Petrotemex Energy Integration Project

Grupo Petrotemex, Mexico

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Prepared by
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CLEAN DEVELOPMENT MECHANISM
PROJECT DESIGN DOCUMENT FORM (CDM-PDD)
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SECTION A. General description of project activity

A.1 Title of the project activity:

Petrotemex Energy Integration Project

A.2. Description of the project activity:

The project activity aims at reducing GHG emissions (mainly carbon dioxide and, to a lesser extent, methane and nitrous oxide) through the implementation of a series of mitigation measures that involve fuel and electricity savings as well as fuel switching and the installation of new electricity self-generation equipment. These goals will be achieved through process energy integration, leading to lower steam consumption that will reduce overall fuel usage and electricity demand. Taking advantage of remaining low-quality steam, additional power will be generated. In addition, the biogas generated in an anaerobic wastewater treatment facility will replace a small part of the fossil fuels currently consumed.

Petrotemex will lead this project activity that involves its two plants, located at Cosoleacaque and Altamira, in Mexico. These plants produce Pure Terephthalic Acid (“PTA”), a raw material for the production of polyester yarn, PET, and other products.

The project activity has the capacity to reduce 3,043,840 tonnes of CO_2 equivalent emissions over a 10-year time frame.

The project activity also generates the inherent benefits of fuel and electricity savings, fuel switching, and self-generation:

- Higher air quality. Less quantity of pollutants and particulate matter in local air.
- Improvement of labor and health conditions of its employees.
- Lower maintenance of the equipment converted to biogas.
- Economic benefits (CER related revenue) that allow Petrotemex to continue implementing mitigation measures.

Thus, the project activity involves social, environmental, and economic benefits, contributing to sustainable development objectives of Mexican federal and state authorities, in accordance with the development plans of Mexico (Plan Nacional de Desarrollo 2001-2006, http://www.presidencia.gob.mx/documentos), Veracruz State (Plan Veracruzano de Desarrollo 1999-2004, http://www.veracruz.gob.mx/), and Tamaulipas State (Plan Estatal de Desarrollo 1999- 2004 del Estado de Tamaulipas, http://www.tamaulipas.gob.mx/).

A.3. Project participants:

Non-Annex 1 Party: United Mexican States (“Mexico”)

Company: Grupo Petrotemex, S.A. de C.V. (“Petrotemex”)

Petrotemex is a business of Alpek Group, subsidiary of Alfa, S.A. de C.V. (http://www.alfa.com.mx), oriented to the production of raw materials for polyester yarn, PET and other products.

Annex 1 Party: Japan

Company: Electric Power Development Company, Ltd. (EPDC).

EPDC is a Japanese electricity generation company, with power plants in Japan and other countries.

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A.4. Technical description of the project activity:

A.4.1. Location of the project activity:

A.4.1.1. Host Party(ies):

Mexico

A.4.1.2. Region/State/Province etc.:

Veracruz and Tamaulipas States

A.4.1.3. City/Town/Community etc:

Cosoleacaque (Veracruz) and Altamira (Tamaulipas)

A.4.1.4. Detail of physical location, including information allowing the unique identification of this project activity (maximum one page):

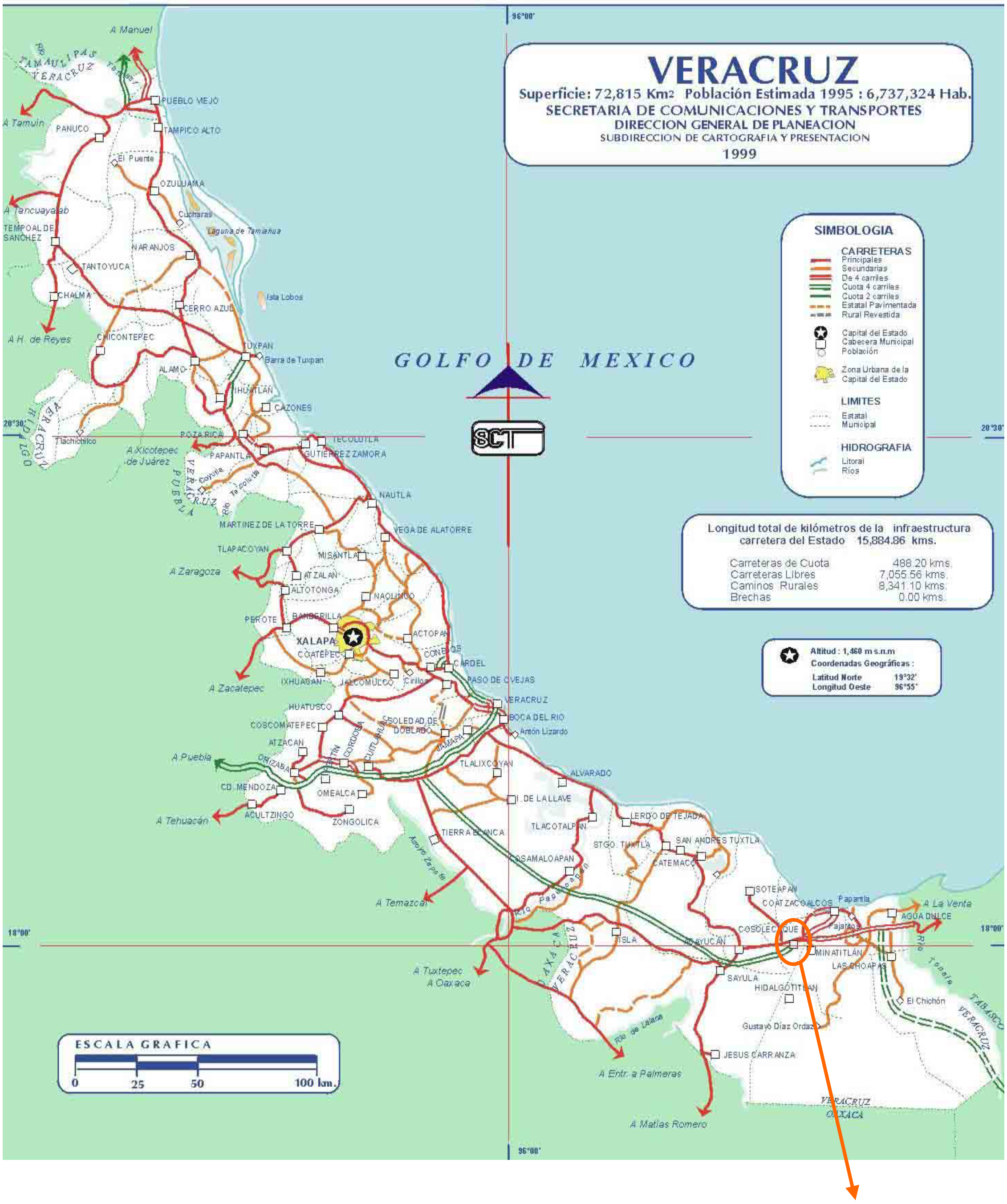
The project activity will be implemented at the production facilities of Petrotemex, located in Cosoleacaque and Altamira, in the States of Veracruz and Tamaulipas respectively.

Veracruz and Tamaulipas States are located in the east of Mexico (Figure 1).

Veracruz State is home to 6.7 million people (Census 1995), and has an area of 72,815 km^2, representing the 3.7% of the national territory. Its capital is Xalapa Enríquez, and its limits are Tamaulipas and the Gulf of Mexico in the North, Chiapas and Oaxaca in the South, Puebla, Hidalgo, and San Luis Potosí in the West, and the Gulf de Mexico, Tabasco, and Chiapas in the East (Figure 2).

Tamaulipas State has 2.5 million inhabitants (Census 1995), and has an area of 79,829 km^2, representing the 4.1% of the national territory. Its capital is Ciudad Victoria, and its limits are the United States of America and Nuevo León in the North, the Gulf of Mexico, Veracruz and San Luis Potosí in the South, Nuevo León and San Luis Potosí in the West, and United States of America and the Gulf of Mexico in the East (Figure 3).

