PROJECT COVER SHEET

TYPE OF PROJECT	Demonstration project
TITLE OF THE PROJECT	**Replacement of a HCFC-22 refrigeration system by a R-717/R-744 (NH3/CO2) system in cold storage warehouse finished product of Premezclas Industriales para Panadería S.A.**
COUNTRY NAME	**Costa Rica**
IMPLEMENTING AGENCY	UNDP
GOV. COUNTERPART	Ozone Unit of Costa Rica. Government of Costa Rica.

DATES OF RATIFICATION OF AMENDMENTS TO THE PROTOCOL			
London	June 1998	**Copenhagen**	June 1998
Montreal	May 2005	**Beijing**	October 2008

GENERAL INFORMATION		
Sector / Sub-sector	Refrigeration and Air Conditioning / Food manufacture industry	
ODS Consumption (sector)	8.92 Ton ODP	
Baseline	14.1 Ton ODP	
Starting Point for Aggregate Reductions		
Project Impact (ODP t.)		
Participating Company (ies)	**Premezclas Industriales para Panadería S.A.**	
Eligibility of participating company (ies)	100 % (A5)	% (non-A5)
Project Costs (US $)	943,000	
MLF Funding (US $)	524,000	
I.A. Supporting Costs (US $)	36,680	
Total cost of the Project for the MLF (US $)	560,680	
Project Duration (months)	14	

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Executive Summary

During the 76th meeting of the Multilateral Fund´s Executive Committee for the Implementation of the Montreal Protocol, Costa Rica´s implementation proposal was approved, it consisted in a pilot project called "Replacement of a HCFC-22 refrigeration system by a R-717/R-744 (NH3/CO2) system in cold storage warehouse finished product of Premezclas Industriales para Panadería S.A."; this refrigeration system is characterized by using two circuits, one of NH3 (ammonia) and another of CO2 (carbon dioxide), being NH3 in the high temperature system and CO2 in the low temperature circuit driven by pumps, where CO2 is used as a heat transfer fluid (*Brine*). This characteristic makes this project not only innovative but also being the first and only one in the Central American region that has been adopted in the food manufacturing industry.

The project replaced an original refrigeration system that used HCFC-22 as a refrigerant with a cooling capacity of 176 kW (50 TR), responsible for maintaining an average temperature of -11° Celcius in the finished product chamber.

The new NH3/CO2 cascade system began its implementation on June 2017 and it was launched on January 2018.

The works were contracted to a Costa Rican company called *CUESA Construcciones HU Sociedad Anónima* under a "turnkey" contract with a total cost of US$943,000, who acquired Mycom brand equipment, through another Costa Rican based company named *Mayekawa de Centroamérica SA*. The direct contribution of the Multilateral Fund for the Montreal Protocol to execute this project was US$444,000, and the rest was funded by a company´s counterpart.

The project´s implementation achieves the displacement of 909 kg of HCFC-22 that were installed in an equipment that exceeded its useful life, for more than 15 years, and reduced the emission of HCFC-22 used in the system´s maintenance activities due to the leaks of this refrigerant, whose average consumption during fiscal years of 2015-2016 and 2016-2017 was 1314 kg. Therefore, considering the ODP and GWP of HCFC-22 there is a benefit in the protecting the ozone layer and climate.

The new technology that was adopted allows PINOVA to reach temperatures of -18° Celcius in the finished product chamber, a result never achieved before with the original system and from the energy consumption point of view, the NH3/CO2 system is more efficient than the original installation. During the first two months of 2018 (January and February) PINOVA company reports a 10% reduction in the billed energy with regards to the normal manufacturing levels during 2017. It is expected that when the system stabilizes and there is better administration culture of opening of freezer´s doors of the finished product chamber, the energy saving can reach up to 20%, according to the estimate that was made.

It is demonstrated that the use of NH3/CO2 cascade system, with recirculated CO2 brine, is an innovative solution for medium manufacturing companies in Costa Rica, which can be adopted by other national and/or regional companies that require finding a definitive solution due to the imminent displacement of refrigerants that deplete the ozone and produce atmospheric warming.

