Project design document form for CDM project activities

(Version 05.0)

Complete this form in accordance with the Attachment "Instructions for filling out the project design document form for CDM project activities" at the end of this form.

PROJECT DESIGN DOCUMENT (PDD)	
Title of the project activity	Electricity and heat Generating through a cogeneration system in GerenciaRefinería Barrancabermeja (GRB), Ecopetrol, S.A.
Version number of the PDD	03
Completion date of the PDD	08/01/2015
Project participant(s)	Ecopetrol, S.A.
Host Party	Colombia
Sectoral scope and selected methodology(ies), and where applicable, selected standardized baseline(s)	Sectoral Scope 1:Energy industries (renewable - / non-renewable sources) and Sectoral Scope 4: Manufacturing industries. AM0014 "Natural gas-based package cogeneration"
Estimated amount of annual average GHG emission reductions	193,648 tCO_2

SECTION A. Description of project activity

A.1. Purpose and general description of project activity

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At Gerencia Refinería Barrancabermeja (GRB), there are two different areas: the Refinery Unit, where most processing plants are located, and the Balance Unit, with a lower number of plants, set-up globally, as if they were a package. Steam demand of each area is covered by means of the equipment located in each unit, while the electrical system consists in a ring that allows interconnecting both refinery areas.

In the current configuration, steam is generated by conventional steam generators (B), powered by water, which use refinery gas as fuel. Some of this steam is used in turbine generators (TG), where it is transformed into electric power.

The project activity consists of operating a cogeneration system, whose input is natural gas, with electricity and steam production, replacing steam and electricity generated in separate systems by means of a conventional system with steam generators and turbine generators. In cogeneration system, steam is generated from the recovery of heat coming from turbine combustion gases, using a Heat Recovery Steam Generator (HRSG).This system offers improved efficiency in the process of electric energy generation through the direct use of natural gas as fuel, instead of steam from generators.

The baseline and monitoring methodology applicable is AM0014 'Natural gas-based package cogeneration'.

The main objective of the project activity is to improve energy efficiency at the Refinery, thus contributing to sustainable development, as follows:

- Reduction of greenhouse gases (GHG), about 193,648 tCO_{2e}/year, positively contributing to the mitigation of climate change effects, which implies an improvement in environmental protection.
- Reduction in the Refinery specific fuel consumption, which means saving primary energy generated by non-renewable resources (fossil fuels).
- Reduction in atmospheric emissions of other polluting gases, such as NOx, due to the use of low emission combustion technologies, contributing to the improvement of the quality of local air.
- Reduction in the levels of noise generated, since the new equipment is soundproof and has a maximum noise level of about 85 dBA.
- Reduction in other environmental aspects (resource consumption, waste production and methane leakages) related to the extraction and transportation of natural gas, which is used to supply facilities, due to the lower specific consumption achieved.
- Contribution to local jobs and to the development of basic local services due to the social measures that Ecopetrol implements as a result of the project.

A.2. Location of project activity

A.2.1. Host Party

>>
Colombia

A.2.2. Region/State/Province etc.

>>
Santander Department

A.2.3. City/Town/Community etc.

>>
Municipality of Barrancabermeja

A.2.4. Physical/Geographical location

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The project will be carried out at Gerencia Refinería Barrancabermeja, which is located in the Municipality of Barrancabermeja, Santander Department, in the Andean region, north east of Colombia (Magdalena Medio).The Municipality of Barrancabermeja is located on the right bank of Magdalena River, and bordered by the Sogamoso River and the Municipality of Puerto Wilches to the north; by the Municipalities of Puerto Parra, Simacota and San Vicente de Chucurí (Betulia) to the south; by the Municipality of San Vicente de Chucurí and Girón to the east; and by the Magdalena River to the west.

The geographic coordinates of the project activity are the following:*7°03' 58.5'' N 73°52' 56'' W.* The coordinates in decimal points are the following: 7.066250 (latitude) and -73.882222 (longitude).

Figure 1- Location of "Gerencia Refinería Barrancabermeja"

A.3. Technologies and/or measures

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The project activity consists of the following:

Replacing conventional electricity and steam generation equipment (400 psi steam by B-901/2/3/4, B-951/2, B-956 steam generators and 30 MW from TG-2401/2/3steam turbine) with a cogeneration system, consisting innew cogeneration unit U-5100 (30 MW from TG-5100 natural gas turbine and 150 psi steam by B-5100 heat recovery steam generator).

To calculate the reduction of emissions generated, it is essential to take into account the alternative to the implementation of the project activity (baseline scenario) and the project activity itself. A description of both is presented below:

<u>Baseline Scenario</u>

The Barrancabermeja Refinery Unit uses 400 psi steam and 150 psi steam. 400 psi steam is generated by steam generators (boilers) powered by pre-treated, pre-heated and de-aired water. In these boilers through heat release from refinery gas combustion, water evaporates at 400 psi. 400 psi steam is used to feed turbogenerators (TG) for electricity production and is also degraded to 150 psi for use in different premises at the Refinery Unit. These steam generators include the following equipment: the water evaporation pipe, the super-heater section (to raise the final steam temperature to 750 ºF), the water supply system, fans to keep the air moving and chimneys to release combustion gases into the atmosphere.

In the baseline scenario the Barrancabermeja Refinery continues to operate with equipment replacement and/or equipment upgrade as needed with no change in equipment efficiency in order to supply steam and electricity demand. The equipment that would be used in the baseline scenario are the existing steam turbines (30 MW from: TG-2401/2/3). The steam generators that would be used in the baseline scenario are the existing steam generators, upgrade as needed (B-901/2/3/4, B-951/2 y B-956).

The Refinery electric consumption would be covered, partially, by the power generated by steam turbine generators TG-2401/2/3 (total-condensation turbines). These turbogenerators basically consist of two units, a turbine, consuming 400 psi steam, which generates movement to a second unit, the electricity generator. TG-2401/2/3 are total-condensation turbines, in which the totality of the steam used by the turbine turns into liquid or condensed water, through a steam condenser, using cooling water. This type of turbines suffer a high loss of energy due to the significant heat content that is lost during steam condensation.

In addition, the Refinery has others generators, which being used in order to complete demand requirements of the refinery and as back-up. This equipment will not be affected by the project activity. Refinery is also connected to the country's national electricity network as back-up.

In order to better understand the operation of the baseline scenario and the equipment that is part of it, a diagram of the baseline scenario is shown below. Also includes the emission sources of the baseline scenario, described in Section B.3

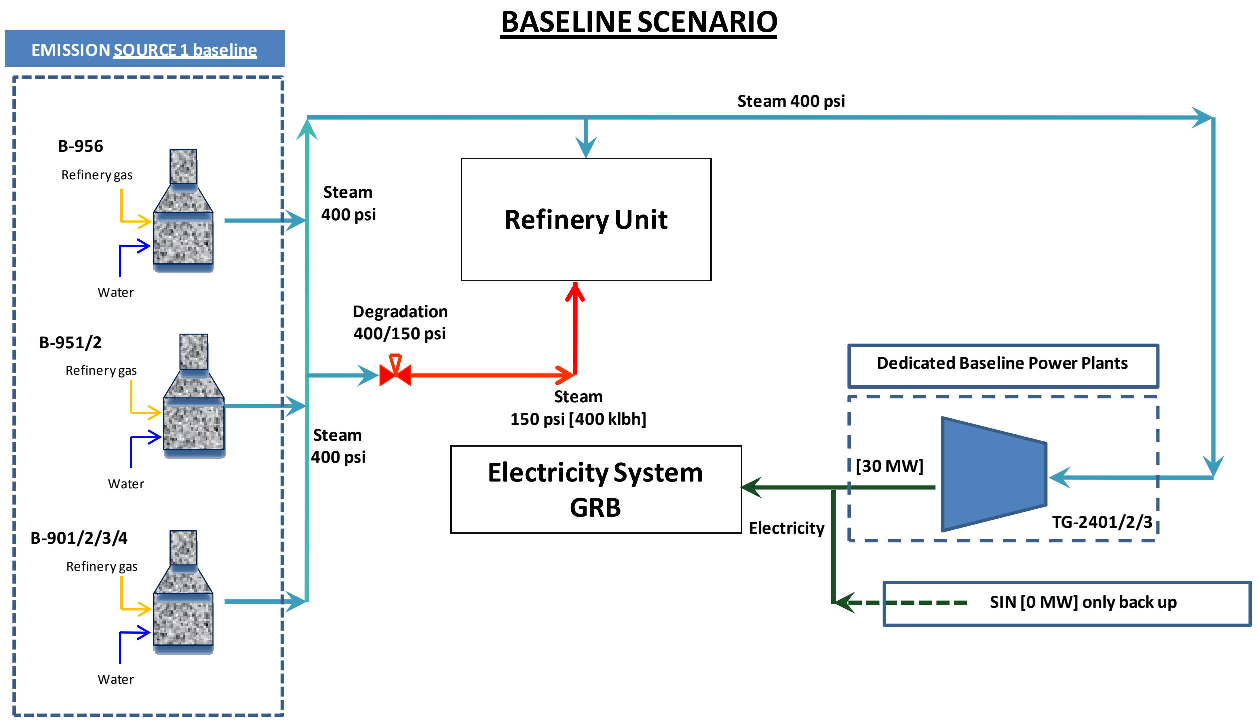

Figure 2- Baseline scenario

Project Activity

The cogeneration system generates both heat and electricity, which involves improved efficiency because heat is utilised. This system basically includes two pieces of equipment: a turbine generator and a residual heat recovery steam generator.

The turbine generator burns natural gas and the kinetic energy released as a result of combustion is used to operate the electric generator system.

A turbine generator is connected to the residual HRSG, which receives the exhaust gas emissions, used to generate 150psi steam, from the turbine generator effluent. In order to increase the steam generation capacity and to meet the demand for steam, the steam generator has an additional refinery gas burning system (post-combustion) under normal conditions. This additional post-combustion energy, which is supplementary to that derived from exhaust gas from the turbine generator, allows for the increase in steam capacity of the generator to the specified value of 400klbh. 183 klbh out of these 400 klbh are produced from the exhaust gases coming from the turbine by burning natural gas and 217 klbh result from the additional burning of refinery gas in the post-combustion of HRSG boiler

The consumption of refinery gas and the steam production (heat output) assigned to refinery gas are not taken into account in the calculation of project activity emissions, according to methodology AM00014.

The two pieces of equipment included in the cogeneration unit have the following features:

Turbine generator:TG-5100

- General Electric MS-6001 B (heavy duty)
- Capacity:35MW (TG is limited to 5 MW, being thus total power limited to 30 MW)
- “Heat rate”: 10952 Btu / KW
- Natural gas consumption: 328.56 MMBtu/h

Heat recovery steam generator (HRSG) B-5100

- Capacity: 400 klbh of steam at 190 psi (max.) and 525 ℉ (183 klbh from natural gas combustion and 217 klbh from refinery gas combustion)
- For design conditions and steam production is 400klbh of steam at 150psi, the consumption of refinery gas is 11,461lbh. (LHV of refinery gas of 20,474 BTU/lb)

The project activity encompasses the installation of a package of cogeneration system whose input is natural gas and whose outputs are electricity and heat supplied to an industry with demand for heat and electricity. Specifically, consists of setting up a cogeneration unit (U-5100) in order to supply 30 MW of electricity generation and 150 psi steam, replacing the steam generators and turbines specified (B-901/2/3/4, B-951/2 and B-956 steam generators and TG-2401/2/3 steam turbine).

As a back-up, the internal electric generation system of the plant will be interconnected with the National Electricity Network of Colombia, with a maximum capacity of 80 MW. This connection will be used in the event of internal failure at the Refinery. In the same way, the Refinery continues to keep others TG as a back up.

A project activity diagram is shown below. This diagram shows the equipment which would operate in the project activity scenario and the related emission sources described in Section B.3.

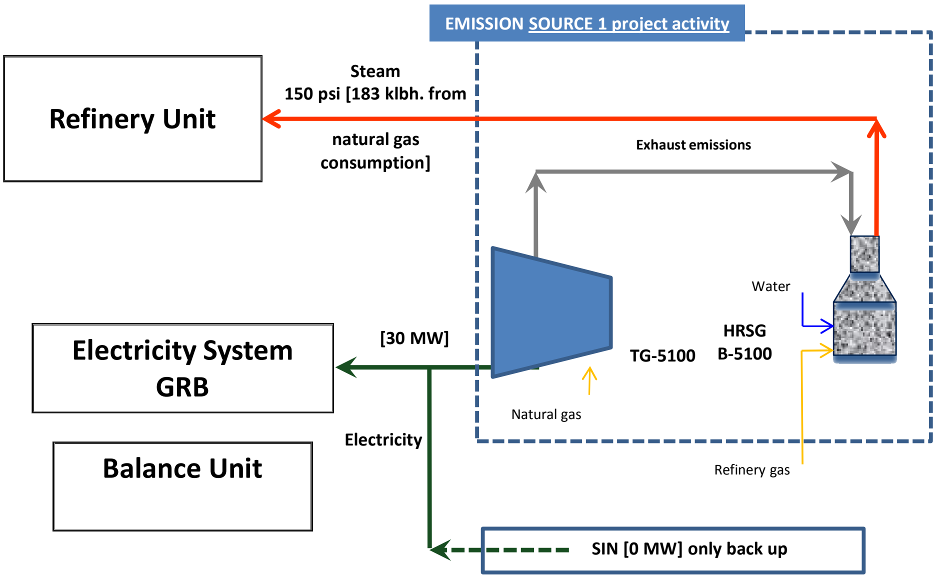

Figure 3-Project activity

A table with a summary of the equipment in baseline and in project activity is detailed below:

Equipment in baseline scenario		Gerencia Refinería Barrancabermeja Unit	Equipment in project activity scenario
Code	**Brand**		
B-901/2/3/4	Foster Wheeler	Refinery Unit	U-5100 (B-5100 + TG-5100)
B-951/2	Babcock&Wilcox	Refinery Unit	
B-956	Distral	Refinery Unit	
TG-2401/2/3	General Electric – "straight condensign"	Refinery Unit	

The following diagrams sow the energy balance of electricity power and steam in the baseline scenario and project scenario.