Figure 1: Map of Mexico



Cosoleacaque

Figure 2: Map of Veracruz State

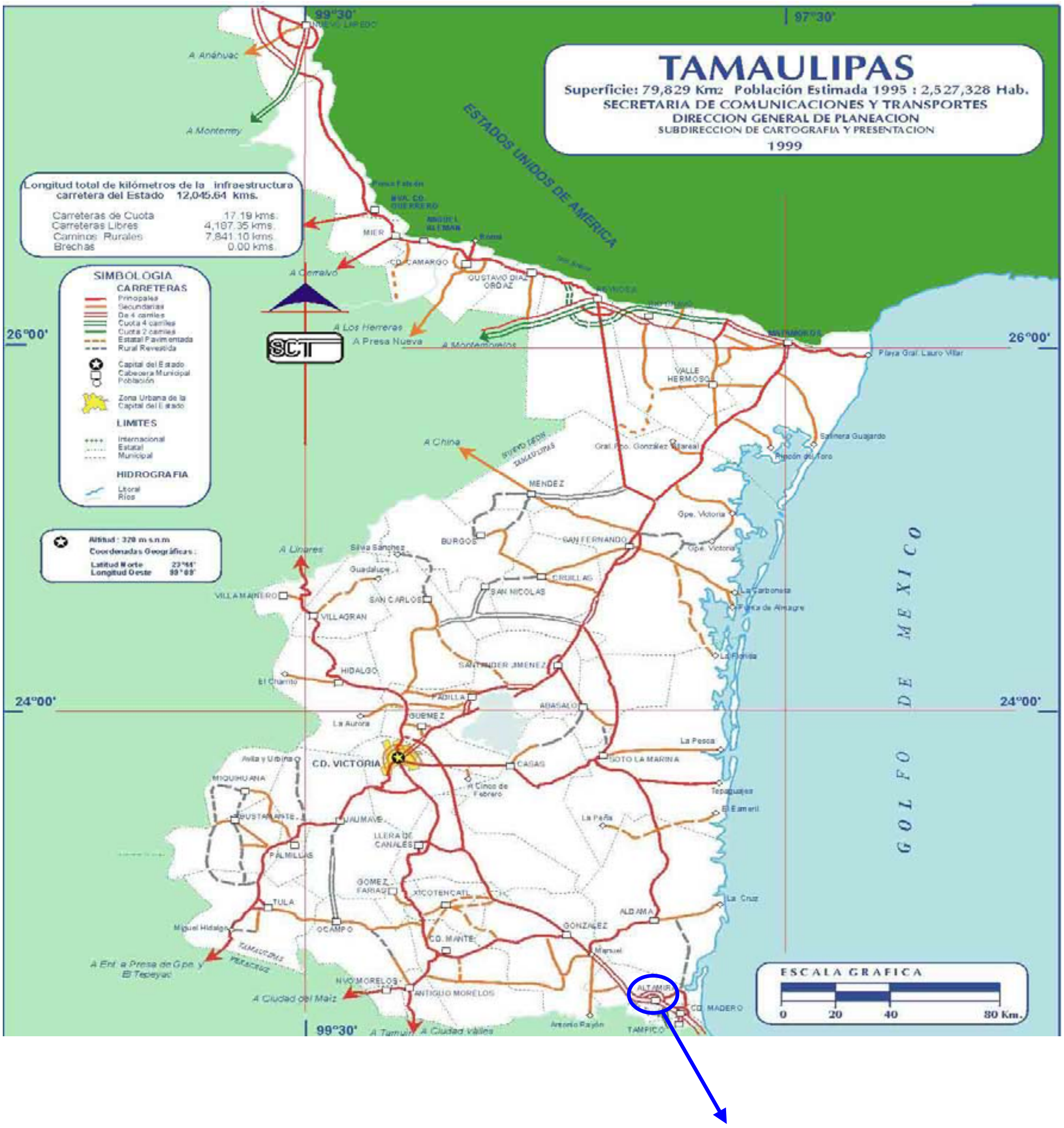


Figure 3: Map of Tamaulipas State

A.4.2. Category(ies) of project activity:

The project activity involves improvements in the petrochemical industry processes, related to a more efficient use of energy giving rise to fuel and electricity savings as well as fuel switching and electricity self-generation.

The UNFCCC CDM web site appears not to provide a list of categories of project activities, from which one might choose one that might be applicable for this proposed project.

If one were to use the “Sectoral Scope” classification as applied to Designated Operational Entities, possible categories might be: (3) Energy demand, (4) Manufacturing industry or (5) Chemical industry.

A.4.3. Technology to be employed by the project activity:

As mentioned above, the project activity involves the two PTA production plants of Petrotemex. One located in Cosoleacaque and the other one in Altamira.

PTA is commonly produced through the exothermic oxidation of p-xilene, using acetic acid as solvent.

Cosoleacaque plant

The plant has the following general characteristics:

Table 1: General characteristics of Cosoleacaque plant

Main Product	Pure Terephthalic Acid	
Beginning of operations	1978	
Plant Useful life	More than 30 years	
Plant Capacity	1978	135,000 t/year
	1997	600,000 t/year
	2004	630,000 t/year

The plant has two dehydration columns (**BT-701** and **BT-703**) in the oxidation area, whose function is to separate the water resulting from the reaction and, at the same time, to recover the acetic acid used as solvent. These columns work by binary atmospheric distillation process.

The dehydration columns use, as condensers, heat exchangers consisting of radiators with finned tubes and integrated fans. Each bay of the condensers has two integrated electric fans. The BT-701 column has 7 bays split in sections of 5 and 2, with 14 fans of 25 HP each (totaling 350 HP) and BT-703 column has 5 bays with 10 fans of 40 HP each (totaling 400 HP). The condensers of such dehydration columns require in sum 750 HP that represent a 560 kW power consumption.

The oxidation process of p-xylene requires an inflow of compressed air. Said flow of air is provided by a series of compressors (**AC-101**, **AC-102**, **AC-103**, and **AC-104)** that are designed to reach 32 kg/cm^2 of discharge pressure after six compressing stages linked to five intercoolers, where air humidity is condensed and removed. Three of the mentioned compressors are operated by means of steam turbines,

while the AC-102 compressor runs on electric power. Technical characteristics of the compressors are shown in Annex 5 submitted with this PDD.

In addition, the plant has 4 boilers to produce overheated steam, which consume heavy fuel oil (*combustóleo*) and natural gas, and whose technical characteristics are shown in Annex 5 submitted with this PDD.

The energy integration project activity is divided into six parts:

- Switching from binary distillation to azeotropic distillation in dehydration columns;
- Installation of a new highly efficient turbo-compressor using low-pressure steam to which an electric power generator will be added;
- Switching the current dehydration columns' condensers to condensers that generate low-pressure steam;
- Installation of new systems generating low-pressure steam using the heat released by the oxidation reaction of p-xylene;
- Incorporation of a new process of thermo-compression of the steam used in the reboiler of the BT-703 dehydration tower.
- Fuel switching from heavy fuel oil to biogas.

The consequences of the proposed project activity are the following:

1. Reduce 5.3 kg/cm^2 steam consumption used as means of heating in reboilers in BT-701 and BT-703 dehydration columns by (i) switching from binary distillation to azeotropic distillation and (ii) the thermo-compression process;
2. Reduce 2.1 and 5.3 kg/cm^2 steam consumption by shutting down the low-pressure steam turbine connected to AC-103 turbo-compressor;
3. Reduce electric power consumption by shutting down the AC-102 moto-compressor;
4. Reduce overheated steam generation (42 kg/cm^2 and 400 °C) in boilers, by switching from AC-101, AC-103 and AC-104 turbo-compressors to a new high-efficiency turbo-compressor. The new turbine of such compressor will not utilize overheated steam but low-pressure steam generated in the PTA production process;
5. Generate 0.05 and –0.33 kg/cm^2 steam in the new generators associated to the oxidation reactors;
6. Generate –0.33 kg/cm^2 steam in the dehydration towers;
7. Reduce power consumption by shutting down the condenser fans of the dehydration towers;
8. Self-generate electricity in the generator integrated to the new compression train to obtain the complete use of energy resulting from the availability of low-pressure steam flows mentioned above.
9. Reduce heavy fuel oil consumption used at the plant, by switching to biogas.

Currently the plant purchases electricity from a private party and the Mexican interconnected grid (managed by Comisión Federal de Electricidad “CFE”, which is the electricity generation, transformation, transmission, distribution, and commercialisation company). As mentioned above, the project involves energy (fuel and electricity) savings and electricity self-generation; in consequence, the proposed project activity will lead to GHG emission reductions from displacing electricity generated outside the plant site.

The new turbo-generator (**BN-101**) has the following technical characteristics.

Table 2: Technical characteristics of the generator

Generator type	Horizontal synchronic
Power output	11,500 kVA
Voltage	4,160 V
No. Phases	3
Frequency	60 Hz
Current intensity	1,733 A
Synchronic speed	900 rpm
Temperature	85 ºC

Table 3: Technical characteristics of the steam turbine

Turbine type	Total condensation
Capacity	27,700 kW
Inlet steam pressure	5.3, 2.1, 0.05, and –0.33 kg/cm^2 man
Outlet steam pressure	3.24 In Hg abs
Outlet steam temperature	48 ºC
Synchronic speed	3,000 rpm

Altamira plant

The plant has the following general characteristics:

Table 4: General characteristics of Altamira plant

Main Product	Pure Terephthalic Acid
Beginning of operations	1997
Plant Useful life	More than 30 years
Plant Capacity	450,000 t/year

The plant has one dehydration column (**BT-701**) in the oxidation area, whose function is to separate the water resulting from the reaction and, at the same time, to recover the acetic acid used as solvent. This column works by binary atmospheric distillation process.

The project activity involves the following activities:

- Switching from binary to azeotropic distillation in the dehydration column;
- Installation of a new electric power turbo-generator with a maximum generation capacity of 6.5 MW, which uses low-pressure steam.

The consequences of the proposed project activity are the following:

1. Reduce 5.3 kg/cm^2 steam consumption used as means of heating the reboilers in BT-701 dehydration column, by switching from binary to azeotropic distillation;
2. Generate 3.3 MW of electricity in the new turbo-generator to obtain the complete use of energy resulting from the availability of low-pressure steam flow mentioned above;
3. Obtain additional energy benefits when expanding plant capacity to 900,000 tPTA/year, generating 2.1kg/cm^2 steam that can be used in the turbo-generator to produce an additional 2.1 MW power output. The proposed project activity already considers such an expansion so as to capture these future benefits with no additional investment.

Currently the plant purchases electricity from a private party. Thus, the proposed project activity will lead to GHG emission reductions from electricity generation outside the plant site.

The new turbo-generator that will be installed at the facility includes a generator and a steam turbine, whose technical characteristics are shown in the following tables.