The new system provides PINOVA lower production costs due to the reduction of the operational costs by lowering the electricity consumption, fewer maintenance interventions, the non-acquisition of HCFC-22 to replace the refrigerant gas that escapes into the environment and the use of natural gases that cost less with respect to chemical refrigerants.

The alternative selected by PINOVA allows it to contribute to the business commitment of Carbon Neutral and to Costa Rica´s Carbon-Neutrality target by 2021.

1. Introduction

1.1 Background.

Premezclas Industriales para Panadería S.A. (PINOVA) requires the use of low temperature refrigeration systems for its manufacturing process and then the temporary storage for the different bakery and confectionary bases that are manufactured.

During the manufacturing process, rapid freezing tunnels are required with temperatures of -35°C, the refrigeration systems operate with ammonia as the main refrigerant in direct expansion.

In order to storage the finished products, a freezing chamber of 9000 cubic meters and a system of three pre-chambers are required for the entry and exit of the finished product. The maximum storage capacity in the chamber is of 250 tons of finished product, which has been limited by the operating capacity of the refrigeration system that worked until December 2107, with an average temperature of -11°C that was directly related to the age of the equipment, that exceeded fifteen years and is based on the use of HCFC-22 with a 909 kg cargo.

During the fiscal year of 2015-2016, the consumption of HCFC-22 refrigerant reached 1,655.71 kg and during the fiscal year of 2016-2017 it reached 971.75 kg of HCFC-22, generating the equivalent of 4730 tons of CO2, compromising the company´s public carbon neutrality agreement.

In 2013 comes the opportunity to present to the Executive Committee of the Montreal Protocol proposals to develop pilot projects with the characteristic that these will be energy and environmentally efficient. Therefore, the reconversion project of a HCFC-22 system to a NH3/CO2 cascade system with recirculated CO2 brine for the finished product freezing chamber of the company Premezclas Industriales para Panadería S.A (PINOVA), is submitted and approved at the 76th meeting of the Executive Committee of the Montreal Protocol.

1.2 HPMP and HCFC-22 consumption

Costa Rica does not produce HCFCs, therefore, all HCFCs that exist in the country is imported. HCFC-22 is the main HCFC imported into the country, used mainly for the service and maintenance of refrigeration and air conditioning equipment (RAC).

Consistent with this situation, a phased approach is adopted for the HCFC phase-out management plan, based on the average consumption for the years 2009 and 2010, respectively.

Since 2010, Costa Rica applies a licensing system for the importation of HCFCs and HFCs covered by regulation 35676 S-H-MAG-MINAET. This system is implemented by the National Ozone Unit, the Office for Environmental Quality Management of the Ministry of Environment and Energy (MINAE), in coordination with other government institutions, universities, business chambers and private companies.

In 2014, Costa Rica eliminated 83% of HCFC-141b import, through the implementation of a project to reconvert the foaming lines in the manufacture of domestic refrigerators. Currently, small amounts of pure HCFC-141b are imported to be used in refrigeration and air-conditioning system (RAC) service, as well as some smaller quantities of pre-blended polyol used by small foam manufacturing companies.

Table #1
HCFC Consumption in Costa Rica.

HCFC ODP tons	2009	2010	2011	2012	2013	2014	2015	2016
HCFC-22	10.60	9.45	18.62	16.98	9.80	9.80	8.56	8.55
HCFC-141b *	3.11	4.06	3.13	5.35	2.58	2.55	2.19	2.23
HCFC-142b	0.34	0.46	0.00	0.61	0.16	0.16	0.14	0.10
HCFC-124	0.13	0.04	0.00	0.05	0.02	0.02	0.01	0.01
HCFC-123	0.01	0.00	0.00	0.01	0.06	0.06	0.05	0.00
HCFC-225ca	0.00	0.00	0.00	0.00	0.00	0.02	0.05	0.00
HCFC-225cd	0.00	0.00	0.00	0.00	0.00	0.03	0.07	0.00
Subtotal	**14.20**	**14.01**	**21.75**	**22.99**	**12.60**	**12.64**	**11.08**	**10.89**

(*) Only use as cleaning agent.