AM0014

30 MW

BASELINE SCENARIO		
GENERATION POWER CAPACITY (3 equipments)		MW
REFINERY UNIT	TG-2401	10
	TG-2402	10
	TG-2403	10
TOTAL		30

PROJECT ACTIVITY SCENARIO		
GENERATION POWER CAPACITY (1 equipments)		MW
REFINERY UNIT	TG-5100	30
TOTAL		30

AM0014

183 Klbh

BASELINE SCENARIO		
STEAM CAPACITY (7 equipments)		Klbh
STEAM 400psi to 150 psi	B-901/2/3, B-951/2, B-956	183
TOTAL		183

PROJECT ACTIVITY SCENARIO		
STEAM CAPACITY (1 equipments)		Klbh
STEAM 150 PSI	B – 5100 (Cogeneration system)	183
TOTAL		183

A.4. Parties and project participants

Party involved (host) indicates host Party	Private and/or public entity(ies) project participants (as applicable)	Indicate if the Party involved wishes to be considered as project participant (Yes/No)
Colombia	Ecopetrol, S.A.	No

A.5. Public funding of project activity

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This Project will not receive public funding.

SECTION B. Application of selected approved baseline and monitoring methodology and standardized baseline

B.1. Reference of methodology and standardized baseline

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The project activity consists of operating a cogeneration system, whose input is natural gas, with electricity and steam production, replacing steam and electricity generated in separate systems, so the baseline and monitoring methodology applicable is AM0014 ‘Natural gas-based package cogeneration’ version 04.

B.2. Applicability of methodology and standardized baseline

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Approved methodology AM0014 is applicable to natural gas based cogeneration projects under the following conditions:

CRITERIA OF THE METHODOLOGY	COMPLIANCE	JUSTIFICATION
The electricity and heat requirement of the consuming facility is generated in separate systems (i.e. electricity and heat in the baseline cannot be generated in another cogeneration facility) in the absence of the project activity	The electricity and heat in the baseline are not generated in a cogeneration facility	The baseline implies that a conventional steam and electricity production system should continue to be operated. Therefore, in the absence of the project activity, heat and electricity would be generated in separate systems.
The cogeneration system is either third party cogeneration systems, i.e. not owned or operated by the consuming facility that receives the heat and electricity from project cogeneration systems or the cogeneration system is owned by the industrial user (henceforth referred to as self-owned) that consumes the heat and electricity from project cogeneration systems	The cogeneration system in Gerencia Refinería Barrancabermeja will be legally owned and operated by Ecopetrol S.A. Gerencia Refinería Barrancabermeja is the only consumer of the electricity and heat produced by the cogeneration system.	The cogeneration model that Ecopetrol suggests for this project activity does not consider the property and/or operation by a third party. Regarding this subject, the cogeneration equipment is purchased by Ecopetrol and this purchase shall be part of the refinery’s licenses.
The cogeneration system provides all or a part of the electricity and or heat demand of the consuming facility;	The cogeneration system will supply electricity and heat to Gerencia Refinería Barrancabermeja.	See energy balance included in section A.3
No excess electricity is supplied to the power grid and no excess heat from the cogeneration system is provided to another user;	No electricity generated by the cogeneration system will be exported to the grid. No heat will be provided to another user	The Gerencia Refinería de Barrancabermeja (GRB) operates its electrical energy generators as Autogenerator, under the category of Non-regulated User, according to Resolution 084 of 1996 of the Energy and Gas Regulatory Commission, a condition under which they are only used to cover their own demand requirements

CRITERIA OF THE METHODOLOGY	COMPLIANCE	JUSTIFICATION
		and does not use the public network for purposes other than getting back-up from the National Interconnected System.
In the case project activity displaces electricity from fossil fuel based, dedicated power plant(s), methodology can only claim reductions from only that fraction of displaced electricity from the baseline dedicated power plant(s), for which it can be demonstrated that project activity led to reduction in generation of baseline dedicated power plant (s).	Baseline dedicated power plant(s) will not be operating along with the project activity, so all electricity produced by the baseline dedicated power plant(s) will be reduced in the same amount as the electricity generated by the project activity cogeneration plant	The baseline dedicated power plant(s) will be removed. The project does not consider that the baseline dedicated power plant(s) may operate in the project activity scenario and, therefore, could generate additional electricity which would entail that the reduction accomplished in these dedicated power plant(s) were not at least equivalent to the generation of the cogeneration.

As seen above, all the applicability criteria of the selected methodology are met by the proposed project. It is a self-owned system, provides all or a part of the electricity and heat demands of the consuming facility, and produces no excess electricity for export to the grid, and no excess heat to other users.

B.3. Project boundary

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The spatial extent of the project boundary encompasses all the anthropogenic emissions by sources of greenhouse gases under the control of the project participants that are significantly and reasonably attributable to the project activity. The project activity encompasses the natural gas based cogeneration system where from no excess heat or electricity is exported outside the industrial facility.

The spatial extent of baseline system boundary encompasses refinery gas boiler to meet up the thermal demand of the industrial facility and steam for steam turbines for generating electricity, and present cogeneration system for electricity generation.

The baseline emission comprises of the following emission sources:

- CO_2, CH_4 and N_2O emissions correspondinding to the combustión of baseline fuel that would have been used if the cogeneration system did not provide heat to the plant and CO_2 emissions associated with the electricity that would have to be generated through dedicated fossil fuel power planta(s) if the cogeneration system not provide electricity to the plant:
  - Direct onsite emission of carbon dioxide, methane and nitrous oxide due to combustion of refinery gas for thermal energy generation (steam).
  - Direct onsite emission of carbon dioxide due to combustion of refinery gas for steam for electricity generation.

The spatial extent of project boundary encompasses emission from combustion of natural gas in the cogeneration system that will be implemented and cogeneration system which will be upgrading.

The project emission comprises of the following emission sources:

- Direct onsite emission of carbon dioxide, methane and nitrous oxide due to combustion of natural gas for steam and electricity cogeneration.
- Indirect off site emission of methane from pipeline leakage associated with transport and distribution of natural gas.

	Source	GHGs	Included?	Justification/Explanation
Baseline scenario	**Source 1 Baseline:** GHG emissions from refinery gas combustion in boilers B-956, B-951/2, B-901/2/3/4 for heat (**183 klbh of steam**) and for **30 MW**	CO_2	Yes	Emitted from combustion of refinery gas
		CH_4	Yes	Emitted from combustion of refinery gas
		N_2O	Yes	Emitted from combustion of refinery gas
Project scenario	**Source 1 Project Activity** GHG emissions from natural gas combustion in Cogeneration System (TG-5100) for heat (**183 klbh of steam**) and and for new **30 MW** installed	CO_2	Yes	Emitted from combustion of natural gas
		CH_4	Yes	Emitted from combustion of natural gas
		N_2O	Yes	Emitted from combustion of natural gas
	Natural gas leakage	CO_2	No	Not considered by the methodology (minor emission source)
		CH_4	Yes	Emission from pipeline leakage associated with transport and distribution of natural gas consumed in generation units
		N_2O	No	Not considered by the methodology (minor emission source)

B.4. Establishment and description of baseline scenario

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The baseline for a CDM project activity is the scenario that reasonably represents the anthropogenic emission by source of greenhouse gas that would occur in absence of the project activity.

The baseline scenario represents the most potential alternatives from among the different scenarios or option existing before the project proponent. The baseline scenario for the project activities are selected through analysis of alternative baseline scenario consistent with current laws and regulation. The scenario below represents the potential alternatives that presented themselves to the project proponent.

The continuation of baseline activity was one of them while implementing the proposed project activity was an option. In accordance with section B.1, the applicable methodology for the selection of the baseline scenario and the assessment of additionality is AM0014 version 04. So, the determination of baseline scenario involves consideration of the following alternatives to the proposed project.

Description of the alternative	Is the Alternative a Baseline Scenario?	Rationale
Alternative 1. Industrial plant continues to operate with equipment replacement as needed with no change in the equipment efficiency (The frozen-efficiency scenario).	Yes	Continuation of the baseline scenario would require investment on the part of the Project Developer in the equipment replacement as need or equipment upgrading as need, and would not face any technological or other barriers. Steam would continue to be provided by boilers upgraded, and the electricity would continue to be provided by steam turbines upgraded. Therefore, the business as usual scenario in this type of industry, and also in this region, would be the continuation of the use of refinery gas boilers and the steam turbine.
Alternative 2. Industrial plant continues to operate with improved efficiency new equipment at the time of equipment replacement using a less carbon intensive fuel.	No	Taking into account there is refinery gas available and that current equipment with separated heat and electricity generation is highly efficient, its replacement by other equipment with similar features (standard heat and steam generation) using less carbon intensive fuels, not being cogeneration systems (project scenario), is not considered, as the reduction would not be significant to justify the high investment needed for the change of the current equipment for similar ones. Therefore consideration of this alternative as the baseline scenario is not feasible.
Alternative 3. Industrial plant upgrades the thermal energy generating equipment and therefore increases the efficiency of the boiler(s) immediately.	No	Given that the baseline scenario considers a high efficiency (conservative approach), there is little scope for increasing the efficiency of the boilers further, nor would this provide outputs (i.e. energy efficiency savings) comparable with the project activity. Therefore this alternative will not be considered further.
Alternative 4. The heat and electricity demand of the industrial plant is reduced through improvement in end use efficiency.	No	The improvement of energy efficiency is a corporate strategy of the project participant and is regularly implemented in the different processes, as it is considered necessary by the "Barrancabermeja Refinery Management" according to the operation conditions and the planned stops and renovations of process units. As the project teams provide auxiliary services (energy and steam) to a large number of process units, the reduction of refinery global nature demand is not considered baseline scenario at the moment but gradually according to the above-said. Therefore this scenario cannot be considered as the baseline scenario.
Alternative 5. Installation of a cogeneration system owned by the industrial plant	Project Scenario	This represents the proposed project scenario. The adoption of a natural gas based package cogeneration system is, as shown in section B.5, among the very few industrial applications of

Description of the alternative	Is the Alternative a Baseline Scenario?	Rationale
		cogeneration in the Host Country. The project activity requires high capital investment, and the Project Developer has to face institutional and technological barriers. Therefore this scenario cannot be considered as the baseline scenario.
Alternative 6. Installation of a package cogeneration system owned by a company other than the industrial plant.	No	In the initial analysis phase of the project, the option of the energy supply being performed under the ESCO energy services modality was evaluated, although aspects such as loss of operational independence, high reliability required and high investment necessary by the possible lending entities made Ecopetrol reject this alternative. Therefore consideration of this alternative as the baseline scenario is not feasible.
Alternative 7. Installation of a cogeneration system by a third party.	No	The consideration of this alternative as the baseline scenario is not feasible for the same reasons stated in the previous section.

B.5. Demonstration of additionality

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The following timeline shows the main actions and milestones achieved.