Table 5: Technical characteristics of the generator

Generator type	Horizontal synchronic
Power output	9,375 kVA, 7,500 kW
Voltage	13,800 V
No. Phases	3
Frequency	60 Hz
Current intensity	1,733 A
Synchronic speed	1,800 rpm
Temperature	80 ºC

Table 6: Technical characteristics of the steam turbine

Turbine type	Total condensation
Nominal capacity	7,343 kW
Inlet steam pressure	5.3 kg/cm^2 man
Outlet steam pressure	0.14 kg/cm^2
Outlet steam temperature	52 ºC
Synchronic speed	4,200 rpm

A.4.4. Brief explanation of how the anthropogenic emissions of anthropogenic greenhouse gas (GHGs) by sources are to be reduced by the proposed CDM project activity, including why the emission reductions would not occur in the absence of the proposed project activity, taking into account national and/or sectoral policies and circumstances:

As explained in Section A.4.3, the project activity consists of the implementation of a series of mitigation measures that involve fuel and electricity savings as well as fuel switching and the installation of new electricity self-generation equipment. As a result, there will be an improvement in plant efficiency in a thermodynamic sense, reducing fuel burning at the plant site, and reducing electricity purchases, thus decreasing electricity generation outside the industrial facility.

As a consequence of all aspects of project implementation, overall emissions of CO_2, and to a minor extent other GHGs, will be reduced, compared to the baseline scenario.

Project additionality was analysed using the "Tools for the demonstration and assessment of additionality," published by the CDM Executive Board at its 16th Meeting early in October 2004. Details are provided in Section B.3 of this PDD.

A.4.4.1. Estimated amount of emission reductions over the chosen crediting period:

The total *ex-ante* emission reductions are estimated to be 3,043,840 tCO_2e during the 10-year crediting period.

Table 7: Total emission reductions during the 10-year crediting period

(tonnes of CO_2 equivalent)

year	year	Emission reductions
1	2005	304,384
2	2006	304,384
3	2007	304,384
4	2008	304,384
5	2009	304,384
6	2010	304,384
7	2011	304,384
8	2012	304,384
9	2013	304,384
10	2014	304,384
Total		**3,043,840**

A.4.5. Public funding of the project activity:

Petrotemex will not deviate any official development assistance whatsoever for project implementation.

SECTION B. Application of a baseline methodology

B.1. Title and reference of the approved baseline methodology applied to the project activity:

The project activity uses the following baseline methodology presented with this PDD as a "new methodology" for submission to and approval by the CDM Executive Board.

The baseline methodology is designated ***"Baseline methodology for project activities involving energy efficiency, self-generation, cogeneration, and/or fuel switching measures at an industrial facility"***

B.1.1. Justification of the choice of the methodology and why it is applicable to the project activity:

This methodology applies to cases where the project activity involves any one or any combination of the following activities at the industrial site:

- Changes in the energy efficiency of any equipment (fuel and electricity savings);
- Installation of electricity self-generation equipment or changes in electricity self-generation equipment;
- Installation of electricity cogeneration equipment or changes in electricity cogeneration equipment;
- Fuel switching for equipment.

The proposed project activity is located in two industrial facilities, and involves the implementation of a series of mitigation measures leading to fuel and electricity savings as well as fuel switching and the installation of new electricity equipment for self-generation, which takes advantage of additional amounts of process steam able to be used due to technological innovation under an energy integration and cleaner production scheme.

Thus the proposed project activity meets the conditions under which the methodology is applicable.

B.2. Description of how the methodology is applied in the context of the project activity:

These industrial facilities have identified a less energy-intensive manner to recover acetic acid that would produce a low-pressure steam flow that can be used to generate electricity and compressed air, as opposed to discarding this energy stream in cooling towers or steam venting.

Specifically, the Cosoleacaque plant contemplates the substitution of three turbo-compressors and one moto-compressor by a sole high-efficiency turbo-compressor with enough capacity to generate the required compressed air for a 100% plant capacity factor. This new turbo-compressor has a generator installed in the shaft with enough capacity to produce up to 11 MW, maximizing the energy available at the site. By self-generating electricity, the plant reduces the purchase of power from third parties. At the end, the plant will become nearly self-sufficient in electric power supply. Moreover, the plant reduces its fuel consumption since the new turbo-compressor does not utilize overheated steam from boilers.

Additionally, a small part of the heavy fuel oil consumed at the boilers will be replaced by biogas collected from an anaerobic wastewater treatment facility.

In addition, the Altamira plant will self-generate 3.3 MW. This power generation is achieved by maximizing the use of energy available at the plant. As a result, the turbine associated with this project activity is tailor-made, not commercially available. By self-generating, the plant reduces the purchase of power from a third party.

The facilities in which the project activity will be developed involve very complex processes and operating conditions that make energy fluxes difficult to follow (fuel and electricity demand and process steam flows) on a one-to-one equipment basis. Therefore, the basic assumptions of the baseline methodology are met in the context of the proposed project activity.

In the following Sections of this PDD we strictly follow the key methodological steps in determining the baseline scenario.

According to the proposed baseline methodology, the key data used to determine *ex-post* the baseline scenario is given in the following table.

Table 8: Key data

Parameters	**Data sources**
Carbon dioxide emission factor per unit energy of fuel *j*, CEF_j ($kgCO_2$/MMBtu)	IPCC default values
Methane emission factor per unit energy of fuel *j*, MEF_j ($kgCH_4$/MMBtu)	IPCC default values
Nitrous oxide emission factor per unit of energy of fuel *j*, NEF_j (kgN_2O/MMBtu)	IPCC default values
Global Warming Potential of methane, $GWP\ (CH_4)$	According to Article 5, Section 3 of the Kyoto Protocol, GWP is as agreed on at COP3
Global Warming Potential of nitrous oxide, $GWP\ (N_2O)$	According to Article 5, Section 3 of the Kyoto Protocol, GWP is as agreed on at COP3
Variables	**Data sources**
PTA annual production, P_{PTA} (tonnes)	Petrotemex
Quantity of fuel *j* consumed at the boiler room in the baseline, BFC_j (m^3)	Petrotemex
Net electricity purchased (electricity purchased less electricity sold) in the baseline, *NBEP* (MWh)	Petrotemex
Net electricity sold (electricity sold less electricity purchased) in the project scenario, *NPES* (MWh)	Petrotemex
Baseline emission factor from electricity generation, *EFel* ($kgCO_2e$/MWh)	El Gallo Hydroelectric Project

B.3. Description of how the anthropogenic emissions of GHG by sources are reduced below those that would have occurred in the absence of the registered CDM project activity:

Following the proposed baseline methodology, we apply the Tools for the demonstration and assessment of additionality to this project activity.

Step 0. Preliminary screening based on the starting date of the project activity

The project activity has partially started, as it takes time to perform the basic and detailed engineering of the core equipment. However, an increase from the required initial investment of more than 50% has put the project on halt. The additional benefits associated by considering it as a CDM project are crucial for the approval of additional funds needed to implement the project activity.

Step 1. Identification of alternatives to the project activity consistent with current laws and regulations

Sub-step 1a. Define alternatives to the project activity

The possible alternatives compatible with the project activity are:

1. Increase the use of natural gas to substitute heavy fuel oil while keeping the current operating conditions equipment without introducing any additional change.
2. Increase the use of heavy fuel oil or switch to more competitive fuels (*e.g.* pet coke) due to fuel prices advantages without changing anything else.
3. Implement some of the measures proposed in the project without modifying the others.
4. Continuation of the current situation.
5. Develop the project itself.

One of these alternatives corresponds to the most likely scenario, *i.e.* the baseline. In order to show this we analyse these alternatives in more detail.

Alternative 1 is not viable, in part, due to the increasing trends natural gas prices are suffering in North America, including Mexico. Some price projections are shown in the table below. However, even if Petrotemex switched from heavy fuel oil to natural gas, the resulting emission reduction of GHG would still be lower than that of the project activity. Thus, the project activity is clearly a better alternative to reduce anthropogenic greenhouse gas emissions than merely switching fuels.

Table 9: Comparison between natural gas and heavy fuel oil prices in North America (US$/MMBtu)

year	USGC Natural gas*	USGC Heavy fuel oil[+]
2005	7.74	4.54
2006	6.88	4.39
2007	6.30	4.42
2008	5.94	4.42

*Source: NYMEX futures Nov 2, 2004
[+]Source: BNP PARIBAS, Nov 2004

Alternative 3 could not displace the option selected as the project activity and the baseline, since a partial implementation of the proposed project activity would lead to an imbalance on the efficient use of process heat and to steam venting. A partial implementation of the complete project activity does not maximize the steam flows available at the site and the resulting deficient energy recovery would lead to a project that is not economically viable, even with MDL.

Alternative 4 is going to become alternative 2. Due to fuel pricing issues, an increased use of heavy fuel oil in the future operation of the plants is expected. This will affect emission estimations from fuel combustion for the case of Cosoleacaque's plant, since it is the only one saving fuels in the project scenario.

Alternative 5 not undertaken as a CDM project activity represents a high risk due to the uncertainty involved after implementation and the huge capital expenditures necessary to implement the project activity. Thus, we consider CDM as a trigger mechanism contributing to overcome an investment prohibitive barrier.

As a consequence of the above, if the project activity is not undertaken, alternative 2 is the most likely and will be considered as the base scenario, since it involves lower investment and risk. We are assuming that heavy fuel oil is the fuel that would have been consumed in the absence of the project activity (alternative 5).

Sub-step 1b. Enforcement with applicable laws and regulations

All alternatives are in line with applicable federal and state regulations in Veracruz and Tamaulipas States. The Mexican Norm NOM-085-ECOL-1994 published on Dec 2, 1994 in the Official Bulletin of the Federation specifies limits regarding emissions of NO_x, SO_x, and particulate matter released from the combustion of primary fuels by stationary sources. Nevertheless, this Norm was later modified on Oct 7, 1997 in order to accommodate those stationary sources for which there is no availability of fuels fulfilling the environmental quality established by the corresponding Mexican Official Norms. This has been the case for the Cosoleacaque plant and will likely remain for the project activity once started, since the fuel supplier has been providing heavy fuel oil with a lower quality than the one specified in the norm for fuels.