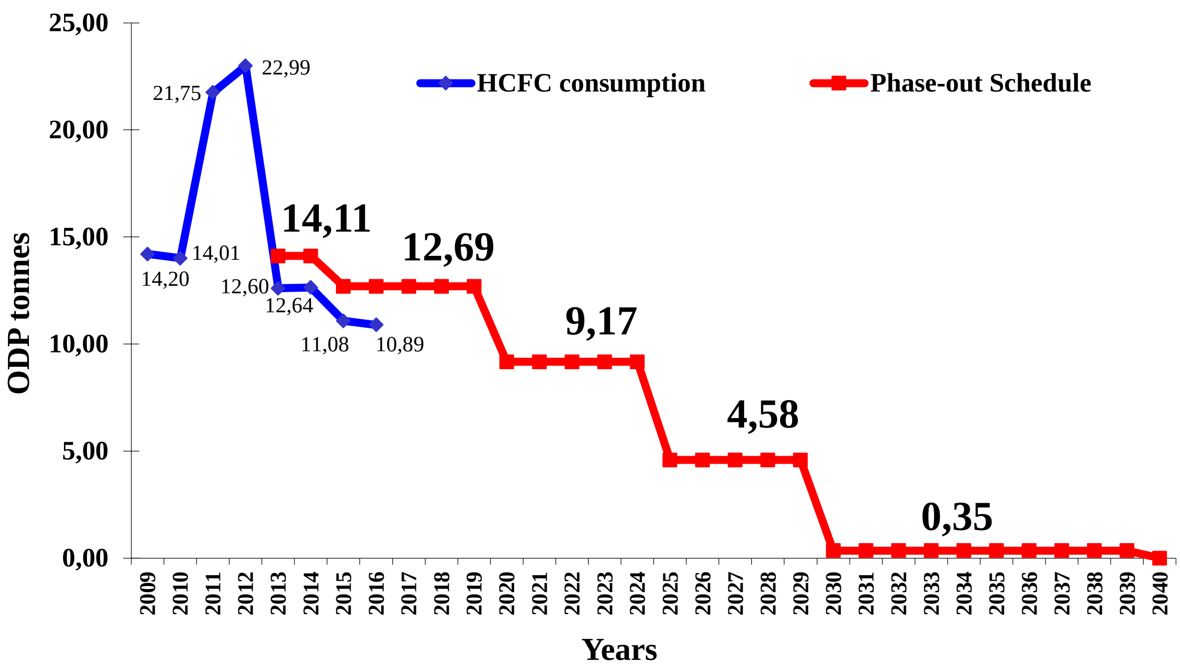
(Source: HPMP CR 2016 Progress Report)

Table # 1 shows the volume of HCFC imports in ODP (Ozone Depletion Potential) for the years 2009 to 2016 compared to the baseline (2009-2010), during 2011 and 2012, imports had an expected increased, because HCFC importers knew about the implementation of the import quota system in 2013. With the implementation of import quotas for HCFC, the consumption of these substances was reduced in 2013 to the maximum levels allowed. The total import of

HCFCs in Costa Rica should not exceed 14.1 ODP tones (baseline value), as established in national legislation.

Chart No. 1

HCFC consumption vs Phase-out Commitment



(Source: HPMP CR 2016 Progress Report)

Chart #1 shows the behavior of HCFC imports with respect to the phase-out commitment assumed by Costa Rica, which shows that the level of consumption is below the authorized quantities.

2 Importance of the pilot project

Regarding the importance of the implemented project, the following points can be highlighted:

- Allows the food manufacturing sector to have a definitive technological option available in light of the HCFC refrigerant elimination process and the HFC refrigerant control process recently approved in the Kigali Amendment of the Montreal Protocol.

