benefit of the cooling technology is ensured by the use of natural refrigerant (water) in the ARM. Today, the Santa Bremor energy complex based on ARM is a demonstration platform for the popularization of such technologies in Belarus.

Results and Replicability: In the summer, there is a large excess of heat and the demand for cooling is around 1.2 MW. The ARM transforms the waste heat into cold air. The produced cold water is used in the A/C system of two facilities to produce red fish delicacy and ice cream with a total area of 9,200 sq. mt. Absorption cooling technologies save up to 1,148,000 kWh of electric energy/year in comparison with convention compressor-based refrigeration units. This is sufficient to provide electricity to 640 private homes throughout the year. On 15 April 2016, Santa Bremor Company (in Brest) held a grand opening of the upgraded energy complex based on the ARM. Thanks to the new technology, over two seasons (2016-2017), the ARM reduced GHG emissions by 707 tonnes of CO_2 equivalent and reduced electricity consumption by 1,750,000 kWh.

Canada/MLF supporting the replacement to Energy Efficient CFC-free Chillers in CUBA

In 2005, as part of the initiative of the Montreal Protocol to tackle the chillers sector in developing countries, UNDP and Canada jointly supported the development of the demonstration project for integrated management of the centrifugal chiller sub-sector in Cuba, focusing on application of energy-efficient CFC-free technologies for replacement of CFC-based chillers. The project replaced old, CFC-based, high energy consuming chillers in key institutions in Cuba with energy efficient, state-of-the-art CFC-free chillers from the Canadian company Smardt.

Results: The project included training of maintenance technicians of the beneficiary institutions on the new equipment operation. Canadian and MLF funds were used for the acquisition of equipment and Smardt provided all the training as its in-kind contribution, conducting 7 training workshops which trained 65 technicians. UNDP's national counterparts were the Ozone Office in the Ministry of Science, Technology & Environment, and the Ministry of Health Although, it was originally planned to replace some equipment and retrofit other units, after the initial evaluation it was determined that all chillers had to be replaced due to their old age and inefficiency to achieve the energy efficiency goals of the project. 9 CFC-based chillers were replaced in 7 public institutions with state-of-the-art magnetic compressors´ chillers.

Lessons Learned: Training of staff was a key component to ensure maximum benefits (efficiency, energy savings) of the new equipment as different operational and maintenance approaches were required. Maintenance staff in each institution and technical staff of the Ozone Unit were trained. Most of the chillers were installed during 2008-2010; however, the project was officially completed in 2013. The benefits of the project reach beyond the protection of the ozone layer.

Thanks to the project, patients and medical personnel of the beneficiary hospitals now have constant and reliable air conditioning, especially in key areas such as surgery rooms, nursery rooms and intensive care units while saving valuable resources in maintenance and energy bills.

GEF supporting the deployment of efficient A/C in TAJIKISTAN:

During 2015-2016 under the UNDP-GEF project, through close collaboration with Tajik mobile operators (Babilon-Mobile, Megafon and Tcell), demonstration projects were implemented in the A/C sector that aimed at reducing the equipment failure and their repair rates at relay stations and towers of cellular phone network providers.

Results: Moreover, the new equipment would significantly reduce HCFC imports for existing A/C equipment in the country. A total of 33 demonstration projects were successfully implemented throughout the country, increasing energy efficiency and reducing ODS emissions. On average, the energy efficient equipment deployed under the UNDP/GEF funded project is now 64% in southern provinces and 70-90% in the northern/eastern provinces.

Post-implementation monitoring was carried out together with the servicing companies as well as UNDP engineers and revealed that 1 station equipped with the equipment might save up to 9,000 kW/h of electricity and reduce CO_2 emissions by over 10,000 kg in a year. There are around 5,000 stations in the country and large-scale deployment of this equipment would result in energy savings up to 44,67 million kW/h. In terms of CO2 equivalent reductions, it would be approximately 50,000 tonnes per year. Return rate (payback) of the investment is calculated between 2.5 and 3 years. Additionally, servicing costs decreased 55-65% and the A/C equipment lifespan increased by over 40%, while HCFC leakage was significantly reduced (up to 60%).

Lessons Learned: follow up is essential to assure the EE results are maintained in the long term. The buy-in from and co-funding provided by the private sector was key to assure implementation and replicability of the project.

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