Eventual problems with SO_2 and particulate matter emissions will be dealt with monitoring procedures and other projects currently under development, in order to control those emissions as a part of the air quality component of the environmental management plan.

Step 2. Investment Analysis

This step has not been selected.

Step 3. Barrier Analysis

Sub-step 3a. Identify barriers that would prevent the implementation of type of the proposed project activity

Investment barrier: The project activity requires a huge investment. In the last five years Petrotemex has not invested in any project of the magnitude of the one proposed here. The investment needs are around twice the total amount invested in the last five years in the plants related to the project activity (Cosoleacaque and Altamira). In order to minimize the associated risk, Petrotemex has applied to national funds for technological innovation to cover a part of the necessary investment. A part of the rest is expected to be compensated by the CDM, mainly contributing to cover unexpected implementation costs (which are typical for technology innovation projects) and to finance additional investment for continuous improvements.

Technological barrier: The project activity involves high risks due to the typical uncertainties of the application of new technology. The first problem is that, as far as we know, there are no international references which detail about taking advantage of low-quality steam and residual process gases for power generation. Usually, the highest steam quality obtained from fuel combustion is used for power generation. On the other hand, there are not facilities around the world combining high-efficiency structural packing technologies with azeotropic distillation, thermal-compression and low-pressure steam generation to condensate steam in the cooling towers. The proposed structural packing has not been proven before in azeotropic distillation of water-acetic acid solutions, and combined with thermal-compression allows Petrotemex to use low quality steam together with medium-pressure steam to obtain enough energy to separate the mixture. All these new developments have an associated risk. New technology is subject to produce unexpected costs not foreseen at the time of implementing the project activity.

Barrier due to prevailing practice: As a consequence of technology innovation as detailed above, this project can be considered as the "first of a kind."

Sub-step 3b. Show that the identified barriers would not prevent the implementation of at least one of the alternatives (except the proposed project activity)

It results clear that the barriers identified in step 3a do not prevent the implementation of alternative 2 selected as the baseline.

Step 4. Common Practice Analysis

Sub-step 4a. Analyse other activities similar to the proposed project activity

Petrotemex is the only company in Mexico producing PTA. As explained in step 3a, there are no known projects similar to the one proposed here.

Sub-step 4b. Discuss any similar options that are occurring

No similar options are occurring around the world.

Step 5. Impact of CDM Registration

According to the expected emission reductions, there is an interesting income owing CER revenue. The benefit obtained by selling CERs will allow Petrotemex to invest in further research and development and to cover part of the initial investment and the unexpected costs of project implementation. Thus, CDM registration becomes very relevant to the decision-making process leading to go ahead with the proposed project activity.

It is clear that baseline emissions are greater than project emissions, since in the baseline case no fuel and electricity savings are included with their corresponding emission reductions. Thus, the proposed project activity is additional.

B.4. Description of how the definition of the project boundary related to the baseline methodology selected is applied to the project activity:

The project boundary of the proposed new methodology is perfectly applicable to this project activity. This boundary includes two disconnected boundaries, each one located at the corresponding industrial facility (Cosoleacaque or Altamira).

B.5. Details of baseline information, including the date of completion of the baseline study and the name of person (s)/entity (ies) determining the baseline:

Date of completing the final draft of this baseline section: 25/10/2004

Name of person/entity determining the baseline:

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Eng. Zaragozi, Eng. Cepón, and Dr. Gaioli are not project participants.

SECTION C. Duration of the project activity / Crediting period

C.1 Duration of the project activity:

C.1.1. Starting date of the project activity:

The project activity is expected to be operating in August 2005.

C.1.2. Expected operational lifetime of the project activity:

30 years

C.2 Choice of the crediting period and related information:

Fixed crediting period

C.2.1. Renewable crediting period

C.2.1.1. Starting date of the first crediting period:

N/A

C.2.1.2. Length of the first crediting period:

N/A

C.2.2. Fixed crediting period:

C.2.2.1. Starting date:

01/08/2005

C.2.2.2. Length:

10 years

SECTION D. Application of a monitoring methodology and plan

D.1. Name and reference of approved monitoring methodology applied to the project activity:

The project uses the following monitoring methodology presented with this PDD as a "new methodology" for submission to and approval by the CDM Executive Board.

The monitoring methodology is designated: ***"Monitoring methodology for project activities involving energy efficiency, self-generation, cogeneration, and/or fuel switching measures at an industrial facility"***

D.2. Justification of the choice of the methodology and why it is applicable to the project activity:

This methodology shall apply to cases where the project activity involves any one or any combination of the following activities at the industrial site:

- Changes in the energy efficiency of any equipment (fuel and electricity savings);
- Installation of electricity self-generation equipment or changes in electricity self-generation equipment;
- Installation of electricity cogeneration equipment or changes in electricity cogeneration equipment.
- Fuel switching for equipment;

The proposed project activity is located in two industrial facilities, and involves the implementation of a series of mitigation measures leading to fuel and electricity savings as well as fuel switching and the installation of new electricity equipment for self-generation, which takes advantage of additional amounts of process steam able to be used due to technological innovation under an energy integration and cleaner production scheme.

Thus the proposed project meets the conditions under which the methodology is applicable.

D.2. 1. Option 1: Monitoring of the emissions in the project scenario and the baseline scenario

D.2.1.1. Data to be collected in order to monitor emissions from the project activity, and how this data will be archived:								
ID number *(Please use numbers to ease cross-referencing to D.3)*	Data variable	Source of data	Data unit	Measured (m), calculated (c) or estimated (e)	Recording frequency	Proportion of data to be monitored	How will the data be archived? (electronic/ paper)	Comment
1	*Quantity of heavy fuel oil consumed at the boiler room* Q_{HFO}	*Petrotemex*	m^3*/year*	*m*	*monthly*	*100%*	*Paper (field record) Electronic (spreadsheet)*	*Before calculation of project emissions, it shall be converted to energy units (MMBtu/yr) by multiplying by its Lower Heating Value.*
2	*Quantity of natural gas consumed, if any, at the boiler room* Q_{NG}	*Petrotemex*	m^3*/year*	*m*	*monthly*	*100%*	*Paper (field record) Electronic (spreadsheet)*	*Before calculation of project emissions, it shall be converted to energy units (MMBtu/yr) by multiplying by its Lower Heating Value.*
3	*Quantity of biogas consumed at the boiler room* Q_B	*Petrotemex*	m^3*/year*	*m*	*monthly*	*100%*	*Paper (field record) Electronic (spreadsheet)*	*Before calculation of project emissions, it shall be converted to energy units (MMBtu/yr) by multiplying by its Lower Heating Value.*
4	*Quantity of any other fuel consumed at the boiler room* Q_{Fi}	*Petrotemex*	m^3*/year*	*m*	*monthly*	*100%*	*Paper (field record) Electronic (spreadsheet)*	*Before calculation of project emissions, it shall be converted to energy units (MMBtu/yr) by multiplying by its Lower Heating Value.*
5	*Project emissions E*	*Petrotemex*	tCO_2e*/year*	*c*	*monthly*	*100%*	*Paper (field record) Electronic (spreadsheet)*	*It will be calculated using data 1 to 4 as explained in Section D.2.1.2.*

D.2.1.2. Description of formulae used to estimate project emissions (for each gas, source, formulae/algorithm, emissions units of CO_2 equ.)

Project GHG emissions within the project boundary correspond to emissions from fuel combustion at the boiler room ("BR") and the furnaces in Cosoleacaque plant.

Project emissions comprise the following components:

a) CO_2 emissions from combustion of fuels, corresponding to those used during the project activity.

b) CH_4 emissions from combustion of fuels, corresponding to those used during the project activity.

c) N_2O emissions from combustion of fuels, corresponding to those used during the project activity.

The methodology and formulae for estimating these components of project emissions are described in the new methodology presented with this PDD, and applied below.

The project emissions ***E*** (expressed in tonne of CO_2 equivalent, tCO_2e/year) are given by:

$$E = \sum_i FC_i \times [CEF_i + MEF_i \times GWP(CH_4) + NEF_i \times GWP(N_2O)]$$

where:

FC_i	Consumption of fuel *i* used in the project scenario, measured in energy units (MMBtu)
CEF_i	Carbon dioxide emission factor per unit energy of combusted fuel *i* ($kgCO_2e$/MMBtu)
MEF_i	Methane emission factor per unit energy of combusted fuel *i* ($kgCH_4$/MMBtu)
$GWP(CH_4)$	Global warming potential of CH_4 set as 21 tCO_2e/tCH_4 for the 1^{st} commitment period
NEF_i	Nitrous oxide emission factor per unit energy of combusted fuel *i* (kgN_2O/MMBtu)
$GWP(N_2O)$	Global warming potential of N_2O set as 310 tCO_2e/tN_2O for the 1^{st} commitment period

During the crediting period, fuel consumption at the BR and the furnaces will be monitored in Cosoleacaque plant, and the measured values will be used for the *ex-post* calculation of project emissions.

In the Altamira plant fuel consumption will not change as a consequence of the project activity. Thus, no fuel saving is considered for this plant.