- Start up a technologically advanced refrigeration system, with less environmental impact and greater energy efficiency.
- Reduce imports of HCFC refrigerants, which impact stratospheric ozone and increase global warming.
- Shows the users of refrigeration systems, both national and Central American, based on the success of the implemented project, that it is possible to adopt a technology based on natural refrigerants that covers the refrigeration needs that currently use HCFC -22.
- Generate confidence within the decision-making levels, related to the adoption of definitive natural technologies in RAC systems, in the commercial and industrial sector of Costa Rica.
- Provide the country with the opportunity to receive technology transfer in the installation, operation and start-up of RAC systems by experts, where this technology has already been implemented.
- Eliminate 900 kg of HCFC-22 installed in one single industrial equipment, which will be destroyed through the program of destruction of refrigerant gases in cement kilns in Costa Rica.
- Create national technical capacity for the use, installation and design of the NH_3/CO_2 cascade technology with recirculated CO_2 brine.
- Innovate technologies used for refrigeration in the food manufacturing sector.
- Develop and implement a pioneering refrigeration NH_3/CO_2 cascade system with recirculated CO_2 brine, in the food manufacturing sector in the Central America and the Caribbean region.
- Break paradigms regarding the installation of refrigeration systems using B3 (NH_3) classified natural refrigerants with high working pressures (CO_2).
- Promote sustainable technologies from a technical, environmental and energy efficient point of view.

3. Project Description

3.1 Characteristics of the original installation with HCFC-22

The original equipment that used HCFC-22 and that the base for this demonstrative project, was the result of a first conversion carried out by the company in the early 2000s, which at that time used CFC-502.

The original refrigeration system, that PINOVA operated for more than 15 years to cool the finished product chamber, was composed of a single-stage direct expansion system, with a refrigerant charge of 909 kg of HCFC-22.

3.1.1 *Characteristics of the equipment installed in the original system.*

The general characteristics of the equipment that constituted the original installation are shown in the following table.

Table #2

General characteristics of the original equipment that used HCFC-22 refrigeration system and power of its electric engines.

Equipment	Quantity	Number of Engines	Type	Unit Power		Total Power
				HP	kW	kW
Compressor #1	1	1	Screw	60	44.76	44.76
Compressor #2	1	1	Screw	60	44.76	44.76
Compressor #3	1	1	Screw	50	37.30	37.30
Compressor #4	1	1	Reciprocating	6	4.48	4.48
Compressor #5	1	1	Reciprocating	6	4.48	4.48
Compressor #6	1	1	Reciprocating	7	5.22	5.22
Evaporator #1	11	13	Axial fan	5	3.73	48.49
Evaporator #2	3	6	Axial fan	1.5	1.12	6.71
Condenser#1	1	2	Axial fan	3	2.24	4.48
Condenser #2	1	2	Axial fan	3	2.24	4.48
Condenser #3	1	8	Axial fan	3	2.24	17.90
						223.05

Source: own creation

The total drive power that was installed in the compressors of the original HCFC-22 system was 223 kW (299 HP), with a cooling capacity of 176 kW (50 TR), this would require a manufacturing process that demanded the operation of the system to be of 24/7[1]. Annex #1 shows photographs of the original installation.

[1] 24 hours a day 7 days a week

3.1.1 System operating parameters.

- Chamber temperature.

  The original system reached an average temperature of -11°C inside the finished product chamber, not allowing lower temperatures in this chamber, which limited the possibility of taking advantage of all the available space for storage.

- Energy consumption

  The energy consumption of the original installation was related to old equipment that was installed, shown in table #2. Due to the conditions of the manufacturing process, the operation of the refrigeration system was 24/7. According to company estimates, 18% of the monthly electricity consumption corresponded to the energy consumption of the HCFC-22 system.

Table #3
Estimate energy consumption of the original cooling system of the finished product chamber.