Timeline of events of the project activity

Date:	Event
10 october 2008	No objection letter of DNA
September 2011	Approval of Fase III of PMSI: Plan Maestro de Servicios Industriales (Industrial Services Master Plan); time of investment decision
18 november 2011	Purchase of equipment that involves major expenditure (TG-5100): start date
22 december 2011	Project participant sent the Prior Consideration of the Project to the UNFCCC
10 january 2012	Project participant sent the Prior Consideration of the Project to the DNA
19 jun 2012	Stakeholders consultation
13 november 2012	Agreement with DOE for validation services
28 december 2012	Letter of approval (LoA) from Colombian DNA
25 january 2013 to 23 february 2013	Public stakeholder consultation of PDD
01 january 2015	Starting Crediting Period

According to the methodology AM0014, the project developer can demonstrate additionality by selecting one of the following two options:

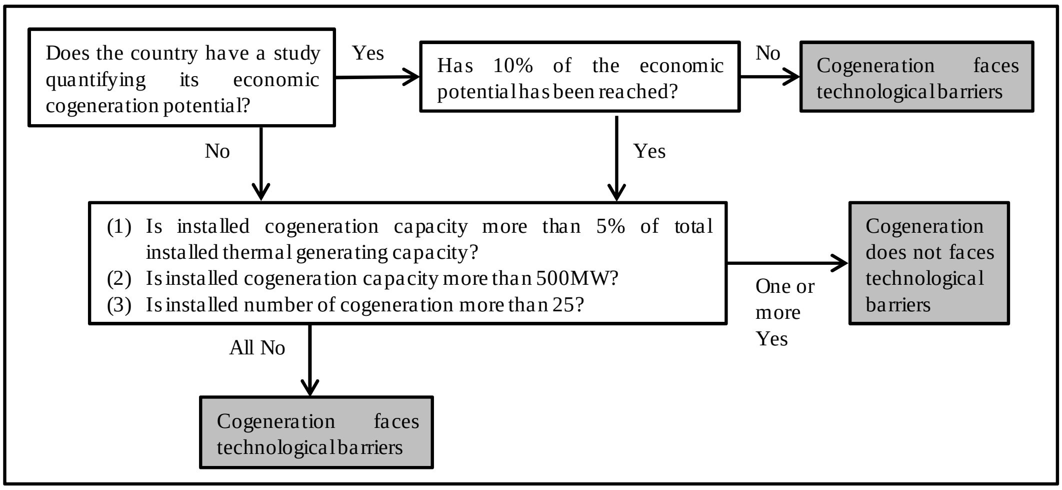
- Option 1: apply step 2 of the latest version of “Tool for demonstration and assessment of additionality” (Investment Analysis).
- Option 2: Methodology-specific process for determination of additionality included in the methodology AM0014.

For this project activity has been selected option 2.

The Methodology-specific process for determination of additionality was applied with four additionalitytest. The first two tests are applicable to any cogeneration ownership scenario. The third test is specific to the “package cogeneration” case where the cogeneration system is owned by a party other than the industry using the heat and electricity from de system. The fourth test is specific to “package cogeneration” case for the self-owned cogeneration system. In the case of self owned Cogeneration project activities, as in this case, the project activity is additional if all the four additionality tests result in project being assessed as additional.

1. **Are there technological barriers to cogeneration in the country?**

Additionality test 1 is applied for following the flow chart below. A low share of cogeneration means that there is insufficient infrastructure to support installation and maintenance of such system, acting as a technological barrier to project participants.

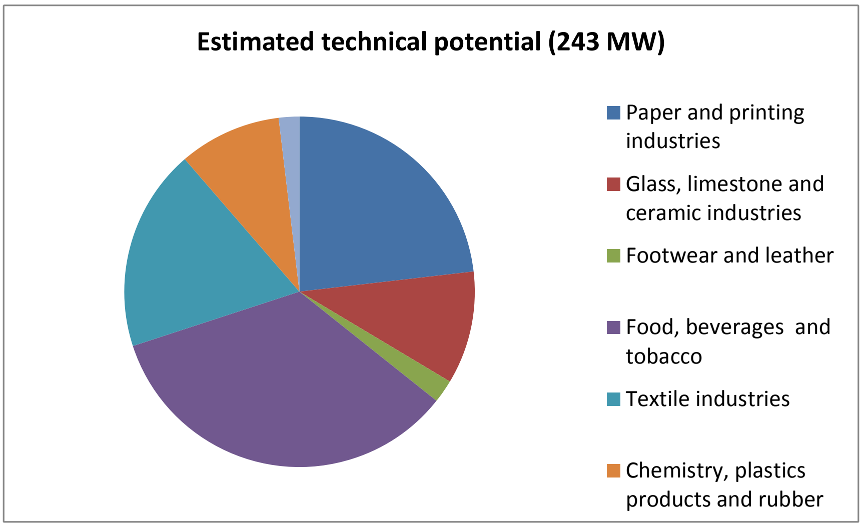


Step 1- Does the country have a study quantifying its economic cogeneration potential?

Between 1996 and 1998, the Mining and Energy Planning Unit (*Unidad de Planificación Minero Energética*, UPME) carried out two studies, namely *Development of Cogeneration Potential in the Country (Desarrollo del potencial de cogeneraciónen el país)* and *Determination of Cogeneration Potential in the Tertiary Sector of the Country (Determinación del potencial de cogeneración en el sector terciario del país).*In the first of these documents, the country's technical potential calculated was 248 MW, excluding the sugar industry, and the resulting economic potential of the country was 177 MW. That potential was calculated based on the answers obtained from 52 industries (of the 150 industries surveyed), which account for 66 % of the total equivalent energy demand.

Taking into account that the electric energy/thermal energy ratio of the industries with the same economic activity is similar, and according to the potential levels resulting from the survey, *UPME* determined that the country's total cogeneration technical potential was 243 MW. Although this extrapolation is less precise due to other influential factors, it may be carried out in the same fashion with the economic potential, with a result of 200 MW.

As the following chart shows, this economic potential is distributed among different industries:



In the second study carried out by *UPME*, an economic potential of 31.6 MW was identified in hotels and hospitals.

In 2002, *UPME* published the report *Determination of the Economic and Technical Potential of the Rational and Efficient Use of Energy in the Colombian Textile Industry (Determinación del potencial técnico y economic del URE en el sector textil colombiano*), in which an economic potential of 100 MW was identified. This potential replaces the potential of almost 38 MW calculated in the 1996 study (18.68 % of the economic potential of 200 MW).

Finally, in 2003, *UPME* carried out the study *Cogeneration in the Sugar Industry Introducing and Using the ESCO Approach* (*Cogeneración para el sector azucarero introduciendo y aplicando el enfoque ESCO*), in which a potential of 164–176 MW was identified. Based on a conservative approach, an economic potential of 164 MW will be considered in the analysis.

Consequently, the estimated economic potential of the country is about 458 MW.

Step 2- Has 10% of the economic potential been reached?

According to Chapter 3.2.1 of the Reference Expansion Plan Generation-Transmission 2010-2014 *(Plan de Expansión de ReferenciaGeneración-Transmisión 2010-2024)* of *UPME* of the Colombian Ministry of Mining and Energy (*Ministerio de Minas y Energía de la República de Colombia*), the cogeneration capacity of the country by the end of 2009 was 57 MW. According to the Reference Expansion Preliminary Plan Generation-Transmission 2011-2025 *(Plan Preliminar de Expansión de ReferenciaGeneración–Transmisión 2011-2025)*, of the projects implemented in 2010 and January 2011 (Table 3-1, Page 45) only one of them was a cogeneration project, with a capacity of 19.9 MW (Mayagüez Cogenerator).This means that, according to the most recently available information, the installed cogeneration capacity of the country is 76.9 MW.

Consequently, according to these values, it may be concluded that 10 % of the estimated economic potential of the country has been reached, since this capacity accounts for 16.8 % of the potential.

Step 3a- Is installed cogeneration capacity more than 5% of total installed thermal generating capacity?

Chapter 3.2.1 of the Reference Expansion Plan Generation-Transmission 2010-2014 of *UPME* indicates that the total effective net capacity by the end of 2009 was 13 543 MW, of which

4467 MW were the result of thermal generation. The following chart shows the division of the total capacity according to the technology used:

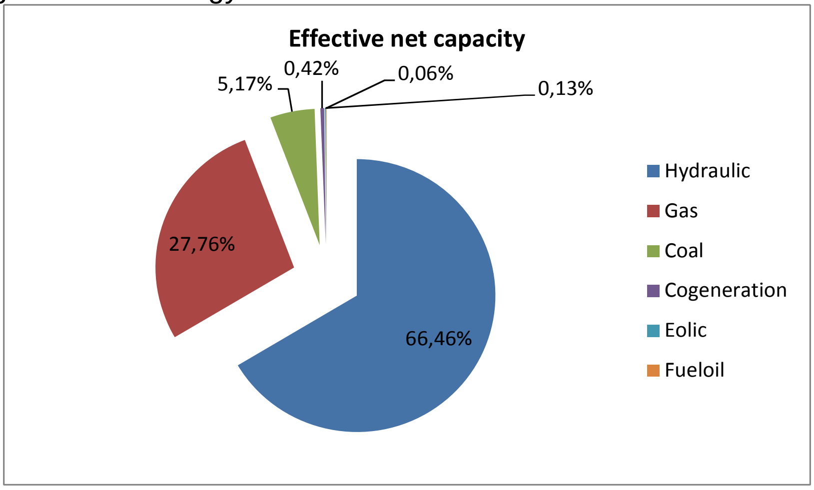


Table 3-1 of the Reference Expansion Preliminary Plan Generation-Transmission 2011-2025 shows a list of the projects that were implemented in 2010 and January 2011, with a total power capacity of 741 MW, that means that total capacity of the country amounts to 14 284 MW (13543 MW + 741 MW).Due that none of these projects listed is thermal, so thermal capacity still is 4467 MW.

According to the cogeneration capacity of the country, it may be noted that it does not account for more than 5 % of the total thermal generation of the country (it accounts for 1.7 %).

Step 3b- Is installed cogeneration capacity more than 500 MW?

According to the most recent data, the installed cogeneration capacity is 76.9 MW. Consequently, it is lower than 500 MW.

Step 3c- Is installed number of cogeneration more than 25?

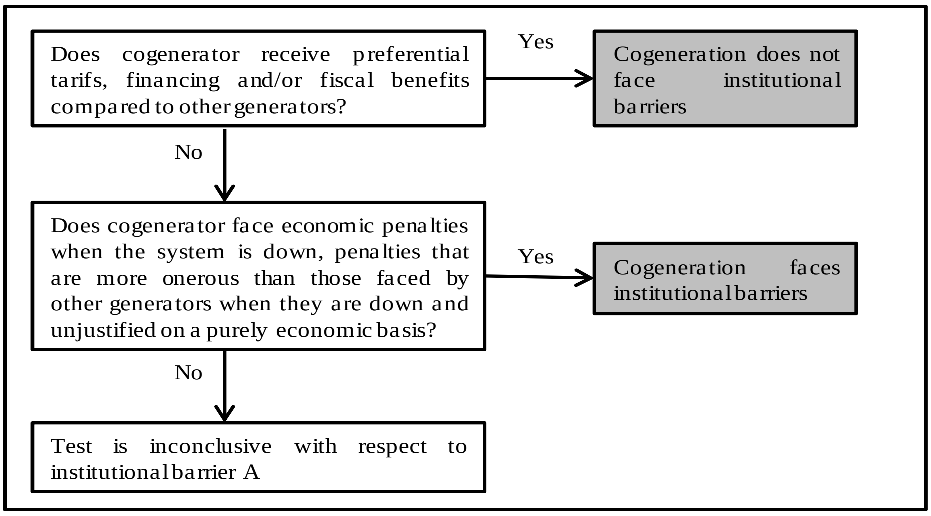
According to the data provided by *UPME*, the total number of cogeneration plants amounts to 13; hence it is lower than 25. Below there is a list of the cogeneration plants.

1. Cogenerador Central Castilla 1
2. Cogenerador Central Tumaco 1
3. CogeneradorIngenio San Carlos I
4. CogeneradosMayagüez
5. CogeneradorPapelesNacionales 1
6. CogeneradorIncauca 1
7. CogeneradorIngenio la Carmelita 1
8. CogeneradorIngenioPichichi 1
9. CogeneradorIngenioProvidencia 21
10. CogeneradorIngenioRiopaila 1
11. CogeneradorIngenio Risaralda 1
12. CogeneradorProenca 1
13. CogeneradorColtejer

Therefore, according to test 1, cogeneration faces a technological barrier.

2. **A. Institutional barrier: Are there institutional barriers to cogeneration in general?**

Additionality test 2A is applied by following the flow chart below. It should be noted that even if preferential tariffs or other incentives do exist, they may not be sufficient to promote cogeneration.



Step 1- Does cogenerator receive preferential tariffs, financing and/or fiscal benefits compared to other generators?

The entity responsible for the control of the cogeneration activity is the Energy and Gas Regulatory Commission (*Comisión de Regulación de Energía y Gas, CREG*), established by Acts 142 and 143 passed in 1994. One of its functions is to guarantee that an efficient energy offer is provided. Therefore, *CREG* establishes, under Resolution 085, passed in 1996, the rules that govern the cogeneration activity in Colombia. Some additional clarifications are detailed in Resolution 107, passed in 1998, and in Resolutions 032 and 039, passed in 2001. One of the specifications of *CREG* for autogenerators and cogenerators is to establish criteria for guaranteed energy and power sales agreements among electricity companies, and between these companies and major users.

In Colombia, there is no differential rate for cogenerators. In fact, until 2008, their surpluses could not be sold in the market unless they complied with a very stringent thermal energy/electric energy ratio checked by audits. The surplus sale of cogeneration systems in the country is governed by Act 1215, passed in 2008.

Moreover, Colombian cogeneration systems must meet technical and efficiency conditions and requirements established by *CREG* under Resolution 005, passed in 2010, and are subject to audits through which compliance with such parameters, regulated under *CREG's* Resolution 047, passed in 2011, is checked.

Step 2- Does cogenerator face economic penalties when the system is down, penalties that are more onerous than those faced by other generators when they are down and unjustified on a purely economic basis?