D.2.1.3. Relevant data necessary for determining the baseline of anthropogenic emissions by sources of GHGs within the project boundary and how such data will be collected and archived:

ID number *(Please use numbers to ease cross-referencing to table D.3)*	Data variable	Source of data	Data unit	Measured (m), calculated (c), estimated (e),	Recording frequency	Proportion of data to be monitored	How will the data be archived? (electronic/ paper)	Comment
6	*PTA annual production* P_{PTA}	*Petrotemex*	*tPTA/year*	*m*	*monthly*	*100%*	*Paper (field record) Electronic (spreadsheet)*	
7	*Proportion of heavy fuel oil consumed at the boiler room in the baseline* p_{HFO}	*Petrotemex*	*%*	*c*	*monthly*	*100%*	*Paper (field record) Electronic (spreadsheet)*	*It will be calculated using data 1, 2, and 4.*
8	*Proportion of natural gas consumed at the boiler room in the baseline* p_{NG}	*Petrotemex*	*%*	*c*	*monthly*	*100%*	*Paper (field record) Electronic (spreadsheet)*	*It will be calculated using data 1, 2, and 4.*
9	*Proportion of any other fuel consumed if any at the boiler room in the baseline* p_i	*Petrotemex*	*%*	*c*	*monthly*	*100%*	*Paper (field record) Electronic (spreadsheet)*	*It will be calculated using data 1, 2, and 4.*
10	*Quantity of heavy fuel oil consumed at the boiler room in the baseline* BFC_{HFO}	*Petrotemex*	*MMBtu/year*	*c*	*monthly*	*100%*	*Paper (field record) Electronic (spreadsheet)*	*It will be calculated using data 6 and 7 as explained in Section D.2.1.4.*
11	*Quantity of natural gas consumed at the boiler room in the baseline* BFC_{NG}	*Petrotemex*	*MMBtu/year*	*c*	*monthly*	*100%*	*Paper (field record) Electronic (spreadsheet)*	*It will be calculated using data 6 and 8 as explained in Section D.2.1.4.*

12	*Quantity of any other fuel consumed if any at the boiler room in the baseline* BFC_i	*Petrotemex*	*MMBtu/year*	*c*	*monthly*	*100%*	*Paper (field record) Electronic (spreadsheet)*	*It will be calculated using data 6 and 9 as explained in Section D.2.1.4.*
13	*Net baseline electricity purchase NBEP*	*Petrotemex*	*MWh*	*c*	*monthly*	*100%*	*Paper (field record) Electronic (spreadsheet)*	*It will be calculated using data 6 as explained in Section D.2.1.4.*
14	*Net project electricity sale NPES*	*Petrotemex*	*MWh*	*m*	*monthly*	*100%*	*Paper (field record) Electronic (spreadsheet)*	
15	*Emission Factor from Electricity Generation EFel*	*CFE*	tCO_2/MWh	*c*	*annually*	*100%*	*Paper (field record) Electronic (spreadsheet)*	*It will be extracted from "El Gallo Hydroelectric Project."*
16	*Baseline emissions BE*	*Petrotemex*	$tCO_2e/year$	*c*	*monthly*	*100%*	*Paper (field record) Electronic (spreadsheet)*	*It will be calculated using data 10 to 15 as explained in Section D.2.1.4.*

D.2.1.4. Description of formulae used to estimate baseline emissions (for each gas, source, formulae/algorithm, emissions units of CO_2 equ.)

Baseline GHG emissions within the project boundary correspond to emissions from fuel combustion at the BR and the furnaces (in Cosoleacaque plant), and CO_2 emissions from avoided electricity generation outside the facilities (Cosoleacaque and Altamira plants) in the absence of the project activity. Baseline emissions comprise the following components:

a) CO_2 emissions from combustion of fuels, corresponding to those used in the baseline situation.

b) CH_4 emissions from combustion of fuels, corresponding to those used in the baseline situation.

c) N_2O emissions from combustion of fuels, corresponding to those used in the baseline situation.

d) CO_2 emissions corresponding to electricity purchased in the baseline and project scenarios. With the project situation, there is surplus electricity generation, avoiding power demand elsewhere. This generation offsets CO_2 emissions outside the industrial facilities, emissions that would be present if the project were not implemented. We consider those emissions as another component of baseline emissions.

The methodology and formulae for estimating these components of baseline emissions are described in the new methodology presented with this PDD, and applied below.

Baseline emissions ***BE*** (expressed in tonne of CO_2 equivalent per year, tCO_2e/year) are given by:

$$BE = \sum_i BFC_i \times [CEF_i + MEF_i \times GWP(CH_4) + NEF_i \times GWP(N_2O)] + (NBEP + NPES) \times EFel$$

where:

BFC_i	Consumption of fuel *i* used in the baseline scenario, measured in energy units (MMBtu)
CEF_i	Carbon dioxide emission factor per unit energy of fuel *i* ($kgCO_2$/MMBtu)
MEF_i	Methane emission factor per unit energy of fuel *i* ($kgCH_4$/MMBtu)
$GWP(CH_4)$	Global warming potential of CH_4 set as 21 tCO_2e/tCH_4 for the 1st commitment period
NEF_i	Nitrous oxide emission factor per unit of energy of fuel *i* (kgN_2O/MMBtu)
$GWP(N_2O)$	Global warming potential of N_2O set as 310 tCO_2e/tN_2O for the 1st commitment period
NBEP	Net electricity (*e.g.* MWh) purchased in the baseline.
NPES	Net electricity (*e.g.* MWh) sold in the project.
EFel	Baseline emission factor from electricity generation, including electricity generation by the grid and/or a private plant (*e.g.* $kgCO_2e$/MWh).

In this project *NBEP*, which is defined as electricity purchased less electricity sold in the baseline, only includes electricity purchased in the baseline. In the same way, *NPES*, which is defined as electricity sold

less electricity purchased in the project, only includes electricity purchased in the project, so that this term is negative in equation set above.

Baseline emissions from fuel combustion

The baseline emissions related to fuel consumption (in energy units) will be determined in a *quasi*-dynamic manner (Option 2 of the new baseline methodology). The procedure involves relations between fuel consumption in the baseline and selected process variables to act as control variables. These relations will be established once a time and forever, and considered unalterable during the crediting period. The procedure for determining the *quasi*-dynamic baseline is given below.

The first step to determine the *quasi*-dynamic baseline is the identification of process variables, that act as control variables of the project, and that will be monitored during project implementation. In this project the control variable will be PTA annual production of Cosoleacaque plant.

The second step involves the establishment of an adequate relation between fuel consumption in the baseline scenario and the control variable identified. In this project the relation is a linear correspondence between annual fuel consumption of Cosoleacaque plant (MMBtu/year) and PTA annual production (tPTA/year). This relation is determined based on trends in consumption prior to project implementation, since the baseline scenario considers the fuels and energy-intensive equipment actually in use at the facility.

The relation established is based on values that are highly scattered.[1] Thus, a linear regression method is applied in order to fix a one-to-one correspondence between the total fuel consumption in the baseline (in energy units) and annual PTA production.

This correspondence shall be considered unalterable during the crediting period.

Following project implementation, the *ex-post* baseline fuel consumption (in energy units) will be determined through the correspondence previously established, based on measurements of the PTA annual production of the plant.

We consider that only heavy fuel oil is consumed in the baseline scenario. However if, following project implementation, heavy fuel oil, natural gas or any other fossil fuel(s) are consumed, the proportion of each fossil fuel burnt during project implementation will be considered for the calculation of *ex-post* baseline emissions.

As explained in the baseline methodology submitted with this PDD, if following project implementation there were any modification not previously contemplated that involves fuel saving or fuel switching, this could be considered in the *ex-post* emission reduction calculation, unless such modification is beyond the PTA annual production range considered in establishing the relation.

In the Altamira plant fuel consumption will not change as a consequence of the implementation of the project activity. Thus, no fuel consumption is considered for this plant.

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[1] Dispersion occurs as a consequence of varying operating conditions. Different capacities are annualised parting from daily values, assuming the same operating conditions along the year. This allows us to establish a relation for different capacities with enough data in order to have a good statistics. However, operating schemes are very dynamical in these plants, since there are test periods in which process improvements are performed, equipment going to maintenance labours, new energy recovering systems not installed in the original design of the plants being under testing conditions, process modifications that require using reheating steam, etc.

Baseline emissions associated with purchase of electricity

The emissions associated with electricity generation outside the industrial facilities depend on the sum of the power purchased in the baseline and project scenarios, and the emission factor for power generation, which is taken from “El Gallo Hydroelectric Project.”

Emission factor for power generation outside the industrial facility

The project activity involves savings in purchases of electricity from the grid. Thus contributing to reduce CO_2 emissions elsewhere in the interconnected grid, considered as baseline emissions. The CDM Executive Board has already approved a consolidated methodology for determining this emission factor, ACM0002.

Note that ACM0002 is actually designated “Consolidated baseline methodology for grid-connected electricity generation from renewable sources.” When the project involves electricity generation from renewable sources, project emissions for electricity generation are negligible, and the baseline emissions are emissions avoided elsewhere in the power grid. The new methodology being proposed here is related to electricity generation at industrial facilities using fuels, which are not renewable. However, the emissions from these fuels are being estimated and counted as part of project emissions, and thus, as far as the baseline is concerned, ACM0002 is applicable.

Power purchased from the grid for the two plants, through an intermediate plant, barely overpass the 15 MW-equivalent threshold set for small-scale project activities. The electricity component of the project is small and can be calculated in the same way as it was used in the already validated project “El Gallo Hydroelectric Project.” (By the way, NM0023 was also approved by the CDM Executive Board, AM0005 “Small grid-connected zero-emissions renewable electricity generation,” and was taken into account for the first option of ACM0002, namely Simple OM.) Note that the electricity component of the proposed project activity is equivalent to a zero-emissions generation, since it takes advantage of residual process steam to self-generate electricity at the facilities sites, reducing power generation elsewhere in the power grid. Since applicability conditions are met, we use the emission factor estimated in that project using a combined margin approach.