Energy consumed (kWh)		
Day	Month	Year
5,353.30	160,598.88	1,927,186.56

Source: own creation

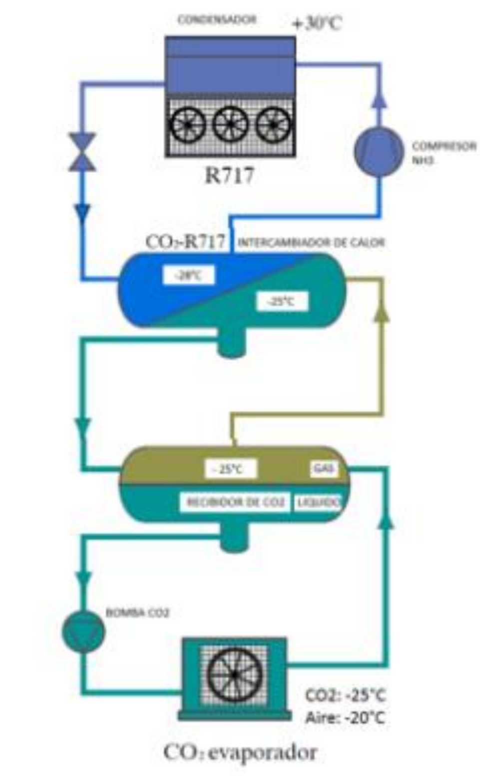
Appendix #1 shows the calculation details made to determine the energy consumption, where the variable is the daily operating time of each equipment. According to the information provided by PINOVA's maintenance and production departments, the limited capacity of the original system versus the demand for finished product, makes this system operate continuously at its nominal capacity (24/7/30/12), data that was used the estimate of the energy consumption in Appendix # 1.

3.2 Characteristics of the new NH3/CO2 cascade installation with recirculated CO2 brine.

The new system that was installed is characterized by having a recirculated CO2 secondary circuit, known as brine system, which operates under a principle similar to "iced water" installation used in central air conditioning systems with chillers. In the installed system, the CO2 refrigerant condensed at low temperature is circulated by a centrifugal pump system. The following diagram shows in a simplified manner the new installation made in PINOVA.

Diagram # 1

NH3/CO2 cascade system with recirculated CO2 *brine*



Source: Mayekawa

Until this date, the existence of another similar facility in Central America is not known. However, if there are 2 "brine" NH3/CO2 installations in South America, specifically in Argentina and Ecuador. Being this last one, the installation that served as inspiration to duplicate this technology in Costa Rica.

3.2.1 Characteristics of the installed equipments.

The new installation has high end technology equipment and systems, the electric engines integrated into the different equipment of the NH3/CO2 "brine" system are Premium efficiency, with electronic low voltage starting systems, solid state type.

The tanks and containers were built in carbon steel, inspected and stamped under ASME standards Section VIII, Div. 1. Year 2005. All the equipments were imported, built under the specifications of PINOVA through the Mayekawa company and its network of suppliers.

The following table shows the general characteristics of the new facilities equipment.

Table #4

General characteristics of the new refrigeration equipment with NH3/CO2 brine cascade system and electric motors power

Equipment	Quantity	Number of engines	Type	Unit Capacity		Total Power
				HP	kW	kW
Compressor #1	1	1	Screw	100	74.60	74.60
Compressor #2	1	1	Screw	100	74.60	74.60
Oil pump Co. #1	1	1	Positive displacer	1.5	1.12	1.12
Oil pump C0. #2	1	1	Positive displacer	1.5	1.12	1.12
Compressor #3	1	1	Reciprocating	30	22.38	22.38
Evaporative condenser	1	1	Axial fan	0	11.00	11.00
Evaporative condenser pump	1	1	Centrifuge	0	1.50	1.50
Evaporator PH #1	1	3	Axial fan	3	2.24	6.71
Evaporator PH #2	1	3	Axial fan	3	2.24	6.71
Evaporator PH #3	1	3	Axial fan	3	2.24	6.71
CO2 pump #1	1	1	Centrifuge	0	2.20	2.20
CO2 pump #2	1	1	Centrifuge	0	2.20	2.20
Antechamber evaporator #1	1	2	Axial fan	0.75	0.56	1.12
Antechamber evaporator #2	1	2	Axial fan	0.5	0.37	0.75
Antechamber evaporator #3	1	2	Axial fan	0.5	0.37	0.75
						213.47

Source: own creation

The total cooling capacity is 359.4 kW (102.2 TR), and total installed electrical power is 213 kW (280 HP), the operation of the system is still 24/7 and all engines are highly efficient.

A detailed characteristic of the equipment that constitutes the new facility are shown in Appendix # 2.

3.2.2 Technical and system operating parameters.

- Chamber temperature.