Ecopetrol operates cogeneration under the Selfgenerator regime, thereby exclusively producing electrical power to cater for its own needs and not being able to sell its energy either partially or totally. Therefore, it cannot use the Public Network for purposes other than gaining SIN's (National Interconnected System) support. To be able to enjoy SIN's support, it is necessary to have an infrastructure complying with a series of parameters and requirements provided by the CREG (Energy and Gas Regulating Committee). As a result of the criticality of the operation, in case the cogeneration system fails, for Ecopetrol to obtain SIN's support, it needs said Support Connection, which implies that Ecopetrol undertakes the construction and continuous maintenance of an associated infrastructure that complies with all the technical requirements provided by the CREG, which will also be subject to permanent audits for the verification of its compliance. This implies an

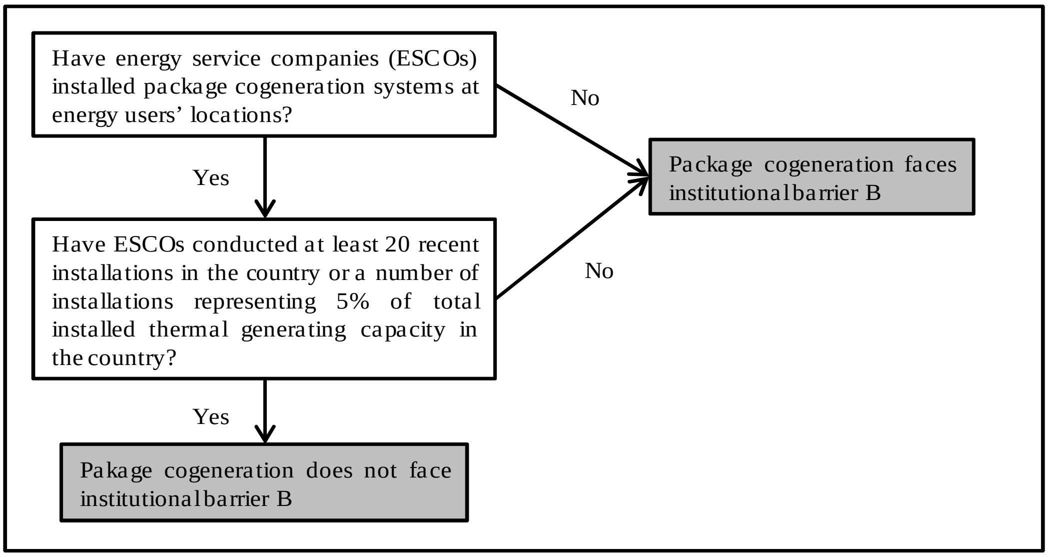
additional investment to the project's activity. Besides all these costs, it is necessary to make additional payments for the purchase of energy in case of cogeneration system failure, according to the market rates applicable in each case, without the possibility of signing continuous supply contracts with more favourable rates. All these extra costs are more onerous than the operation of other generators and cogeneration system under the modality of energy sale to the SIN, which would make it possible to obtain remuneration for the sale of energy excesses, which would in turn improve the recovery of investments.

Therefore, according to test 2A, cogeneration faces an institutional barrier.

2. **B. Institutional barrier for ESCOs: Are there institutional barriers to the "package cogeneration" operational context?In other words, is there enough experience in which one company installs a cogeneration system at the location of a separate energy user?**

The traditional practice is for an industrial user to meet their electricity and natural gas demand by purchases from power and gas companies respectively. In a packaged cogeneration system, the institutional arrangement is very different. In this case, the project developer invests in and installs the cogeneration system at the industrial user site, and provides electricity and heat to that user. This institutional arrangement requires project developer to have special management resources and organizational capacity, and for the industrial energy user to accept this arrangement. Where such experience is lacking, promoting the new arrangement involves a significant institutional barrier.

Additionality test 2B is applied by the following flow chart below:



Step 1- Have energy service companies (ESCOs) installed package cogeneration systems at energy users' locations?

In Colombia, there is no available information about the implementation of cogeneration packages by ESCOs. However, it is widely known that this type of management is being implemented in the country. The purpose of the Colombian Programme for the Rational and Efficient Use of Energy and Non-Conventional Sources (*Programa de Uso Racional y Eficiente de Energía y Fuentes no convencionales, PROURE*), within the strategic sub-programme Financial Strategy and Market Boost *(Estrategia Financiera e Impulso al Mercado)*, consists of "Promoting and fostering new market schemes based on performance agreements through the promotion of ESCO-like business configurations, adapted to our legal systems, for the design of contracts and agreements among the parties."

The United Nations Development Programme (UNDP), the Colombian Association of Sugarcane Growers (*Asociación de Cultivadores de Caña de Azúcar de Colombia, ASOCAÑA*), the Mining and Energy Planning Unit(*UPME*) and the Ministry of Environment, Housing and Territorial Development (*Ministerio de Ambiente, Vivienda y Desarrollo Territorial, MAVDT*) carried out a study for the implementation of the ESCO approach in the sugar industry.

Step 2- Have ESCOs conducted at least 20 recent installations in the country or a number of installations representing 5% of total installed thermal generating capacity in the country?

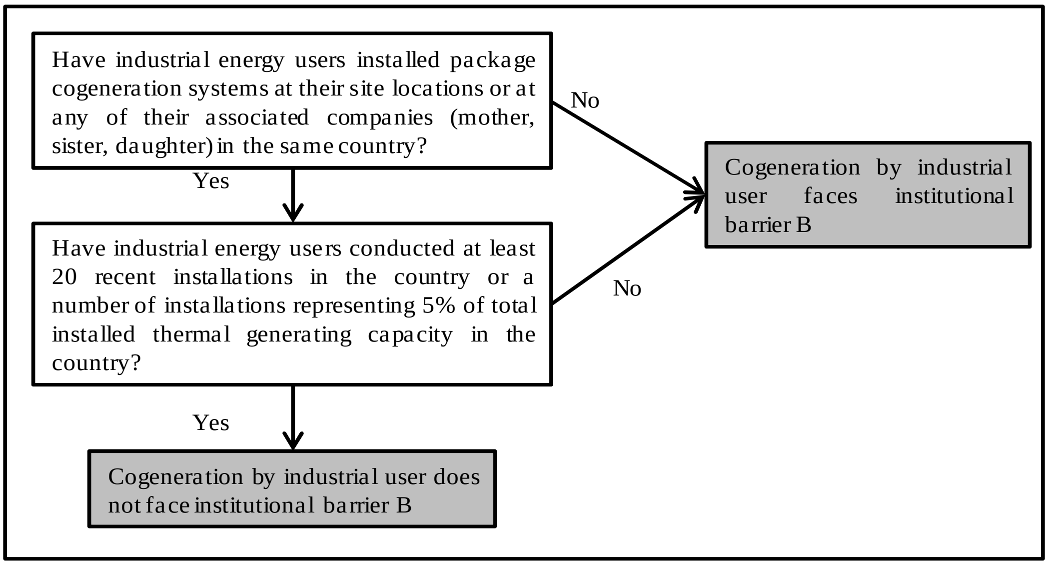
In the country, no data on the number of facilities developed using an ESCO approach has been published. The abovementioned study, *Cogeneration in the Sugar Industry Introducing and Using the ESCO Approach*, indicated that, when it was carried out, in Colombia, ESCOs were not strongly consolidated. This was one of the reasons why the study was carried out. The document *ESCOs and SMART GRID. Analysis and Concepts(ESCOs y SMART GRID. Análisis y Conceptos),* written by Juan Carlos Castro Castro, Fabio Nelson Orrego and Professor Carlos Jaime Franco from the National University of Colombia (*Universidad Nacional de Colombia*), February 18, 2011, explains that, in Colombia, ESCOs are not strongly implemented.

In order to improve the percentage of installed thermal capacity (5 %) in the country, the installed capacity of cogeneration implemented by ESCOs should be higher than 223.35 MW.

Therefore, according to test 2B, cogeneration faces an institutional barrier.

2. **C. Institutional barriers for Industrial Users: Are there institutional barrier to the "Package Cogeneration" operational context? In other words it there enough experience in which an industrial user can install and operate a cogeneration system at it's plant premises?**

Additionality test 2C is applied by the following flow chart below:



Step 1- Have industrial energy users installed package cogeneration system at their site locations or at any of their associated companies (mother, sister, daughter) in the same country?

As seen in step 3c of the point 2 of the paragraph B.5., there are 13 cases of installed cogeneration systems in the energy user´s Host Country, so the answer to the question is "YES" as there are industrial co-generation users in the country.

Ecopetrol has only a cogeneration system (TG-2961), which is the system repowered in the project activity, so Ecopetrol has no experience in the operation of these kind of systems. In addition, Ecopetrol has two cogeneration systems in operation in the department of Meta, but they do not exploit the residual energy of the exhaustgases from the turbine, so really they don't function as cogeneration systems.

Step 2- Have industrial energy users conducted at least 20 recent installations in the country or a number of installations representing 5% of total installed thermal generating capacity in the country?

The number of current installation is below 20, and their thermal capacity is below 5% of the installed thermal generating capacity in Colombia.

Therefore, it is demonstrated that and institutional barrier to "package cogeneration" is faced by industrial energy users in the Host Country.

B.6. Emission reductions

B.6.1. Explanation of methodological choices

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Baseline Emission calculation

According to AM0014, baseline emissions are those emissions that those associated with the production of heat and electricity that are offset by the output of the cogeneration system.Baseline emissions comprise five components:

a) **CO_2 from combustion.**CO_2 emissions corresponding to the combustion of a baseline fuel that would have been used if the cogeneration system did not provide heat to the plant.
b) **CH_4 from combustion.**CH_4 emission corresponding to the combustion of a baseline fuel that would have been used if the cogeneration system did not provide heat to the plant.
c) **N_2O from combustion.**N_2O emissions corresponding to the combustion of a baseline fuel that would have been used if the cogeneration system did not provide heat to the plant.
d) **CH_4 leaks during production of the baseline fuel.** If the baseline fuel is natural gas, CH4 emissions from natural gas production and leaks in the transport and distribution pipeline supplying the plant and leaks in the gas distribution piping within the plant, associated with the natural gas consumption identified in item (a) above. For other types of fuel, the baseline emissions associated with production and transportation are assumed zero for simplification and conservatism.
e) **CO_2 from electricity generation.**CO_2 emissions associated with the electricity that would have to be purchased from the power grid or CO_2 emissions associated with the electricity that would have to be generated through dedicated fossil fuel power plant(s) if the cogeneration system did not provide electricity to the plant.

The baseline emissions for the first four emission sources listed above are proportional to the amount of baseline fuel consumption in the plant that is offset by heat supplied by the natural gas cogeneration system.Each can be represented as the product of an emissions factor and an energy consumption, which depends on the heat output of the cogeneration system.

The consumption of the fuel avoided in the baseline for the supply of heat is determined as follows:

$$ABEC_{BF} = \frac{CAHO}{e_b}$$

[Equation 1]

Where

- $ABEC_{BF}$ (GJ/year)= Annual energy consumption for heat supply at baseline plant
- CAHO = annual heat output from cogeneration system (GJ/year)
- eb = industrial boiler efficiency (fraction, lower heating value basis).

The annual heat output from the cogeneration system (CAHO) is estimated on the basis of the heat output rate of the cogeneration system (CHOR) and an estimate of annual operating hours (AOH) of the cogeneration system. The formula is described below:

$$ABEC_{BF} = \frac{CHORx\ AOH}{e_b}$$

[Equation 2]

Where:

- $ABEC_{BF}$ (GJ/year)= Annual energy consumption for heat supply at baseline plant
- CHOR = cogeneration system heat output rate (GJ/h),
- AOH = Annual operating hours (h/year)
- eb = boiler efficiency (fraction, lower heating value basis)

In order to be conservative, the default value of 0.90 proposed by the methodology has been chosen.

The value of **CHOR** has been determined from the specifications of the cogeneration system and has value of 246.6 GJ/h. (183 klbh). **AOH** has been determined from the engineering study of the proposed cogeneration system and has a value of 8,540 h.