Petrotemex purchases part of its power demand from a private party. Even though the project implies that Petrotemex could reduce power intake from both, the private party and CFE, avoided CO_2 emissions are those of the national interconnected power grid. The reason is the following:

The private electricity supply could be considered as more competitive than the equivalent CFE supply. Therefore, the power not required by Petrotemex will be available for third parties currently purchasing power from CFE. In this sense, self-generation by Petrotemex will avoid emissions from CFE’s marginal plants within the National Electrical System. Conservatively, we have assumed a grid emission factor given by the Simple Operating Margin approach. From “El Gallo Hydroelectric Project” currently this value is 0.584 tCO_2/MWh.

In particular, the expected capacity expansions of plants in the Altamira complex would have implied a greater power demand from the private party in the mid-term. Without the implementation of the project activity —which reduces power demand from the private party— this party would have not been able to supply the increased demand. Thus, the additional demand would have been met by CFE.

Energy purchase in the baseline scenario

In the case of Cosoleacaque's plant, *ex-post* baseline emissions related to energy purchase can be determined in a *quasi*-dynamic manner from project monitoring data and relations between electricity purchase in the baseline and annual PTA production of the plant. These relations are established *ex-ante*, from historical data, and considered unalterable during the crediting period. The procedure is the same that is described above for estimating *ex-post* baseline emissions related to fuel consumption.

A one-to-one correspondence is established between electricity purchase and annual PTA production, from which, by monitoring annual PTA production, the amount of electricity purchase in the baseline scenario can be obtained.

For Altamira's plant, only self-generated power will be monitored *ex-post* to determine displaced energy from the CFE grid, since no self-generation exists prior to project implementation.

Energy purchase in the project scenario

The *ex-post* baseline emissions related to energy purchase in the project scenario can be determined from project monitoring data.

D. 2.2. Option 2: Direct monitoring of emission reductions from the project activity (values should be consistent with those in section E).

D.2.2.1. Data to be collected in order to monitor emissions from the project activity, and how this data will be archived:

ID number *(Please use numbers to ease cross-referencing to table D.3)*	Data variable	Source of data	Data unit	Measured (m), calculated (c), estimated (e),	Recording frequency	Proportion of data to be monitored	How will the data be archived? (electronic/ paper)	Comment

N/A

D.2.2.2. Description of formulae used to calculate project emissions (for each gas, source, formulae/algorithm, emissions units of CO_2 equ.):

N/A

D.2.3. Treatment of leakage in the monitoring plan **D.2.3.1. If applicable, please describe the data and information that will be collected in order to monitor leakage effects of the project activity**								
ID number *(Please use numbers to ease cross-referencing to table D.3)*	Data variable	Source of data	Data unit	Measured (m), calculated (c) or estimated (e)	Recording frequency	Proportion of data to be monitored	How will the data be archived? (electronic/ paper)	Comment

No significant leakage (***LE***) is envisaged in this project, since only fuel saving is involved, implying an extremely low impact on emission reductions. Moreover, it is conservative to disregard these emissions here, since they would have been accredited in favor of project participants.

D.2.3.2. Description of formulae used to estimate leakage (for each gas, source, formulae/algorithm, emissions units of CO_2 equ.)

N/A

D.2.4. Description of formulae used to estimate emission reductions for the project activity (for each gas, source, formulae/algorithm, emissions units of CO_2 equ.)

Baseline emissions ***BE*** and project emissions ***E*** (tCO_2e/year) are given by:

$$BE = \sum_i BFC_i \times [CEF_i + MEF_i \times GWP\ (CH_4) + NEF_i \times GWP\ (N_2O)] + (NBEP + NPES) \times EFel$$

$$E = \sum_i FC_i \times [CEF_i + MEF_i \times GWP\ (CH_4) + NEF_i \times GWP\ (N_2O)]$$

As mentioned above, no significant leakage ***LE*** is envisaged in this project.

Thus the emission reductions ***ER*** (tCO_2e/year) achieved by the project activity are given by:

$$ER = BE - E - LE = \sum_i BFC_i \times [CEF_i + MEF_i \times GWP\ (CH_4) + NEF_i \times GWP\ (N_2O)] +$$
$$+ (NBEP + NPES) \times EFel -$$
$$- \sum_i FC_i \times [CEF_i + MEF_i \times GWP\ (CH_4) + NEF_i \times GWP\ (N_2O)]$$

Total emission reductions should be estimated *ex-ant*e as is shown below in Section E.5, and determined *ex-post* as explained in Sections D.2.1.2, D.2.1.4, and D.2.3.2 above.

D.3. Quality control (QC) and quality assurance (QA) procedures are being undertaken for data monitored		
Data *(Indicate table and ID number e.g. 3.-1.; 3.2.)*	Uncertainty level of data (High/Medium/Low)	Explain QA/QC procedures planned for these data, or why such procedures are not necessary.*
1 Q_{HFO}	*Low*	*Petrotemex has a series of internal procedures that ensures data have low uncertainties during monitoring process*
2 Q_{NG}	*Low*	*Petrotemex has a series of internal procedures that ensures data have low uncertainties during monitoring process*
3 Q_B	*Low*	*Petrotemex has a series of internal procedures that ensures data have low uncertainties during monitoring process*
4 Q_i	*Low*	*Petrotemex has a series of internal procedures that ensures data have low uncertainties during monitoring process*
6 P_{PTA}	*Low*	*Petrotemex has a series of internal procedures that ensures data have low uncertainties during monitoring process*
14 NPES	*Low*	*Petrotemex has a series of internal procedures that ensures data have low uncertainties during monitoring process*

*See Section D.4 below.

D.4 Please describe the operational and management structure that the project operator will implement in order to monitor emission reductions and any leakage effects, generated by the project activity

Measurements in the levels of fuel consumption as well as electric generation and purchases so as to determine the decrease in energetic intake after the project implementation will be made by the production departments of the respective plants.

Table 10: Operational and management structure

Department	Responsibility	Monitoring	Methodology
Utilities	Roberto Gómez Gómez	Continuous fuel flow measurement on line to the boilers and furnaces	Chart Recorded measurement of fuel consumption (DCS, PI and meter calibration)
Raw Material	Fernando Vásquez	Daily Inventory consumption	Physical tanks Level Measurement & balance in-out
Instruments Maintenance	Juan Alonso Iparrea	Quality assurance for low uncertainties in the measurement instruments	ISO-9001 Instructions, procedures and planning Maintenance
Environmental	Carlos R. Vergara H.	Emissions of NO_x, CO_x, SO_x, and particulate matter	For third party inspection (External company)

D.5 Name of person/entity determining the monitoring methodology:

Eng. Marisa Zaragozi, Eng. Ivana Cepón, and Dr. Fabián Gaioli, MGM International SRL.

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Eng. Zaragozi, Eng. Cepón, and Dr. Gaioli are not project participants.

SECTION E. Estimation of GHG emissions by sources

E.1. Estimate of GHG emissions by sources:

As mentioned in Section D, project GHG emissions within the project boundary correspond to emissions from fuel combustion at the boiler room and the furnaces in Cosoleacaque plant.

Project emissions ***E*** (tCO_2e/year) are given by:

$$E = \Sigma_i FC_i \times [CEF_i + MEF_i \times GWP(CH_4) + NEF_i \times GWP(N_2O)]$$

Ex-ante project emissions are not estimated since available data allow one to calculate emission reductions directly. However, following project implementation, the *ex-post* project emissions will be determined —from project monitoring data— using the equation above.

E.2. Estimated leakage:

N/A

E.3. The sum of E.1 and E.2 representing the project activity emissions:

N/A

E.4. Estimated anthropogenic emissions by sources of greenhouse gases of the baseline:

As mentioned in Section D, baseline GHG emissions within the project boundary correspond to emissions from fuel combustion at the boiler room and the furnaces (in Cosoleacaque plant), and CO_2 emissions from avoided electricity generation outside the facilities (Cosoleacaque and Altamira plants) in the absence of the project activity.

Baseline emissions ***BE*** (tCO_2e/year) are given by:

$$BE = \Sigma_i BFC_i \times [CEF_i + MEF_i \times GWP(CH_4) + NEF_i \times GWP(N_2O)] + (NBEP + NPES) \times EFel$$

Ex-ante baseline emissions are not estimated since available data allow one to calculate emission reductions directly. However, following project implementation, the *ex-post* baseline emissions will be

determined —from project monitoring data and through correspondences previously established, based on measurements of the PTA annual production— using the equation above.

E.5. Difference between E.4 and E.3 representing the emission reductions of the project activity:

Baseline emissions ***BE*** and project emissions ***E*** (tCO_2e/year) are given by:

$$BE = \sum_i BFC_i \times [CEF_i + MEF_i \times GWP\ (CH_4) + NEF_i \times GWP\ (N_2O)] + (NBEP + NPES) \times EFel$$

$$E = \sum_i FC_i \times [CEF_i + MEF_i \times GWP\ (CH_4) + NEF_i \times GWP\ (N_2O)]$$

No significant leakage ***LE*** is envisaged in this project.

Thus the emission reductions ***ER*** (tCO_2e/year) achieved by the project activity are given by:

$$ER = BE - E - LE = \sum_i BFC_i \times [CEF_i + MEF_i \times GWP\ (CH_4) + NEF_i \times GWP\ (N_2O)] +$$
$$+ (NBEP + NPES) \times EFel -$$
$$- \sum_i FC_i \times [CEF_i + MEF_i \times GWP\ (CH_4) + NEF_i \times GWP\ (N_2O)]$$

For the *ex-ante* calculation of emission reductions related to fuel combustion, it is considered that only heavy fuel oil will be consumed at the Cosoleacaque plant in the project scenario as well as in the baseline scenario. Additionally, the use of biogas will displace a small part of the heavy fuel oil consumed at the boiler room, in Cosoleacaque plant. Therefore, *ex-ante* emission reductions related to fuel combustion are proportional to the emission factors of heavy fuel oil (see Annex 3).