  The operating conditions of the new brine NH_3/CO_2 refrigeration system are defined by:

  - Temperature of the finished product chamber of -18°C.
  - Antechamber temperature from 0°C to 5°C.
  - Evaporation temperature on the ammonia side (NH_3) of -30°C.
  - Condensation temperature 35°C.
  - Wet bulb temperature of 26°C.
  - Thermal load of finished product chamber 274.2 kW (78 TR).
  - Thermal load of the loading platform 30.9 kW (8.8 TR)
  - Thermal load of the band area 27.8 kW (7.9 TR)
  - Thermal load of the filling chamber 22.9 kW (6.5 TR)

  Table # 5 shows the monitoring of three points of the finished product chamber, points specially defined by PINOVA´s technical staff which were define as hot spots by the effect of convection currents. The monitoring was performed for a period of 6 days, 17 hours, 20 minutes. It shows that the average temperature remains above -18°C, which was the design temperature of the new cooling system.

Table #5

Temperature monitoring of finished product chamber with NH_3/CO_2 system

Temperature	Zone 1	Zone 2	Zone 3
Minimum (°C)	-13.10	-13.90	-12.10
Maximum (°C)	-21.80	-21.50	-20.10
Average (°C)	-19.65	-20.11	-19.65

Source: Cuesa Construcciones HU Sociedad Anónima.

- Estimated energy consumption.

Just like in the original cooling system, the new NH3/CO2 system also works 24/7. Table # 6 shows the average energy consumption of the new system.

Table #6

Estimated energy consumption of the NH3 / CO2 cascade "brine" cooling system of the finished product chamber.

Energy Consumption (kWh)		
Day	Month	Year
4,258.11	127,743.30	1,532,919.60

Source: own creation

As it can be seen, between the data that is shown in tables #3 and #6, there is a reduction in energy consumption, estimated in regards with the original system, of 20%.

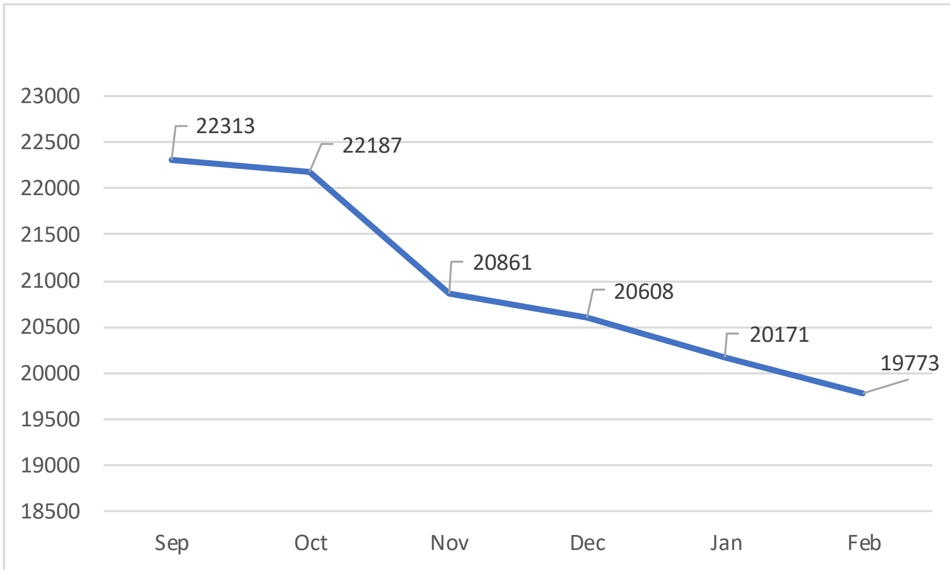
Appendix #2 shows the calculations made to estimate the energy consumption, where the variable is the daily operation time of each equipment. According to PINOVA´s maintenance and production department records, the new system works 24/7, however, of the three compressors installed, only one worked at nominal capacity during this period.

The new refrigeration system began its trial and tuning period during January 2018. Since that moment, the original system went out of operation, therefore, according to the electricity bill there was a saving of energy consumption recorded during the months of January and February of 2018.

Graphic #2 shows the behavior for the first two months of 2018, with respect to the 4th quarter of 2017. During November and December there is a reduction in the amount billed on electricity, this corresponds to non-working days according to PINOVA´s production schedule, also during December there were some non-working days because of the social activities carried out by the staff.