Once the boiler energy consumption has been quantified, the four GHG emissions components (a to d, above) can be determined, as indicated below.

a) Baseline CO_2 emissions from combustion of baseline fuel for heat supply

Baseline CO_2 emissions from combustion of baseline fuel for heat supply, $\mathbf{BE_{th}}$ (tonnesCO2/year):

$$BE_{th} = ABEC_{BF} \cdot EF_{BF}$$

[Equation 3]

Where:

- BE_{th} = Baseline CO_2 emissions from combustion of baseline fuel for heat supply (tonnesCO_2/year)
- $ABEC_{BF}$ = annual energy consumption for heat supply at baseline plant (GJ/year)
- EF_{BF} = CO_2 emission factor of the fuel used to generate heat (tCO_2/GJ)

The value of $\mathbf{EF_{BF}}$ has been estimated from the first data sources listed in the methodology AM0014, national GHG inventory, with a value of 54.227 tCO_2/TJ for refinery gas. It has been used the FECOC tool. Tool from the UPME for calculation of emission factor of Colombian fuels.

b) Baseline methane emissions from combustion of baseline fuel for heat supply to plant

$$BE_{met\ comb} = \frac{ABEC_{BF}}{10^6}\ x\ MEF$$

[Equation 4]

Where:

- $BE_{met\ comb}$ = Baseline methane emissions from combustion of baseline fuel for heat supply (tonne CH_4/year)
- $ABEC_{BF}$ = annual baseline energy consumption for heat supply (GJ/year)

- MEF = methane emission factor for baseline fuel combustion (kg CH_4/TJ), lower heating value basis)

In units of carbon dioxide equivalent, **BE** $_{\text{equity met comb}}$ **(tonne CO_{2eq}/year)** is:

$$BE_{equiv\,met\,comb} = BE_{met\,comb}\, x\, GWP(CH_4)$$

[Equation 5]

Where:

- GWP (CH_4) isglobal warming potential of methane = 25

The value of **MEF** has been estimated from the second data sources listed in the methodology AM0014, the IPCC, fuel type and technology specific, with a value of 0.3 kgCH_4/TJ.

c) Baseline nitrous oxide emissions from combustion of baseline fuel for heat supply to plant

$$BE_{N2O\,comb} = \frac{ABEC_{BF}}{10^6}\, x\, NEF$$

[Equation 6]

Where:

- $BE_{N2O\ comb}$ = Baseline nitrous oxide emissions from combustion of baseline fuel for heat supply ((tonne N_2O/year)
- $ABEC_{BF}$= annual baseline energy consumption for heat supply (GJ/year)
- NEF = nitrous emission factor for fuel combustion (kg N_2O/TJ), lower heating value basis.

In units of carbon dioxide equivalent**, BE** $_{\textbf{equity met comb}}$ (tonne CO_2eq/year) is:

$$BE_{equiv\ N2O\ comb} = BE_{N2O\ comb}\, xGWP(N_2O)$$

[Equation 7]

Where:

- GWP (N_2O) = global warming potential of nitrous oxide = 298

The value of **NEF** has been estimated from the second data sources listed in the methodology AM0014, the IPCC, fuel type and technology specific, with a value of 0.03 kgN_2O/TJ.

d) Baseline methane emissions from natural gas production and pipeline leaks in the transport and distribution

This section is applicable only for projects that displace natural gas in the baseline for heat generation. In this case, the fuel displaced is refinery gas, so this section has not been considered.

e) Baseline emissions of CO2 from electricity supply to industrial plant that is offset by electricity supplied from cogeneration system

The final item of GHG emissions in the baseline arises from electricity, corresponding to the emissions avoided at the power plants supplying the public grid / CO_2 emissions associated with the electricity that would have to be generated through dedicated fossil fuel power plant(s). The relevant formulae are described below:

1. Electricity Displaced from Public System:

Baseline carbon dioxide emissions for electricity supplied, **BE** $_{\textbf{elec grid}}$(tonne CO_2/year):

$$BE_{elec\ grid} = \frac{CEO}{10^3} x\ BEF_{elec\ grid}$$

[Equation 8]

Where:

- *CEO* **=** cogeneration electricity output (MWh/year), and
- $BEF_{elec\,grid}$= baseline CO_2 emissions factor for electricity from public supply (kg CO_2/MWh)

There are no emissions avoided at the power plants supplying the public grid, because all electricity in baseline scenario would have to be generated through dedicated fossil fuel power plants.

2. Electricity displaced, that would have to be generated through dedicated fossil fuel power plant(s):

Baseline carbon dioxide emissions for electricity supplied,**BE** $_{\textbf{elec fossil fuel}}$(tonne CO2/year):

$$BE_{elec\ fossil\ fuel} = \frac{CEO}{10^3} x\ BEF_{elec\ fossil\ fuel}$$

[Equation 9]

Where:

- *CEO* **=** Cogeneration Electricity Output (MWh/year), and
- $BEF_{elec\,fossil\ fuel}$ = Baseline CO_2 emissions factor for electricity from the dedicated fossil fuel power plant(s) (kg CO_2/MWh)

$$BEF_{elec\ fossil\ fuel} = \frac{\sum\left(PG_{i,n} * SEF_{i,n}\right)}{\sum\left(PG_{i,n}\right)}$$

[Equation 10]

Where:

- o $PG_{i,n}$= Power generated by sources i (in MWh), by relevant power sources n, sources delivering electricity to the consuming facility
- o $SEF_{i,n}$= Specific CO_2 emissions factor of the fossil fuel power generation sources n (in terms of kg/ MWh), sources delivering electricity to the consuming facility
- o *n* = Number of fossil fuel power generation sources

The actual baseline emissions are determined by monitoring cogeneration electricity output (*CEO*) and calculating BE_{elec}. For an *a priori* estimation of the baseline CO_2 emissions for electricity supply to the plant, *CEO* is determined by the cogeneration electric power output (*CPO*) and annual operating hours (*AOH*), in a manner similar to Eq.2 for heat output, and is described below:

$$CEO(MWh / year) = \frac{CPO\ x\ AOH}{10^3}$$

[Equation 11]

Where:

- CEO =Annual electricity generation from the cogeneration system, CEO (MWh/year)
- CPO = cogeneration system net power output capacity (MWe)
- AOH = annual operating hours of cogeneration system (h/year)

In the baseline scenario all electricity would have to be generated thought existing equipment TG-2401/2/3, (dedicated fuel power plants), so the value of CEO is 256,2 MWh/year. The efficiency considered for each conventional electricity generator unit (boiler and steam generator) are indicated in section B.6.2. These values have been determined under a conservative approach, taking into account the technical specifications of the existing updated equipment and the operating conditions thereof.

AOH has been determined from the engineering study of the proposed cogeneration system and has a value of 8,540 h./year.

Total baseline emissions are given by the sum of the components analyzed above:

$$BE_{total} = BE_{th} + BE_{equivmetcomb} + BE_{equivN2O\,comb} + BE_{thequivfug} + BE_{elecgrid/\,fossilfuel}$$

[Equation 12]

Project Emissions calculation

According to AM0014, project emissions correspond to natural gas combustion by the cogeneration system, and includes the same four components as in the baseline (CO_2, CH_4 and N_2O emissions from combustion) and CH_4 emissions from natural gas production and leaks in the transport and distribution pipeline supplying the plant and leaks in the gas distribution piping within the plant, associated with the natural gas consumption. Each of these is proportional to the natural gas consumption in the cogeneration system, which is monitored. Emissions are then calculated as follows:

a) CO_2 emissions from natural gas combustion in cogeneration system

Carbon dioxide emissions from natural gas combustion in the cogeneration system, **E_{cs}**(tonnesCO_2/year):

$$E_{CS} = \frac{AEC_{NG}}{10^3} \, x \, EF_{NG}$$

[Equation 13]

Where:

- AEC_{NG}= annual energy consumption of natural gas in cogeneration system (GJ/year)
- EF_{NG}= CO_2 emission factor of natural gas (kg CO_2/GJ, lower heating value basis)

The value of **EF_{NG}**has been estimated from FECOC tool from the UPME, with a value of 55.341 tCO_2/TJ for natural gas from Guajira area. FECOC is the tool from the UPME for calculation of emission factor of the Colombian fuels.

b) Methane emissions from natural gas combustion in cogeneration system

A certain amount of methane is generated in the combustion of natural gas. These are generally expressed in terms of natural gas energy consumption. Emissions are estimated using formulae described below:

$$E_{met\ comb} = \frac{AEC_{NG}}{10^3} \, x \, MEF$$

[Equation 14]

Where:

- $E_{met\ comb}$ =Methane emissions from natural gas combustion in the cogeneration system (tonne CH_4/year)
- AEC_{NG}= annual energy consumption of natural gas in cogeneration system (GJ/year)
- MEF = methane emission factor for natural gas combustion (kg CH_4/TJ, lower heating value basis)

In units of carbon dioxide equivalent emission, **$E_{equiv\ met\ comb}$** (tonne CO_2 equiv/year) is:

$$E_{equivmetcomb} = E_{metcomb} \, x GWP(CH_4)$$

[Equation 15]

Where:

- GWP (CH_4) is global warming potential of methane = 25

The value of **MEF** has been estimated from the second data sources listed in the methodology AM0014, the IPCC, fuel type and technology specific, with a value of 0.3 $kgCH_4/TJ$.

c) Nitrous oxide emissions from natural gas combustion in cogeneration system

A certain amount of nitrous oxide is generated in the combustion of natural gas. These are generally expressed in terms of natural gas energy consumption. Emissions are estimated using formulae similar to those for methane emissions in combustion, and are described below:

$$E_{N2O\,comb} = \frac{AEC_{NG}}{10^3}\ x\ NEF$$

[Equation 16]

Where:

- $E_{N2O\ comb}$= Nitrous oxide emissions from natural gas combustion in the cogeneration system, (tonne N_2O / year),
- *AECNG* = annual energy consumption of natural gas in the cogeneration system (GJ/Year)
- *NEF* = nitrous oxide emission factor for natural gas combustion (kg N_2O/TJ, lower heating value basis)

In units of carbon dioxide equivalent emission, **E** $_{\mathbf{equiv\ N2O\ comb}}$(tonne CO2 equiv/year) is:

$$E_{equivN2O\,comb} = E_{N2O\,comb}\,xGWP(N_2O)$$

[Equation 17]

Where:

- GWP (N_2O) = global warming potential of nitrous oxide = 298

The value of **NEF** has been estimated from the second data sources listed in the methodology AM0014, the IPCC, fuel type and technology specific, with a value of 0.03 kgN_2O/TJ.

d) Methane emissions from natural gas production and pipeline leaks in the transport and distribution of natural gas, including leakage within the industrial plant

These project emissions are associated with natural gas consumption in the cogeneration system. The procedure for estimating these emissions is described below:

$$E_{thfug} = \frac{AEC_{NG}}{10^3}\ x\ MLR$$

[Equation 18]

Where:

- $E_{th\ fug}$ = Methane emissions from natural gas production and pipeline leaks in the transport and distribution of natural gas, including leakage within the industrial plant (tonneCH_4/year)
- MLR = Methane Leakage Rate in natural gas production, transport and distribution leakage, including leaks at the industrial site (kg CH_4/GJ natural gas energy consumption, lower heating value basis).It has a value of 0.377 $kgCH_4/GJ$.
- AEC_{NG} = annual energy consumption of natural gas in cogeneration system (GJ/year)

In units of carbon dioxide equivalent, **E** $_{\mathbf{thequiv\ fug}}$ (tonne CO_2 equiv/year):

$$E_{th\,equivfug} = E_{th\,fug}\,xGWP(CH_4)$$

[Equation 19]

Where:

- GWP (CH_4) is global warming potential of methane = 25

Total project emissions are given by the sum of the components analyzed above:

$$E_{total} = E_{CS} + E_{equivmetcomb} + E_{equivN2O\,comb} + E_{th\,equivfug}$$

[Equation 20]

Emission Reductions

Emission reductions are calculated as the difference between baseline and project emissions, taking into account any adjustments for leakage: Project emissions are those associated with natural gas consumption by the cogeneration system, including CO_2, CH_4, and N_2O emissions from natural gas combustion and CH_4 emissions from natural gas production and pipeline leakage, associated with the gas consumption of the cogeneration system.

$$ER = BE_{total} - E_{total}$$

[Equation 21]

B.6.2. Data and parameters fixed ex ante

Data / Parameter	CHOR
Unit	GJ/h
Description	Cogeneration system heat output rate
Source of data	Project developer
Value(s) applied	246.6
Choice of data or Measurement methods and procedures	The value is taken from the specification of the cogeneration equipment: steam generation of 400 klb/h at 525ºF and 190 psi.183 klb/h out of 400 klb/h are produced from exhaust gases coming from the turbine by burning natural gas and 217 klbh result from the additional burning of refinery gas in the post-combustion of HRSG boiler. Steam enthalpy is 712.9 kcal/kg.
Purpose of data	Calculation of baseline emissions
Additional comment	Note that this value is only use for ex-ante estimates. Actual power of the cogeneration is measured to calculate the monitored emission reductions (parameter MCHO in section B.7.1)

Data / Parameter	e_b
Unit	fraction
Description	boiler efficiency
Source of data	Default value proposed by AM0014 Methodology
Value(s) applied	0.9
Choice of data or Measurement methods and procedures	-
Purpose of data	Calculation of baseline emissions
Additional comment	-

Data / Parameter	AOH
Unit	h/year
Description	Annual operating hours
Source of data	Project developer
Value(s) applied	8,540
Choice of data or Measurement methods and procedures	-
Purpose of data	Calculation of baseline emissions
Additional comment	-

Data / Parameter	EF
Unit	tCO_2/TJ
Description	CO_2 emission factor of the fuel used to generated heat
Source of data	FECOC tool. Tool from the UPME for calculation the emission factor of the Colombian fuels.
Value(s) applied	55.341 (natural gas from Guajira area) 54.227 (refinery gas)
Choice of data or Measurement methods and procedures	-
Purpose of data	Calculation of baseline emissions and project emissions
Additional comment	-