As a consequence of self-generating electricity and the reduction of electricity consumption through the implementation of the project activity, Petrotemex will avoid emissions in the CFE grid. Thus, total emission reductions related to electricity purchases are proportional to the emission factors of the grid (see Annex 3).

Thus *ex-ante* emission reductions are calculated in the following way:

$$ER = (BFC_{HFO} - FC_{HFO}) \times [CEF_{HFO} + MEF_{HFO} \times GWP\ (CH_4) + NEF_{HFO} \times GWP\ (N_2O)] +$$
$$+ (NBEP + NPES) \times EFel$$

***Ex-ante* calculation of emission reductions related to fuel combustion**

As mentioned above, project emissions from fuel combustion correspond to the emissions from fuels burnt at the boiler room and the furnaces, in Cosoleacaque plant.

According to the project boundary definition, total fuel consumed at the boilers is only accessible through monitoring. Only a part of this consumption will be affected by the proposed project activity, since there is fuel consumed for operation of equipment that is not involved in the project activity.

For the *ex-ante* calculation of emission reductions related to fuel savings, since the three turbo-compressors will be left as backup of the new equipment in the project scenario, it is considered that these turbo-compressors will not consume steam from boilers anymore. As a consequence, fuel consumption in the boilers will be lower than the baseline fuel consumption.

Total fuel saved by the project is the fuel that would have been consumed for generating the steam used in the turbo-compressors in the absence of the project activity (in energy units).

For the *ex-ante* calculation of emission reductions related to fuel savings in Cosoleacaque plant, it is assumed a PTA annual production of 600,000 metric tonnes per year for the next 10 years, based on estimations given by Petrotemex. For this PTA annual production, the fuel saved (in energy content) is 2,620,895 MMBtu/year, which was estimated from historical data of the industrial facility.

Thus emission reductions related to fuel saving are:

$$(BFC_{HFO} - FC_{HFO})_{FSaving} \times [CEF_{HFO} + MEF_{HFO} \times GWP\ (CH_4) + NEF_{HFO} \times GWP\ (N_2O)] =$$

$$= 2{,}620{,}895 \text{ MMBtu/year} \times (81.63 + 0.0032 \times 21 + 0.0003 \times 310)/1000 \text{ } tCO_2e\text{/MMBtu} =$$

$$= 214{,}376 \text{ } tCO_2e\text{/year}$$

Additionally, it is expected that 1,260,000 m^3/year of biogas will displace a small part of the heavy fuel oil consumed at the boiler room. The quantity of heavy fuel oil displaced (in energy units) is proportional to the lower heating value of biogas and the relation between thermal efficiency of biogas and thermal efficiency of heavy fuel oil (see Annex 3).

Thus the quantity of heavy fuel oil displaced (in energy units) is:

$$1{,}260{,}000 \text{ } m^3\text{/year} \times 0.0213 \text{ MMBtu/}m^3 \times 0.85/0.8505 = 26{,}874 \text{ MMBtu/year}$$

Thus emission reductions related to fuel switching are:

$$(BFC_{HFO} - FC_{HFO})_{FSwitching} \times [CEF_{HFO} + MEF_{HFO} \times GWP\ (CH_4) + NEF_{HFO} \times GWP\ (N_2O)] =$$

$$= 26{,}874 \text{ MMBtu/year} \times (81.63 + 0.0032 \times 21 + 0.0003 \times 310)/1000 \text{ } tCO_2e\text{/MMBtu} =$$

$$= 2{,}198 \text{ } tCO_2e\text{/year}$$

Summarising, total emission reductions related to fuel combustion are:

214,376 tCO_2e/year + 2,198 tCO_2e/year = **216,574 tCO_2e/year**

***Ex-ante* calculation of emission reductions related to electricity purchases**

Cosoleacaque plant

As a consequence of self-generating electricity and the reduction of electricity consumption through the implementation of the project activity, Petrotemex will decrease its power intake from the private party and CFE. For a production level of 600,000 tPTA/year the project activity has the potential to save 12.5 MW generated outside de industrial facility.

Considering that power generators are working 24 hours per day, during 350 days per year on average, avoided energy generation in the CFE grid is:

12.5 MW × 24 hour/day × 350 day/year = 105,000 MWh/year

Altamira plant

Altamira plant has the potential to self-generate 3.3 MW of electricity power equivalent through the implementation of the project activity. An expected expansion will increase this generation to 5.4 MW.[2] Once more, energy self-generated corresponds to avoided emissions in the CFE grid.

Considering that power generators are working 24 hours per day, during 350 days per year on average, avoided energy generation in the CFE grid is:

5.4 MW × 24 hour/day × 350 day/year = 45,360 MWh/year

Thus total avoided energy generation in the CFE grid is:

105,000 MWh/year + 45,360 MWh/year = 150,360 MWh/year

Summarising, emission reductions related to electricity purchases are:

(NBEP + NPES) × EFel =

[2] For the *ex-ante* estimation of emission reductions we consider the expanded capacity of Altamira's plant for the entire crediting period. However, this expansion is only on a pre-feasibility stage. Actual electricity self-generation will be monitored following project implementation.

$$= 150{,}360 \text{ MWh/year} \times 0.584 \text{ tCO}_2\text{/MWh} =$$

$$= \mathbf{87{,}810 \text{ tCO}_2\text{/year}}$$

***Ex-ante* calculation of total emission reductions**

Total emission reductions are:

$$216{,}574 \text{ tCO}_2\text{e/year} + 87{,}810 \text{ tCO}_2\text{/year} = \mathbf{304,\ 384 \text{ tCO}_2\text{/year}}$$

E.6. Table providing values obtained when applying formulae above:

The project activity has the capacity to reduce 3,043,840 tonnes of CO_2 equivalent emissions over a 10-year time frame.

The following tables summarises the values obtained above:

Table 11: *Ex-ante* emission reductions in Cosoleacaque plant

(tonnes of CO_2 equivalent)

year	year	Emission reductions related to fuel savings	Emission reductions related to fuel switching	Total emission reductions related to fuel combustion	Emission reductions related to electricity purchases	Total emission reductions
1	2005	214,376	2,198	216,574	61,320	277,894
2	2006	214,376	2,198	216,574	61,320	277,894
3	2007	214,376	2,198	216,574	61,320	277,894
4	2008	214,376	2,198	216,574	61,320	277,894
5	2009	214,376	2,198	216,574	61,320	277,894
6	2010	214,376	2,198	216,574	61,320	277,894
7	2011	214,376	2,198	216,574	61,320	277,894
8	2012	214,376	2,198	216,574	61,320	277,894
9	2013	214,376	2,198	216,574	61,320	277,894
10	2014	214,376	2,198	216,574	61,320	277,894
Total		**2,143,757**	**21,981**	**2,165,738**	**613,200**	**2,778,938**

Table 12: *Ex-ante* emission reductions in Altamira plant

(tonnes of CO_2 equivalent)

year	year	Emission reductions related to fuel savings	Emission reductions related to fuel switching	Total emission reductions related to fuel combustion	Emission reductions related to electricity purchases	Total emission reductions
1	2005	---	---	---	26,490	26,490
2	2006	---	---	---	26,490	26,490
3	2007	---	---	---	26,490	26,490
4	2008	---	---	---	26,490	26,490
5	2009	---	---	---	26,490	26,490
6	2010	---	---	---	26,490	26,490
7	2011	---	---	---	26,490	26,490
8	2012	---	---	---	26,490	26,490
9	2013	---	---	---	26,490	26,490
10	2014	---	---	---	26,490	26,490
Total		---	---	---	**264,902**	**264,902**

Table 13: *Ex-ante* emission reductions during the 10-year crediting period

(tonnes of CO_2 equivalent)

	Emission reductions related to fuel savings	Emission reductions related to fuel switching	Total emission reductions related to fuel combustion	Emission reductions related to electricity purchases	Total emission reductions
Cosoleacaque	2,143,757	21,981	2,165,738	613,200	**2,778,938**
Altamira	---	---	---	264,902	**264,902**
Total	**2,143,757**	**21,981**	**2,165,738**	**878,102**	**3,043,840**

SECTION F. Environmental impacts

F.1. Documentation on the analysis of the environmental impacts, including transboundary impacts:

F.2. If environmental impacts are considered significant by the project participants or the host Party, please provide conclusions and all references to support documentation of an environmental impact assessment undertaken in accordance with the procedures as required by the host Party:

SECTION G. Stakeholders' comments

G.1. Brief description how comments by local stakeholders have been invited and compiled:

G.2. Summary of the comments received:

G.3. Report on how due account was taken of any comments received:

Annex 1

CONTACT INFORMATION ON PARTICIPANTS IN THE PROJECT ACTIVITY

Organization:	**Grupo Petrotemex, S.A. de C.V.**
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Represented by:	
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Salutation:	
Last Name:	Montemayor
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Annex 2

INFORMATION REGARDING PUBLIC FUNDING

Other than the technological fund awarded by Mexican authorities mentioned in Section B.3, no funds from public sources were used in any aspect of the proposed project activity.

<u>Annex 3</u>

BASELINE INFORMATION

The key data used to determine the *ex-ante* baseline scenario are given in the following table.