Graphic # 2

Average energy invoiced per day during the first months of fiscal year 2018



Source: PINOVA´s maintenance department

Considering the average billed between September-October and January-February, a decrease of 10.23% in energy consumption was obtained. This value can grow once the system is stabilized, and the company generates a better management culture of opening the chamber doors to reduce infiltration, which should reach about 20%, according to estimates made.

4. Project´s installation process and start-up

The project´s installation and start-up process was carried out under a series of duly planned activities, with the goal of minimizing risks that could generate delays, compromising the installation and start-up of the new equipment.

4.1 Structural evaluation

Before starting with the assembly process of the acquired equipment, the structural assessment of the sites where the new equipment would be installed was carried out by specialists in structural engineering.

4.2 Bidding process

A bidding process was carried out where the technical and administrative conditions of the execution of the project were defined.

4.3 Offer Reviews.

UNDP national and international consultants reviewed and validated the offers that were received. From this review, PINOVA selected the most convenient offer.

4.4 Execution of contracts, agreements and purchase orders.

The parties (applicant and supplier) transcribed their agreements into a contract, in which all the conditions were established, they included:

- The project would be executed turnkey.
- The supplier would supply all the equipment, materials, labor and structures necessary for the project´s start-up.
- The project´s total cost and the amount to be paid was established as $943,000 USD.
- The execution period would be 22 weeks.
- Once signed, the execution period of the project was considered official, and the purchase orders were issued in order to contract the necessary services and equipment.

A MINAE-PINOVA agreement was also executed, this agreement defined how the project´s disbursements will be made with the co-financing received by the Multilateral Fund of the Montreal Protocol, which was $ 444,000 USD for the acquisition of equipment. The funds were administered by UNDP Costa Rica, and the disbursements were executed according to the project´s progress.

4.5 Work Plan.

The supplier developed a work plan, this was reviewed and approved by the technical committee that was established to follow up the project and assess the compliance of the proposed activities.

4.6 Follow up meetings.

During the project´s execution period a weekly meeting was held to show the implementation progress and coordinated the weekly activities that interfered with the operation of the manufacturing plant, transportation and internal movements of equipment

4.7 Equipment Assembly.

The equipment was acquired from the company Mayekawa of Central America S.A., through the project´s contractor, CUESA Construcciones HU Sociedad Anónima. The import and nationalization of the equipment was in charge of Mayekawa de Centroamérica S.A. The assembly, electromechanical installation and testing of mechanical systems was in charge of the contractor CUESA Construcciones HU S.A.

Annex #1 shows the chronological photographic record of the project´s development from the beginning of the works until the start-up of the new system.

4.8 Testing process.

Before the start-up, the system was subjected to different tests, among them:

- Testing of welded connections of pipes and parts, using non-destructive tests such as penetrating liquids and ultrasound. (See Annex #3)
- Sweep pipes with nitrogen to remove solid waste.
- Leak test of the refrigeration circuit, by positive gauge and vacuum pressure, under the recommendations of the specialists, the project´s national and international consultant from UNDP.

4.9 Refrigerant charge in the equipment.

The refrigerant charge was executed with the participation of specialized companies that supply of industrial gases and natural refrigerants, with the assistance of CUESA and Mayekawa of Central America´s technical personnel, under protocols established for this purpose.

5. Benefits expected with the project.

5.1 Environmental.

From an environmental point of view, the project provides the following benefits.

- Lower emissions of ozone-depleting gases and greenhouse gases. Both, the direct emissions from the consumption of R22 in the maintenance processes of the previous system, and the indirect emissions due to the consumption of energy.
- Opportunity to maintain PINOVA and Costa Rica´s social commitment of "Carbon Neutrality".
- The project is consistent with Costa Rica´s commitment acquired in the Paris agreement.
- Reduction of indirect effect due to lower energy consumption

5.2 Technological and business

- Technology transfer that involves the acquisition of new knowledge for national technical personnel.
- Strengthening of national capacity (contractor and technicians) in the installation of refrigeration systems that work with natural refrigerant gases in Costa Rica (NH_3/CO_2).
- Real opportunity to show the benefits of using natural technologies in refrigeration systems.
- Offer of technical capacity for new future projects in the country or in the Central American region.
- South-South cooperation between PINOVA in Costa Rica and UNILEVER in Guayaquil, Ecuador, before and after the system´s start-up.