Data / Parameter	MEF
Unit	$kgCH_4/TJ$
Description	CH_4 emission factor (combustion)
Source of data	2006 IPCC Guidelines for National Greenhouse Gas Inventories, Volume 2, Table 2.2 page 2.16, lower value
Value(s) applied	0.3
Choice of data or Measurement methods and procedures	AM0014 ver.4 gives the following options for choice of data (in decreasing order of preference: 1.IPCC, fuel type and technology specific 2.IPCC, near fuel type and technology IPCC data correspond to emissions for stationary combustion in Energy Industries. IPCC does not provide a technology specific value. The fuel is refinery gas in baseline scenario and natural gas in project scenario.
Purpose of data	Calculation of baseline emissions and project emissions
Additional comment	-

Data / Parameter	GWP (CH_4)
Unit	tCO_2/tCH_4
Description	Global Warming Potential of CH_4
Source of data	Decision 4/CMP.7. Table 2.14 of the errata to the contribution of Working Group I to the Fourth Assessment Report of the Intergovernmental Panel on Climate Change
Value(s) applied	25
Choice of data or Measurement methods and procedures	Standard IPCC value
Purpose of data	Calculation of baseline emissions and project emissions
Additional comment	-

Data / Parameter	NEF
Unit	kgN_2O/TJ
Description	N_2O emission factor (combustion)
Source of data	2006 IPCC Guidelines for National Greenhouse Gas Inventories, Volume 2, Table 2.2 page 2.16, lower value
Value(s) applied	0.03
Choice of data or Measurement methods and procedures	AM0014 ver.4 gives the following options for choice of data (in decreasing order of preference: 1.IPCC, fuel type and technology specific 2.IPCC, near fuel type and technology IPCC data correspond to emissions for stationary combustion in Energy Industries. IPCC does not provide a technology specific value. The fuel is refinery gas in baseline scenario and natural gas in project scenario.
Purpose of data	Calculation of baseline emissions and project emissions
Additional comment	-

Data / Parameter	GWP (N_2O)
Unit	tCO_2/tN_2O
Description	Global Warming Potential of N_2O
Source of data	Decision 4/CMP.7. Table 2.14 of the errata to the contribution of Working Group I to the Fourth Assessment Report of the Intergovernmental Panel on Climate Change
Value(s) applied	298
Choice of data or Measurement methods and procedures	Standard IPCC value
Purpose of data	Calculation of baseline emissions and project emissions
Additional comment	-

<table>
<tr><td>Data / Parameter</td><td>MLR</td></tr>
<tr><td>Unit</td><td>$kgCH_4/GJ$</td></tr>
<tr><td>Description</td><td>Methane Leakage Rate in natural gas production, transport and distribution leakage including leaks at the industrial site</td></tr>
<tr><td>Source of data</td><td>2006 IPCC Guidelines for National Green House Gas Inventories, Tier 1:
Table4.2.5.</td></tr>
<tr><td>Value(s) applied</td><td>0.377</td></tr>
<tr><td>Choice of data or Measurement methods and procedures</td><td>
<table>
<tr><td>Natural gas production</td><td>Gg $CH_4/10^6$ m^3</td><td>0.01219</td><td>Table 4.2.5, page 4.55: $3.8*10^{-4}$ to $2.4*10^{-2}$ $Gg/10^6$ m^3 of gas produced. An average value of 0.01219 $Gg/10^6$ m^3 is considered</td></tr>
<tr><td>Natural gas transmissio n& storage</td><td>Gg $CH_4/10^6$ m^3</td><td>0.00063 3</td><td>Table 4.2.5, page 4.57:$16.6*10^{-5}$ to $1.1*10^{-3}Gg/10^6$ m^3 of marketable gas. An averagevalue of 0.633 m^3 is considered.</td></tr>
<tr><td>Natural gas distribution</td><td>Gg $CH_4/10^6$ m^3</td><td>0.0018</td><td>Table 4.2.5, page 4.57:$1.1*10^{-3}$ to $2.5*10^{-3}Gg/10^6$ m^3 of gas produced. An average value of 0.0018 $Gg/10^6$ m^3 is considered</td></tr>
</table>
Total=0.014623 Gg $CH_4/10^6$ m^3
Density applied for transformation of unit= 0.8076 kg/m^3
PCI= 48 TJ/Gg</td></tr>
<tr><td>Purpose of data</td><td>Calculation of baseline emissions and project emissions</td></tr>
<tr><td>Additional comment</td><td>-</td></tr>
</table>

Data / Parameter	CPO
Unit	MWe
Description	Cogeneration electric power output
Source of data	Project Developer
Value(s) applied	30 (30MW U-5100)
Choice of data or Measurement methods and procedures	The value is taken from the specifications of the new cogeneration equipments (U-5100).
Purpose of data	Calculation of baseline emissions
Additional comment	-

Data / Parameter	Efficiency of conventional electricity generator units (boilers and steam generators)
Unit	%
Description	Efficiency (%) of: B-901/2/3/4, B-951/2, B-956 and TG-2401/2/3
Source of data	Process engineering information based on operating conditions. The years selected match the last years the equipment was operating continuously and in optimal conditions. Therefore, the data are considered reliable.
Value(s) applied	<table><tr><td>System</td><td>Efficiency (%)</td></tr><tr><td>U-2401</td><td>19.3</td></tr><tr><td>U-2402</td><td>17.9</td></tr><tr><td>U-2403</td><td>21.2</td></tr></table>
Choice of data or Measurement methods and procedures	-
Purpose of data	Calculation of baseline emissions
Additional comment	-

Data / Parameter	$BEF_{elec\ fossil}$ fuel
Unit	$kgCO_2/MWh$
Description	Baseline CO2 emissions factor for electricity from the dedicated fossil fuel power plant(s)
Source of data	Efficiency of conventional electricity generator units from process engineering information based on technical specifications of equipment and operating conditions.
Value(s) applied	1,008
Choice of data or Measurement methods and procedures	-
Purpose of data	Calculation of baseline emissions
Additional comment	The calculation of $BEF_{elec\ fossil}$ fuel takes into account $PG_{i,n}$ and $SEF_{i,n}$ values for U-2401/2/3equipment. The baseline scenario is to refurbish these pieces of equipment and make them operate at nominal capacity. The same applies to the equipment in the project scenario. Furthermore, a conservative approach is that in the baseline scenario these pieces of equipment would operate with the actual performance they had in the years with reliable data, rather than operate with the maximum design performances (which are higher than the actual ones). This is why historical performances of these units are used.

B.6.3. Ex ante calculation of emission reductions

>>

Baseline Emission calculation

According to AM0014, baseline emissions comprise five components. The baseline emissions for the first four emission sources listed above are proportional to the amount of baseline fuel consumption in the plant that is offset by heat supplied by the natural gas cogeneration system. The consumption of the fuel avoided in the baseline for the supply of heat is determined as follows:

$$ABEC_{BF} = \frac{CHOR\,x\,AOH}{e_b} = 2{,}339{,}631\,GJ/year$$

Where:

- CHOR = cogeneration system heat output rate =246.6 GJ/h
- AOH = Annual operating hours =8,540 h/year
- eb = boiler efficiency =0.9

a) Baseline CO_2 emissions from combustion of baseline fuel for heat supply

Baseline CO_2 emissions from combustion of baseline fuel for heat supply, BE_{th} (tonnesCO2/year):

$$BE_{th} = AEBC_{BF} \cdot EF_{BF} = 126{,}871\,tCO_2/year$$

Where:

- $ABEC_{BF}$ = annual energy consumption for heat supply at baseline plant =2,339,631 GJ/year
- EF_{BF} = CO_2 emission factor of the fuel used to generate heat =0.0542 tCO_2/GJ

b) Baseline methane emissions from combustion of baseline fuel for heat supply to plant

$$BE_{met\,comb} = \frac{AEBC_{BF}}{10^6}\,x\,MEF = 1\,tonneCH_4/year$$

Where:

- $ABEC_{BF}$ = annual baseline energy consumption for heat supply =2,339,631 GJ/year
- MEF = methane emission factor for baseline fuel combustion =0.3 $kgCH_4$/TJ

In units of carbon dioxide equivalent, $BE_{equity\ met\ comb}$ (tonne CO_{2eq}/year) is:

$$BE_{equiv\,met\,comb} = BE_{met\,comb}\,x\,GWP(CH_4) = 18\,tCO_2e/year$$

Where:

- GWP (CH_4) is global warming potential of methane = 25

c) Baseline nitrous oxide emissions from combustion of baseline fuel for heat supply to plant

$$BE_{N2O\,comb} = \frac{AEBC_{BF}}{10^6}\,x\,NEF = 0.07\,tonneN_2O/year$$

Where:

- *$ABEC_{BF}$*= annual baseline energy consumption for heat supply =2,339,631GJ/year
- NEF = nitrous emission factor for fuel combustion =0.03 kgN2O/TJ.

In units of carbon dioxide equivalent, BE $_{equity\ met\ comb}$ (tonne CO_2eq/year) is:

$$BE_{equivN2O\,comb} = BE_{N2O\,comb} x GWP(N_2O) = 21 tCO_2 e / year$$

Where:
- GWP (N_2O) = global warming potential of nitrous oxide = 298

d) Baseline methane emissions from natural gas production and pipeline leaks in the transport and distribution

Baseline methane emissions from natural gas production and leakage in transport and distribution, corresponding to heat supply, BE $_{th\ fug}$ (tonne CH_4/year), are not calculated because de fuel baseline is refinery gas.

e) Baseline emissions of CO2 from electricity supply to industrial plant that is offset by electricity supplied from cogeneration system

1. Electricity Displaced from Public System:

Baseline carbon dioxide emissions for electricity supplied, BE $_{elec\ grid}$(tonne CO_2/year):

$$BE_{elec\ grid} = \frac{CEO}{10^3} x\ BEF_{elec\ grid}$$

Where:
- *CEO* **=** cogeneration electricity output
- $BEF_{elec\mathbf{grid}}$= baseline CO_2 emissions factor for electricity from public supply

There are no emissions avoided at the power plants supplying the public grid, because all electricity in baseline scenario would have to be generated through dedicated fossil fuel power plants.

2. Electricity displaced, that would have to be generated through dedicated fossil fuel power plant(s):

Baseline carbon dioxide emissions for electricity supplied, BE $_{elec\ fossil\ fuel}$ (tonne CO2/year):

$$BE_{elec\ fossil\ fuel} = \frac{CEO}{10^3} x\ BEF_{elec\ fossil\ fuel} = 258{,}344\ tCO_2 / year$$

Where:
- *CEO* **=** Cogeneration Electricity Output =256,200MWh/year
- $BEF_{elec\mathbf{fossil\ fuel}}$ = Baseline CO_2 emissions factor for electricity from the dedicated fossil fuel power plant = 1,008kg CO_2/MWh

Total baseline emissions, according to the methodology AM0014, are given by the sum of the components analyzed above:

$$BE_{total} = BE_{th} + BE_{equivmetcomb} + BE_{equivN2O\,comb} + BE_{th\,equivfug} + BE_{elecgrid/\,fossilfuel} = 385{,}254 tCO_2 / year$$

Emission from pipeline leakage associated with transport and distribution of natural gas consumed in baseline is not included because conservative approach is applied.