Table 14: Key data

Data	Value	Data sources
Carbon dioxide emission factor per unit energy of heavy fuel oil	81.63 $kgCO_2/MMBtu$	IPCC Guidelines for National Greenhouse Gas Inventories, Reference Manual, Volume 3 (1996), Table 1-1, Page 1.13, Residual Fuel Oil: 21.1 tC/TJ = 77.37 tCO_2/TJ = 81.63 $kgCO_2/MMBtu$
Methane emission factor per unit energy of heavy fuel oil	0.0032 $kgCH_4/MMBtu$	IPCC Guidelines for National Greenhouse Gas Inventories, Reference Manual, Volume 3 (1996), Table 1-16, Page 1.54, Residual Fuel Oil Boilers: 3 $kgCH_4/TJ$ = 0.0032 $kgCH_4/MMBtu$
Nitrous oxide emission factor per unit of energy of heavy fuel oil	0.0003 $kgN_2O/MMBtu$	IPCC Guidelines for National Greenhouse Gas Inventories, Reference Manual, Volume 3 (1996), Table 1-16, Page 1.54, Residual Fuel Oil Boilers: 0.3 kgN_2O/TJ = 0.0003 $kgN_2O/MMBtu$
CFE emission factor	0.584 tCO_2/MWh	El Gallo Hydroelectric Project
Global Warming Potential of methane	21	According to Article 5, Section 3 of the Kyoto Protocol, GWP is as agreed on at COP3. For Methane this was 21.
Global Warming Potential of nitrous oxide	310	According to Article 5, Section 3 of the Kyoto Protocol, GWP is as agreed on at COP3. For Nitrous oxide this was 310.
Lower Heating Value of heavy fuel oil	37 $MMBtu/m^3$	Petrotemex
Lower Heating Value of biogas	0.0213 $MMBtu/m^3$	Petrotemex
Thermal efficiency of boilers using heavy fuel oil	85.05%	Petrotemex
Thermal efficiency of boilers using biogas	85.00%	Petrotemex
PTA annual production	600,000 tPTA/year	Petrotemex
Quantity of fuel saved at Cosoleacaque plant	2,620,895 MMBtu/year	Petrotemex

Quantity of biogas consumed at Cosoleacaque plant	1,260,000 m^3/year	Petrotemex
Avoided energy generation in the CFE grid	150,360 MWh/year	Petrotemex

For the *ex-ante* calculation of emission reductions in the Cosoleacaque plant, it is assumed a PTA annual production of 600,000 metric tonnes per year for the next 10 years, based on estimations given by Petrotemex. For this PTA annual production, the fuel saved (in energy content) is 2,620,895 MMBtu/year, and the avoided power generation in the CFE grid is 12.5 MW equivalent, which were estimated from historical data of the industrial facility. Additionally, it is expected that 1,260,000 m^3/year of biogas will displace a small part of the heavy fuel oil consumed at the boiler room.

For the *ex-ante* calculation of emission reductions in the Altamira plant, we consider that the plant has the potential to self-generate 5.4 MW of electricity power equivalent.

Annex 4

MONITORING PLAN

The Monitoring and Verification Plan describes the procedures for data collection, and auditing required for the project, in order to determine and verify emissions reductions achieved by the project. This project will require only very straightforward collection of data, described below, most of which is already collected routinely by the staff of Petrotemex plants, where the proposed CDM project is to be implemented.

The Monitoring and Verification Plan (MVP) document fulfills the CDM Executive Board requirement that CDM projects have a clear, credible, and accurate set of monitoring and verification procedures. The purpose of these procedures is to direct and support continuous monitoring of project performance and periodic auditing, verification and certification activities to determine project outcomes, in particular in terms of greenhouse gas (GHG) emission reductions. The MVP is a vital component of project design, and as such is subject to a formal third-party validation process —along with the project baseline and other project design features.

Managers of the Project must maintain credible, transparent, and adequate data estimation, measurement, collection, and tracking systems to successfully develop and maintain the proper set of information to undergo an audit for a greenhouse gas (GHG) emission reduction investment. These records and monitoring systems are needed to subsequently allow an Operational Entity to verify project performance as part of the verification and certification process. In particular, this process reinforces the fact that GHG reductions are real and credible to the buyers of the Certified Emissions Reductions (CERs). This set of information will be needed to meet the evolving international reporting standards developed by the UNFCCC.

The document must be used by the project implementers and operators of the Technical Departments of the Petrotemex plants. Strict adherence to the guidelines set out in this monitoring plan is necessary for the project managers and operators to successfully measure and track project impacts for audit purposes. MGM International will provide capacity building to the Technical Departments Petrotemex plants, in order to meet the requirements presented in this MVP.

The new methodology describes the procedure and equations for calculating project and baseline emissions from monitored data. For the specific project, the methodology is applied through spreadsheet models, one for each plant. The staff responsible for Project monitoring must complete the electronic worksheets on a monthly basis. The spreadsheets automatically provide annual totals in terms of GHG reductions achieved through the project.

The models contain a series of worksheets with different functions:

For Cosoleacaque plant

- Data entry sheets (*PTA production*, *fuel consumption, and electricity purchase*)
- Calculation sheets (*baseline emissions, project emissions*)
- Result sheet (*emission reductions*)

For Altamira plant

- Data entry sheets (*electricity generation*)
- Calculation sheets (*baseline emissions*)
- Result sheet (*emission reductions*)

There are worksheets where the user is allowed to enter data. Even in these sheets, only those cells where the staff of each plant is required to enter data have been left unblocked. All other cells contain model fixed parameters or computed values that cannot be modified by the staff.

A color-coded key is used to facilitate data input. The key for the code is as follows***:***

- ***Input Fields:*** Pale yellow fields indicate cells where project operators are required to supply data input, as is needed to run the model;
- ***Result Fields:*** Green fields display key result lines as calculated by the model.

Other sheets are shown in subsequent pages. All fields in these sheets include fixed values, or values that are computed from data in the data entry sheets. The last sheet shows the results, comparing year-by-year GHG emissions with the project with baseline values in order to determine annual emissions reductions, shown in the last column.

All electronic data will be backed up on a monthly basis, and two electronic copies of each document will be kept in different locations. (Each plant and its respective Head Office)

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Annex 5

TECHNICAL CHARACTERISTIC OF CURRENT EQUIPMENT

Cosoleacaque plant

Technical characteristics of the compressor AC-101	
AC101	Type: centrifugal, horizontal, 4 stages
First body	Guarantee horsepower: 12,644 bhp ± 4 %
	Input to compress train: 14,000 bhp
	Casing design: succ/dis 2.81/9.49 kg/cm^2 x 218.3 °C
	Temperature (design/max. operating): 218.3/193.3 °C
	Impeller: (1016/1016/1016/ 991) mm ∅, ss, enclosed
AC 101	Type: centrifugal, horizontal, 2 stages
Second body	Input to compress train: 14,000 bhp
	Casing design: succ/dis 42.5/42.5 kg/cm^2 x 218.3 °c
	Impeller: (686/610/610/724/686/686/686) mm ∅ s.s, enclosed

Technical characteristics of the compressor AC-102	
AC 102	Type: turbo, horizontal, 4 stages
First body	Guarantee horsepower: 7,086 bhp
	Capacity: 40,521.4 m^3/hr
	Weight flow: 43,856 kg/hr
	Pressure (inlet/discharge): 0.97/9.01 kg/cm^2
	Temperature (inlet/discharge): 38.8/115 °C
	Motor: 8,000/4,000 hp, 4,160 v, 60 hz, 960/620 a, 4/8 p, 1,800/900 rpm
AC 102	Type: turbo, horizontal, 7 stages
Second body	Guarantee horsepower: 7,086 bhp
	Capacity: 4,179.5 m^3/hr
	Weight flow: 42,085 kg/hr
	Pressure (inlet/discharge): 8.87/23.8 kg/cm^2
	Temperature (inlet/discharge): 37.7/23.8 °C

Technical characteristics of the compressor AC-103	
AC 103	Type: centrifugal, horizontal, 4 stages
First body	Capacity: 69,282.2 m^3/hr
	Pressure (inlet/discharge): 2.72/9.18 kg/cm^2
	Temperature (design/maxim): 232.2/135 °C
AC 103	Type: centrifugal, horizontal, 8 stages
Second body	Capacity: 8,867.13 m^3/hr
	Pressure (inlet/discharge): 42.51/42.51 kg/cm^2
	Temperature (design/maxim): 260/193.3 °C

Technical characteristics of the compressor AC-104	
AC 104	Type: centrifugal, horizontal, 4 stages (14,800 bhp)
First body	Capacity: 69,282.2 m^3/hr
	Pressure (inlet/discharge): 2.72/9.18 kg/cm^2
	Temperature (design/maxim): 232.2/135 °C
AC 104	Type: centrifugal, horizontal, 8 stages
Second body	Capacity: 8,867.13 m^3/hr
	Pressure (inlet/discharge): 42.51/42.51 kg/cm^2
	Temperature (design/maxim): 260/193.3 °C

Technical characteristics of the boiler AB-301A	
Boiler type	Water tube
Capacity	90,720 kg/hr
Start-up year	1978
Remaining useful life of equipment	20 years
Current fuel	Heavy fuel oil/natural gas
HHV Fuel (F.O. No. 6)	39,970 Btu/Lt

Technical characteristics of the boiler AB-301B	
Boiler type	Water tube
Capacity	90,720 kg/hr
Start-up year	1978
Remaining useful life of equipment	20 years
Current fuel	Heavy fuel oil/natural gas
HHV Fuel (F.O. No. 6)	39,970 Btu/Lt

Technical characteristics of the boiler AB-301C	
Boiler type	Water tube
Capacity	81,647 kg/hr
Start-up year	1983
Remaining useful life of equipment	20 years
Current fuel	Natural gas
HHV Fuel (Nat. Gas)	36,510 Btu/M3 Std.

Technical characteristics of the boiler AB-301D	
Boiler type	Water tube
Capacity	90,000 kg/hr
Start-up year	1994
Remaining useful life of equipment	20 years
Current fuel	Heavy fuel oil/natural gas
HHV Fuel (F.O. No. 6)	39,970 Btu/Lt