- Opportunity to provide technical assistance and carry out a technology transfer to other national and regional industries.
- The technical training stage of PINOVA´s personnel held in March 2018 in Guayaquil, Ecuador; the new installation of PINOVA and specifically the use of Penhouse type evaporators, represent an option that could be adopted by UNILEVER Ecuador, in order to solve maintenance problems in their installation.

5.3 Economic.

- Savings due to the elimination of HCFC-22 consumption in PINOVA´s finished product chamber, which reached on average of 1314 kg during 2015-2016 and 2016-2017 fiscal years.
- Reduction of service operations demanded by the finished product chamber and unscheduled shutdowns of the cooling system.
- Savings in energy consumption and in the cost for cooling PINOVA´s finished product chamber.
- Decrease in the outsourcing of refrigerated warehousing services contracted due to the lack of cooling capacity of the old HCFC-22 system.

5.4 Dissemination for other users in Costa Rica and Latin America

- It is expected to disseminate the project within the national business chambers where food manufacturing industries are located in the following sectors:
  - Baking industry.
  - Dairy industry.
  - Meat and sausage industry.
  - Fishing industry.
  - Frozen products storage services industries.
- At the regional level, the project will be disseminated through the national ozone offices, which are the focal point for programs and projects under the Montreal Protocol.

- It will also be disseminated among other non-governmental organizations that support migration to the use of natural refrigerants that generate less environmental impact and more efficient in energy consumption.

6. Problems faced and lessons learned.

- During the development of the project there were climatic phenomena (hurricanes) that affected the process of importing equipment, these are incidental causes that cannot be considered in the general planning of the project.
- It is necessary to maintain a strict control of the projects in order to generate corrective actions when there are unforeseen events, so that the schedule is not affected.
- It is important that the implementation of projects, such as the one adopted by PINOVA, generate national capacity.
- The option provided to PINOVA´s staff to previously know a similar facility in Guayaquil, Ecuador; was fundamental for the final decision about the technology to be adopted.

7. Conclusions and recommendations

- It is demonstrated that the use of NH_3/CO_2 cascade system, with recirculated CO_2 brine, is an innovative and viable solution to be implemented in medium manufacturing companies in Costa Rica.
- The implementation carried out by PINOVA can be adopted by other national and/or regional companies, that need to find a definitive solution to replace refrigerants that deplete the ozone and produce atmospheric warming.
- The implementation of the new cooling system for the finished product chamber based on the use of NH_3/CO_2 cascade, with recirculated CO_2 brine, provides PINOVA savings in electricity consumption.
- During the first two months of operation with the new system, the electric power billing already reflects a reduction of 10%.
- According to the estimate that was done, the new system can save up to 20% in the electricity billing, as long as there is a culture in managing the door openings of PINOVA´s finished product chamber.

- The technology based on natural refrigerant gases, adopted by PINOVA, eliminates the emission of ozone-depleting substances and will reduce emissions and greenhouse gases.
- The technology adopted and implemented by PINOVA, demonstrates that it is possible to break the barriers to apply natural gases with levels of toxicity, flammability and that work at high pressures.
- The start-up of the new system provides PINOVA with lower production costs due to the reduction in electricity consumption, less maintenance interventions, the non-acquisition of HCFC-22 to replace the refrigerant gas that escape into the environment, the use of natural gas of lower cost in comparison to chemical refrigerants.
- The alternative selected by PINOVA allows it to contribute to the business commitment and the government of Costa Rica´s target of Carbon Neutral and the Carbon-Neutrality target by 2021.
- In the medium term it will be necessary to execute another training to the technical personnel, according to the increased experience in the operation, service and maintenance of the new NH_3/CO_2 equipment. As well as specific service procedures required as the age of operation of the new system advances.
- The technology should be shown to technicians, refrigeration and engineering students as a role model and recommend. Likewise, business decision-makers are key to promote the change in similar industries.
- It is fundamental to perform a regular monitoring of the system´s operation in order to document and show the stakeholders the benefits of the technology related to energy consumption and operational data. Additionally, this information can be published in business journals, institutional publications, including UNDP.