Project Emissions

According to AM0014, project emissions correspond to natural gas combustion by the cogeneration system, and include the same four components as in the baseline. Emissions are then calculated as follows:

a) CO_2 emissions from natural gas combustion in cogeneration system

Carbon dioxide emissions from natural gas combustion in the cogeneration system, E_{cs}(tonnesCO_2/year):

$$E_{CS} = \frac{AEC_{NG}}{10^3} x\ EF_{NG} = 163{,}667 \quad tCO_2 / year$$

Where:

- AEC_{NG}= annual energy consumption of natural gas in cogeneration system =2,957,421.13 GJ/year
- EF_{NG}= CO_2 emission factor of natural gas =55. 341 kg CO_2/GJ

b) Methane emissions from natural gas combustion in cogeneration system

Emissions are estimated using formulae described below:

$$E_{met\ comb} = \frac{AEC_{NG}}{10^3} x\ MEF = 0.89\ tCH_4 / year$$

Where:

- AEC_{NG}= annual energy consumption of natural gas in cogeneration system =2,957,421.13 GJ/year
- MEF = methane emission factor for natural gas combustion =0.3 kgCH_4/TJ

In units of carbon dioxide equivalent emission, $E_{equiv\ met\ comb}$ (tonne CO_2 equiv/year) is:

$$E_{equiv\,met\,comb} = E_{met\,comb} x GWP(CH_4) = 22.18\, tCO_2e / year$$

Where:

- GWP (CH_4) isglobal warming potential of methane = 25

c) Nitrous oxide emissions from natural gas combustion in cogeneration system

Emissions are estimated using formulae similar to those for methane emissions in combustion, and are described below:

$$E_{N2O\ comb} = \frac{AEC_{NG}}{10^3} x\ NEF = 0.09\ tN_2O / year$$

Where:

- AEC_{NG}= annual energy consumption of natural gas in the cogeneration system =2,957,421.13 GJ/year
- *NEF* = nitrous oxide emission factor for natural gas combustion = 0.03kg N_2O/TJ

In units of carbon dioxide equivalent emission, $E_{equiv\ N2O\ comb}$(tonne CO2 equiv/year) is:

$$E_{equiv\,N2O\,comb} = E_{N2O\,comb} x GWP(N_2O) = 26.44\, tC_2Oe / year$$

Where:

- GWP (N_2O) = global warming potential of nitrous oxide = 298

d) Methane emissions from natural gas production and pipeline leaks in the transport and distribution of natural gas, including leakage within the industrial plant

These project emissions are associated with natural gas consumption in the cogeneration system.The procedure for estimating these emissions is described below:

$$E_{thfug} = \frac{AEC_{NG}}{10^3} x\ MLR = 1{,}116\ tCH_4 / year$$

Where:

- MLR = Methane Leakage Rate in natural gas production, transport and distribution leakage, including leaks at the industrial site = 0.377 $kgCH_4/GJ$.
- AEC_{NG} = annual energy consumption of natural gas in cogeneration system =2,957,421.13 GJ/year

In units of carbon dioxide equivalent, $E_{thequiv\ fug}$ (tonne CO_2 equiv/year):

$$E_{th\,equiv\,fug} = E_{th\ fug} x GWP(CH_4) = 27{,}890\, tCO_2e / year$$

Where:

- GWP (CH_4) is global warming potential of methane = 25

Total project emissions are given by the sum of the components analyzed above:

$$E_{total} = E_{CS} + E_{equiv\,met\,comb} + E_{equiv\,N2O\,comb} + E_{th\,equiv\,fug} = 191{,}605\, tCO_2 / year$$

Emission Reductions

Emission reductions are calculated as the difference between baseline and project emissions:

$$ER = BE_{total} - E_{total} = 385{,}254 - 191{,}605 = 193{,}648\, tCO_2 / year$$

B.6.4. Summary of ex ante estimates of emission reductions

Year	Baseline emissions (t CO_2e)	Project emissions (t CO_2e)	Leakage (t CO_2e)	Emission reductions (t CO_2e)
2015	288,941	143,704	0	145,236
2016	385,254	191,605	0	193,648
2017	385,254	191,605	0	193,648
2018	385,254	191,605	0	193,648
2019	385,254	191,605	0	193,648
2020	385,254	191,605	0	193,648
2021	385,254	191,605	0	193,648
2022	96,314	47,901	0	48,412
Total	269,777	1,341,238	0	1,355,538
Total number of crediting years	7 (Renewable twice until 21 years are completed)			
Annual average over the crediting period	385,254	191,605	0	193,648

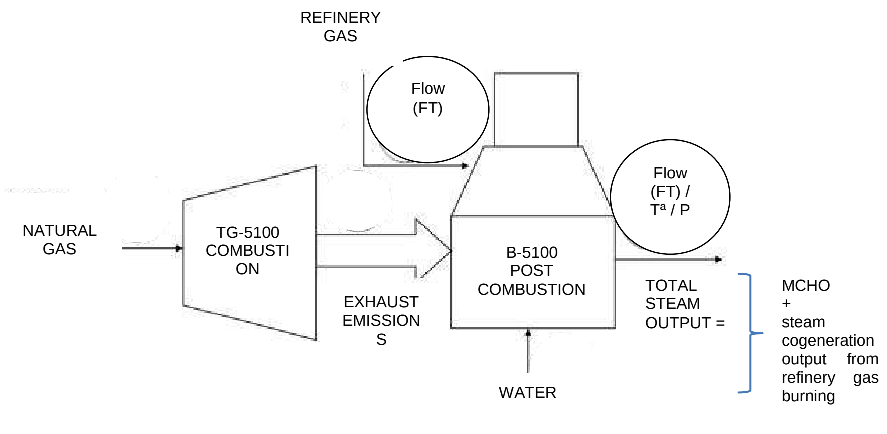
B.7. Monitoring plan

B.7.1. Data and parameters to be monitored

Data / Parameter	MEC_{GN}
Unit	m^3
Description	Volume of natural gas consumed in cogeneration system (TG-5100)
Source of data	Measured
Value(s) applied	76,291,407 (annual)
Measurement methods and procedures	In the cogeneration system, natural gas consumption will be obtained through fuel flow meters installed in the cogeneration system equipment (TG-5100:FT-50008). These meters include an orifice plate for differential pressure measurement and smart HART protocol, with a precision rate of +/- 0.25 %. The data storage methodology is based on the transmitter signal to the Remote Terminal Unit (RTU)—via communications to the Power Control Centre (*Centro de Control de Potencia, CCP*)—, the historical record of events and consumption statistics .
Monitoring frequency	Monthly
QA/QC procedures	Two redundant transmitters, and pressure and temperature compensation are available. Parameters are checked by “Hand help” (meter adjustment according to reference values), and the card will be replaced if necessary.
Purpose of data	Calculation of project emissions
Additional comment	For ex-ante calculations have been applied the following values:

	TG-5100
Power capacity	30 MW
Heat rate	10,952 BTU/kWh

Data / Parameter	MCEO
Unit	MWh
Description	Cogeneration electricity supplied to industrial plant
Source of data	Measured
Value(s) applied	256,200 (annual)
Measurement methods and procedures	Monitoring activities will be carried out through a direct-measuring Power Quality Meters (PQM) with internal memory storage installed in the TG-5100.
Monitoring frequency	Monthly
QA/QC procedures	This meters will be checked according to the manufacturer's specifications or the applicable regulations in order to guarantee that measurements are correct.
Purpose of data	Calculation of project emissions
Additional comment	For ex-ante calculations have been applied the following values: - 30 MW - 8,540 h.

Data / Parameter	MCHO
Unit	GJ
Description	Cogeneration heat supplied to industrial plant
Source of data	Measured
Value(s) applied	2,105,668 (annual)
Measurement methods and procedures	Cogeneration heat supplied to industrial plant (MCHO) is the steam produced from the volume of natural gas consumed by cogeneration. Therefore steam produced as a result of refinery gas consumption in the post-combustion of HRGS boiler should not be taken into account. For this purpose, MCHO shall be determined through an energy balance performed from the data monitored through the measurement instruments indicated (see graph below): MCHO = *total steam cogeneration output – steam cogeneration output from refinery gas burning*. Where: - *total steam cogeneration output* [BTU] = total steam flow [lb/h] x steam enthalpy [BTU/lb] x annual operating hours [h]. ▪ Total steam flow will be monitored through a Venturi FT-50001 meter, installed in the B-5100 steam generator. ▪ steam enthalpy will be calculated from thermodynamic tables using values of temperature and pressure monitored through measurement instruments installed in the B-5100 steam generator - *steam cogeneration output from refinery gas burning* [BTU] = refinery gas consumption [lb/h] x LHV of refinery gas [BTU/lb] x annual operating hours [h]. ▪ Refinery gas consumption will be monitored through fuel flow meters FT-50009 installed in the cogeneration system equipment B-5100. ▪ LHV of refinery gas, will be monitored through laboratories accredited pursuant to applicable standards. Units of "MCHO" will be converted from BTU to GJ using appropriated conversion factors. 
Monitoring frequency	Monthly

QA/QC procedures	Steam meter will be checked according to the manufacturer's specifications or the applicable regulations in order to guarantee that measurements are correct. Relating to the meters for refinery gas consumption, two redundant transmitters, and pressure and temperature compensation will be available. Parameters will be checked by “Hand help” (meter adjustment according to reference values), and the card will be replaced if necessary. Composition and calorific value analysis of the refinery gas shall be performed by laboratories accredited pursuant to applicable standards.
Purpose of data	Calculation of project emissions
Additional comment	Ex-ante calculations have considered the same energy balance, using the raw data (steam enthalpy, steam generation, refinery gas consumption and LHV of refinery gas) from the technical specifications of the cogeneration system. Cogeneration heat supplied to industrial plant (MCHO) = [total steam cogeneration output] - [steam cogeneration output from refinery gas burning] =2,105,668 GJ/year. Where: - Total steam cogeneration output (GJ/year) =4,602,552. - Steam cogeneration output from refinery gas burning (GJ/year) = 2,496,884

Dedicated power plants TG-2401/2/3 will not continue to operate along with the project activity cogeneration systems, so according to AM0014, electricity generated by dedicated power plant(s) is not necessary to be monitored.

B.7.2. Sampling plan

>>
There is not necessary a sampling plan for the monitoring plan of this project activity

B.7.3. Other elements of monitoring plan

>>
A description of emission sources and GHGs included in the project boundary are included in Section B3. In addition, Section A.3 includes a diagram of the baseline scenario and project activity scenario.

Project emissions are determined from natural gas consumption bythe cogeneration. Baseline emissions depend on heat and electricity output from the cogenerationsystem that is supplied to the industrial plant, and are determined in a dynamic manner fromdata indicated in section B.7.1.

According to paragraph 56 of the CDM-Project Standard, the measurement equipments will be calibrated either in accordance with the local/national standards, or as per the manufacturer’s specifications. If local/national standards or the manufacturer’s specifications are not available, international standards will be used.

The monitoring plan will be implemented through a series of monitoring activities, in order to guarantee that all aspects related to greenhouse gas emission reductions of the project activity projected are controlled and reported. Therefore, it is necessary to monitor the project to guarantee

the performance levels, in accordance with the project design and the real attainment of Certified Emission Reductions (CER) calculated.

In this sense, a monitoring plan has been designed with the purpose of guaranteeing that the project activity is correctly organised from the start, in terms of data gathering and maintenance, as required to obtain realistic GHG emission data.

Data collection procedures

The parameters will be recollected as it is indicated in the tables of B.7.1.

Organizational structure, roles and responsibilities

The responsible for monitoring calibration and measurement equipment is the area of instrumentation of Gerencia Refinería Barrancabermeja.

Emergency procedures

Emergency procedures are based on review of the parameters by "Hand help".

B.7.4. Date of completion of application of methodology and standardized baseline and contact information of responsible persons/ entities

>>
Ending date of the baseline study:
08/01/2015

Contact information of the responsible person(s) / entity(ies):

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NOVOTEC CONSULTORES S.A. is not a project participant.

SECTION C. Duration and crediting period

C.1. Duration of project activity

C.1.1. Start date of project activity

>>
18/11/2011

C.1.2. Expected operational lifetime of project activity

>>
20 years

C.2. Crediting period of project activity

C.2.1. Type of crediting period

>>
Renewable

C.2.2. Start date of crediting period

>>
01/04/2015

C.2.3. Length of crediting period

Seven years

SECTION D. Environmental impacts

D.1. Analysis of environmental impacts

>>
Gerencia Complejo Barrancabermeja has the following permits required by environmental laws in force: Water Concession, Discharge Permit and Emission Permit.

- Water Concession: Under Resolution 80, passed on February 10, 1994, the National Institute for Renewable Natural Resources and the Environment *(Instituto de Recursos Naturales Renovables y del Ambiente, INDERENA)* granted Ecopetrol, S.A. the first 10-year concession for Magdalena River, Miramar Swamp and San Silvestre Swamp. This permit was renewed on several occasions. The last renewal was granted under Resolution 1194, passed on October 22, 2010, for a 5-year period as from the Resolution date.
- Discharge Permit: On February 25, 2009, under Resolution 204,*INDERENA* granted Ecopetrol, S.A. the Discharge Permit for a 5-year period as from the Resolution date.
- Atmospheric Emission Permit: Under Resolution 846, passed on September 5, 2011, the Atmospheric Emission Permit was granted to Ecopetrol, S.A., Gerencia Refinería Barrancabermeja, to transform and refine hydrocarbons to obtain fuels, lubricating oils and petrochemical products for twenty-five fixed emission sources.

Ecopetrol, S.A. has an "*Environmental Management Plan for Gerencia Complejo Barrancabermeja (GCB).*"The purpose of this Plan is to have an environmental management tool in place, taking into account the potential impacts of projects, works and activities, and to determine the management measures necessary for mitigating, avoiding, monitoring, and off-setting the impacts of all GCB

operations on its surrounding environment to make the sustainability of its operations viable. The Plan is applicable to the projects developed within the Refinery perimeter.

The Environmental Management Plan is developed in 7 programmes, including 22 Environmental Management Files. These files comprise the following sections:

- Purpose
- Environmental Assessment (type of impact to be managed, importance and subcomponents that will be affected)
- Environmental Management (implementation stage, type of measure, location where it will be implemented)
- Responsibility (person in charge of the execution, necessary staff)
- Follow-up and Monitoring Activities
- Actions to be taken/technologies used

Consequently, the environmental aspects resulting from the building stage and the operation of the project activity will be handled according to the Environmental Management Plan.

D.2. Environmental impact assessment

>>

Taking into account the project activity characteristics and the project location, the potential impacts of the building and operation stages (atmospheric emissions, discharge, water consumption, noise) are included in the general impacts of the Refinery, and are handled as such in the Environmental Management Plan. The project activity requires neither an environmental impact assessment nor a specific environmental permit.

A summary of the analysis of the environmental impact assessment are stated below.
The assessment of the environmental impact caused by the operation of the Barrancabermeja refinery is performed according to its current and future situation considering projects planned or under way, among which the project “Assurance of Electricity Reliability of GCB” is included, and which comprises the CDM project activity and the main goal of which is: to ensure the reliability of the electricity system of GCB through the replacement, technological update and enhancement of generation, control, distribution, consumption and electrical interconnection areas, with priority classification of the investment required to satisfy the needs of internal and external clients.

The conclusion of the impact assessment is included in section 4.3.3 “Conclusions current impact” of Chapter 4.3 “Impact Assessment. Summary” of the Environmental Management Plan. This section states that the aspects assessed for the current scenario are summarized in the impact prioritisation matrix (Table 4.58).According to the results obtained, the highest-priority aspects are the following: Discharge of industrial waste water, discharge of rain water, management of underground waters, particulate material, sulphur oxide and discharge of domestic waters. Specifically, in the "Air" dimension, the results of the assessment indicate a “moderate” negative impact assessment for the emissions of particulate material and sulphur oxide and an “irrelevant” negative impact assessment for the emissions of nitrogen oxides.

Section “4.3.2 Future projection of the Refinery” states that among the future projects currently under way, the largest and with the highest impact both in operation and construction is the hydro-treatment project. The rest show a relatively low impact. In this regard, section 4.3.4 “Conclusions future impact” states that once the impact detected in each of the aspects assessed (water, air and solid waste) are controlled, the refinery will be able to smoothly manage the waste currents to be generated from the implementation of future and enhancement projects, provided the basic engineering involves the use of clean technologies and the detailed engineering defines waste current minimization aspects and specific disposal procedures for each of them.

According to the impacts identified in the assessment, the environmental management measures during the operation of current and future projects are aimed at the following:

- Defining and quantifying the impacts of the new projects in the basic engineering stage and, based on said stage, setting minimization and control actions.
- Minimizing and performing preliminary treatment of effluents of the plants involved.
- Monitoring the quality of the current led to the PTAR, once the projects come into operation.
- Monitoring the emissions generated in the new processes in the annual monitoring, verifying the impact foreseen and setting new actions, when required.
- Defining disposal procedures for industrial waste which is to be generated and for which no disposal route has been defined.

SECTION E. Local stakeholder consultation

E.1. Solicitation of comments from local stakeholders

>>

A project socialisation session was held at Barrancabermeja Plaza Hotel on June 19, 2012. Ecopetrol and PMC (Applus+ Consortium) representatives, and the Novotec-Applus+ taskforce participated in this session.

The organisations/entities invited to the session, to which a formal invitation was sent, were the following:

- Ministry of Environment and Sustainable Development *(Ministerio de Ambiente y Desarrollo Sostenible)*
- Municipal Secretariat of Environment *(Secretaria Municipal de Medio Ambiente)*
- Town Council
- Regional Autonomous Corporation of Río Grande de la Magdalena *(Corporación Autónoma Regional del Río Grande de la Magdalena, CORMAGDALENA)*
- Regional Autonomous Corporation of Santander *(Corporación Autónoma Regional de Santander, CAS)*
- Monasterio Verde Corporation
- Conciencia Verde Environmental Foundation
- Oikos Environmental Corporation
- Barrancabermeja Ecological Oversight
- Local Administrative Boards and Community Action Committee *(Juntas de Acción Comunales, JAC)* Chairpersons, Community Development Office

In addition to the specific invitations sent, general announcements were made on the radio (as from May 31, 2012), and in the national (Vanguardia) and in the local (Qhubo Newspaper) press (as from May31, 2012).Moreover, the socialisation announcement was posted in the Town Council.

E.2. Summary of comments received

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During the socialisation session, the following feedback was provided by participants:

- *Q:*Participants asked if the environmental benefit had to do with the quality of air only, and argued that it would be convenient to adopt measures to avoid water and soil pollution.
  *A:*It was confirmed that the main environmental benefit of the project activity was the improvement of the quality of air, but that, in future projects, the accomplishment of other environmental benefits would be analysed.

- *Q:*A participant argued that although refinery gas would be replaced with natural gas, this new option is also a fossil fuel and it also releases CO_2 during combustion.
  *A:*The answer was that, although this argument was true, natural gas was the fossil fuel that released the lowest amount of CO_2.
- *Q:*Information about the future of the refinery gas that will be replaced with natural gas was requested.
  *A:*Refinery gas will be used in the future, but it will be used in other refinery process.
- *Q:*Participants asked if the equipment was going to be replaced with an environmental purpose in mind, or if the purpose of the replacement was just to change the equipment because it was indeed necessary.
  *A:*The answer was that, although the steam generators that will be replaced have already reached the end of their service lives, these generators will not be replaced with new ones with the same features (which would be the baseline), but with a cogeneration system that provides much higher energy efficiency.
- *Q:* A citizen wants to know if, taking into account his career profile, he could participate in the development of the project activity.
  A: The answer was that his particular case would be analysed in order to determine if his profile was suitable to fill a position created as a consequence of the project activity development.
- Several participants recognised the importance of this socialisation session held by Ecopetrol.

In addition to the questions made and the answers provided during the socialisation session, a perception survey about Gerencia Refinería Barrancabermeja CDM project was handed over. The answers of this survey are analysed below:

- *Location where you live:* All the people that answered this section indicated that they lived in Barrancabermeja.

- *Age*: 23 % of the people surveyed did not indicate their age, and of the remaining 73 % that did answer the question, 50 % indicated that they were between 20 and 30 years old, 20 % between 30 and 40 years old, and the remaining 30 % between 40 and 50 years old.

- *Sex*: 77 % of the people surveyed were men; the remaining 33 % were women.

- *Marital status:* 54 % of the people surveyed were single; 39 % married and 7 % common-law couples.

- *Level of schooling:* 15 % of the people surveyed did not answer this question; whereas of the ones that did answer the question, 64 % completed secondary school, 18 % university studies, and the remaining 18 % vocational training.

- *Work:* As regards the sectors in which the people surveyed worked, 36 % of the people worked in the service sector, 28 % in the industrial sector, 7 % in the public sector, 7 % in the environmental sector, and the remaining 22 % were unemployed.

- *Main aspects that should be improved in your location*
  In the surveys answered, the aspects that should be improved were the following:
    - Lack of organisation
    - Unemployment
    - Lack of schools
    - Lack of healthcare facilities
    - Other:
        - Protection and conservation of natural wetlands, forests and green areas in Barrancabermeja
        - Deficient road infrastructure

- Lack of opportunities to build and purchase houses of social interest
- Lack of preparation to work in the community

- *Do you believe the Gerencia Refinería Barrancabermeja CDM project contributes to the sustainable development of the location?*
  92.3 % of the people surveyed think that the project contributes to the sustainable development of the location; the remaining 7.7 % do not think so.
  The reasons for this contribution are the following:
    - Reduction in greenhouse gases that are harmful to health
    - Reduction in energy consumption (fuels)
    - Mitigation of at least a small proportion of respiratory diseases caused by pollutants released into the atmosphere
    - Increase in equipment efficiency, and the resulting reduction in emissions
    - Improvement in the environment

- *Do you believe the Gerencia Refinería Barrancabermeja CDM project offers social and environmental benefits to the location?*
  92.3 % of the people surveyed think that the project contributes to the sustainable development of the location; the remaining 7.7 % do not think so. It is important to note that, of the 7.7 % of the people that think the answer is no, all of them think that the project offers environmental benefits; hence 100 % of the people surveyed consider there are environmental benefits.
  The benefits are the following:
    - People training for the development of new jobs
    - Creation of jobs
    - Reduction in greenhouse pollutants
    - Improvement in environmental quality
    - Reduction in electric and thermal energy consumption
    - New opportunities for suppliers
    - Sustainable development
    - New opportunities for inexperienced professionals
    - Community participation
    - Improvement in the quality of life of the community

E.3. Report on consideration of comments received

>>

Ecopetrol's "Great Social Agreement for Barrancabermeja City-Region 100 Years" *("Gran Acuerdo Social Barrancabermeja-Ciudad Región 100 Años")* includes the CDM project "Electric and Thermal Energy Generation through the use of Cogeneration at Gerencia Refinería Barrancabermeja (GRB), Ecopetrol S.A." *("Generación de energía eléctrica y térmica mediante el uso de la cogeneración en la Gerencia Refinería Barrancabermeja (GRB), Ecopetrol S.A."),*whose objectives are the following:

- Human talent development
- Citizenship Culture
- Economy strengthening
- Infrastructure necessary for sustainability
- Family as development core
- Institutional strengthening

The feedback provided has been gathered in order to use it during the implementation of the "Great Social Agreement for Barrancabermeja City-Region 100 Years". Under this agreement, some of the concerns of the interested parties, such as employment and investment in social issues, have already been addressed.

In this regard, for the implementation of this great agreement, Ecopetrol has the ECP-DAB-P-054 procedure: "*Corporate Social Responsibility Procedure for Activities Outsourced by Ecopetrol S.A.",* in which a series of mutual obligations between ECOPETROL and its Contractors, and between the Contractors and its Subcontractors are established. This procedure also guarantees the fulfilment of Ecopetrol obligations in relation to Corporate Social Responsibility. In this procedure, the following points are detailed:

- Employment of Non-Specialised Workforce from the Area of Influence of the Project
  In order to execute the project or the agreement, the Contractor and its Subcontractors shall recruit 100 % of the non-specialised workforce from the area of influence and/or the social territory, as long as this workforce exists and is available.
- Employment of Specialised Workforce from the Area of Influence of the Project
  Pertaining to specialised workforce, based on the workers' specialisation, the Contractor and its Subcontractors shall prioritise the recruitment and employment of workers from the influence area and the social territory.
- Use of the National Employment Service *(Servicio Nacional de Empleo, SNE)* of the National Learning Centre *(Servicio Nacional de Aprendizaje, SENA)*
  Both the Contractor and the Subcontractors shall recruit specialised and non-specialised workforce necessary for the execution of the project or agreement through the *SNE* of the *SENA*.
- Workforce Report
  The Contractor, without any exception, shall notify, on a monthly basis, the agreement Administrative Agent of the workforce employed for the execution of the outsourced work, and shall request the applicable information from Subcontractors.
- Social and Environmental Issues
  The Contractor and its Subcontractors shall carry out all of the activities with a preventive approach in mind, and avoid warning, incidents and social and/or environmental effects in the communities and territories where they work to execute the agreement.
- Training and Creation of Jobs
  Under Corporate Social Responsibility, for all agreements (other than purchase agreements) effective for six (6) months or longer, irrespective of their values, and for whose execution specialised workforce is required, the Contractor shall foster the participation of in-training, inexperienced workers from the influence area and/or social territory in the following manner:
  - · Employment of 1 university professional for every 25 professionals hired exclusively for the execution of the agreement.
  - Employment of 1 technician, technologist or student in productive phase for every 40 workers hired exclusively for the execution of the agreement.

During the year 2011, Ecopetrol has signed several social investment agreements worth 214,123 million of colombian pesos, as stated in the Integrated sustainable management report 2011.

SECTION F. Approval and authorization

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The letter of approval from Colombia for the project activity is available since december 28, 2012.

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Appendix 1. Contact information of project participants and responsible persons/ entities

Project participant and/or responsible person/ entity	☒ Project participant ☐ Responsible person/ entity for application of the selected methodology (ies) and, where applicable, the selected standardized baselines to the project activity
Organization name	ECOPETROL, S.A.
Street/P.O. Box	
Building	Bloque II - Oficinas 25 de Agosto- Refinería de Barrancabermeja
City	Barrancabermeja
State/Region	
Postcode	
Country	Colombia
Telephone	057 (7) 6209339
Fax	057 (7) 6209030
E-mail	
Website	
Contact person	
Title	Gerente Proyecto Plan Maestro de Servicios Industriales
Salutation	
Last name	Martínez Parada
Middle name	
First name	José David
Department	
Mobile	
Direct fax	
Direct tel.	
Personal e-mail	Jose.MartinezP@ecopetrol.com.co

Project participant and/or responsible person/ entity	☐ Project participant ☒ Responsible person/ entity for application of the selected methodology (ies) and, where applicable, the selected standardized baselines to the project activity
Organization name	NOVOTEC CONSULTORES S.A
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State/Region	
Postcode	28022
Country	Spain
Telephone	+34 91 210 79 00
Fax	+34 91 210 79 03
E-mail	
Website	
Contact person	

Title	Project Manager
Salutation	
Last name	Llorente Onega
Middle name	
First name	David
Department	Environment Department
Mobile	
Direct fax	
Direct tel.	
Personal e-mail	david.llorente@novotec.es

Appendix 2. Affirmation regarding public funding

This project does not include Public finance sources.

Appendix 3. Applicability of methodology and standardized baseline

Applicability of methodology is indicated in section B.2.

Appendix 4. Further background information on ex ante calculation of emission reductions

All information on ex ante calculation of emission reductions are indicated in section B.6.3 and in the spreadsheets submitted to validation process.

Appendix 5. Further background information on monitoring plan

All data will be archived electronically, and data will be retained for the full crediting period, plus seven years.

Appendix 6. Summary of post registration changes

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