NAMA

OGE&EE

Optimization of Power Generation and Energy Efficiency

MAE- Petroamazonas EP

FOCAM

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Contents

Table List

Acronyms

ARCONEL: Agency for Regulation and Control of Electricity

BAU: Business as Usual

CENACE: National Center for Energy Control

CICC: Inter-Agency Committee on Climate Change

CNEL: National Electricity Corporation

DCH: Development of Hydropower Plants

ENCC: National Climate Change Strategy

FOCAM: Capacity Building Project for Climate Change Mitigation

GHG: Greenhouse Gases

INER: National Institute of Energy Efficiency and Renewable Energy

ITT: Ishpingo Tambococha Tiputini

LEAP: Long-range Energy Analysis Planning System

MAE: Ministry of Environment

MDL: Clean Development Mechanism

MEER: Ministry of Electricity and Renewable Energy

MICSE: Ministry Coordinator of Strategic Sectors

MRV: Measurement, reporting and verification

MTOP: Ministry of Public Works

MtCO2e: Millions of tons of carbon dioxide equivalent

NAMAs: National Appropriate Mitigation Actions

OGE&EE: Optimization Program of Electricity Generation and Energy Efficiency

PAM: PETROAMAZONAS EP

PEC: Energy Efficient Cooking Program

PEM: National Strategic Plan for Mobility and Transport

PME: Electrification Master Plan

PNBV: National Plan for Good Living

SEIP-E: Oil-Extended Interconnected Electricity System

SNI: National Interconnected System

TCN: Third National Communication Project

UNFCCC: United Nations Framework Convention on Climate Change

1. Introduction

Climate change and the associated effects of global warming have been recognized as one of the greatest threats to our planet. Consequently, a framework of collaboration based on the principles of accountability, equity, cooperation and solidarity was put into place, whereafter its first fruits were demonstrated in the creation of the Intergovernmental Panel on Climate Change (IPCC) established in 1988 by the United Nations Environment Programme (UNEP) and the World Meteorological Organization. The goal of this Panel is to provide comprehensive assessments of the state of scientific, technical and socioeconomic knowledge on the subject of climate change, including its causes, consequences and possible solutions[1]. From 1990 up until this year, the Panel has received five reports in which it has advanced and integrated relevant information on climate change, the latest report of the IPCC[2] confirmed that the warming of the climate system is unequivocal and that human activities are changing the climate of our planet. Thus, reducing GHG emissions to contain the effects of climate change within reasonable boundaries becomes a clear solution.

The UN Framework Convention on Climate Change (UNFCCC) was approved in 1992 and represents the first international treaty on climate change. Each year, since 1995, the UNFCCC calls together the members to assess progress in the fight against climate change. The "Kyoto Protocol" represents the first agreement that was negotiated through the UNFCCC, wherein the parties defined binding obligations for developed countries (also known under the Protocol Annex I countries) aimed at reducing GHG emissions. The Kyoto Protocol entered into effect in 2005 and its aim was for developed countries to commit to an initial five-year plan (2008-2012) to reduce GHG emissions by 5% from what they were in 1990. Under the Kyoto Protocol, three market-based mechanisms to help countries reduce emissions were created: the Clean Development Mechanism (CDM), Joint Implementation (JI) and International Emissions Trading. The CDM was the only mechanism in which non-developed countries (called in the Country Protocol - Annex No 1) could participate, Ecuador being among them.

From 2013, once the commitments made in the Kyoto Protocol had culminated, the UNFCCC called on the parties (developed and developing countries) to take country-appropriate, mitigat-

[1] See: http://www.ipcc.ch/home_languages_main_spanish.shtml (último acceso: 10.03.2015)

[2] See: http://www.ipcc.ch/pdf/assessment-report/ar5/wg3/ipcc_wg3_ar5_chapter5.pdf (último acceso: 10.03.2015)

ing actions (called NAMA: Nationally Appropriate Mitigation Actions). In the Ecuadorian context, NAMA is a voluntary action to reduce emissions of greenhouse gases based on the Millennium Development Goals for Ecuador and it is being promoted through national and sectoral policies; and it contributes to the country's sustainable development, generating co-benefits. The results of this action should be measurable, reportable, and verifiable.

This document shows the conceptualization of a NAMA based on Petroamazonas EP's Optimization of Power Generation and Energy Efficiency Program (OGE & EE) aimed at changing the energy matrix of Ecuador's Oil Industry through the design and implementation of more robust and more efficient Collection Systems, Transportation and Handling of Associated Gas Systems, and Generation and Distribution Systems in order to prioritize the use of lower cost resources that have lesser impact on the environment.

The actions of the OGE & EE Program are primarily based on: (i) Optimizing the associated gas for the production of electricity generation (usually associated gas has been flared); (ii) reducing, largely imported, diesel consumption, which has been used traditionally in the oil sector for electricity generation. Given that these measures reduce emissions of greenhouse gases, this program is constituted as a mitigation action (Petroamazonas EP, 2013). Hence the OGE&EE Program is the main Ecuadorian initiative in the transformation of the oil sector into a sustainable energy industry, which facilitates the principal objectives of national development towards a transformation of the Energy and Production Matrix.

2. Outlook of Ecuador's energy sector

With regard to the energy supply over the past 40 years, oil has been the most important energy resource, not only in terms of meeting domestic demand (load to refineries and power generation), but also in terms of the income generated from exports. Historically, renewable energies such as biomass (wood and bagasse), have had minimal participation in the primary energy mix. On the other hand, the demand for energy at the national level has depended primarily on population growth trends and the national economy, therein lays the need to incorporate loads in the energy system to give attention to the demand for mining projects, isolated petroleum systems, refineries, and the national interconnected electric system.

2.1. State of the oil sector

The National Interconnected System (SNI) is the most important system in terms of the generation and supply of electricity; in 2012, 98% of average electricity generation was based on hydroelectric and thermoelectric energy (53% and 45%, respectively). In 2012, the average electricity generation of SNI was 23,086 GWh (MICSE, 2013). However, given that SNI does not cover the demand for all users and activities that require electricity, there are other isolated systems. The oil sector relies on its own power generation systems because the handling of fluids such as water and oil, among other activities in the oil sector, requires electricity, evident in the 2,800 GWh generated to meet demands in 2012.

State-owned oil companies have power generation systems that run on diesel fuel, which is generally acquired via outsourcing services. In some cases, they have power generation systems fueled with crude oil or associated gas. The distribution is far from reliable and consequently, each production platform is required to have its own generating capacity. Monitoring systems in place do not allow to dispatch according to economic merits in a centralized and automatized fashion. In the case of private-owned oil companies, power generation systems are fueled with crude oil or diesel and a lower percentage are operated with associated gas. Each private operator operates independently, thus the criteria specifics of the dispatch are unknown.

In 2014, an inventory of electricity generation facilities within the oil sector (Amazon District) determined that this sector had an installed capacity of electricity generation of 1,012 MW to meet a demand of 330 MW, which translates into a utilization factor of 34.57% (see Figure 1).

Despite the surplus of installed capacity (682 MW over electricity demand in the oil sector) there is still a shortfall of electricity generation for the following reasons:

a. Excess of installed capacity as "Stand-By" (cold and hot).

b. Some facilities have completed their life cycle and do not contribute to meeting the demand efficiently (for 30 years no investments were made).

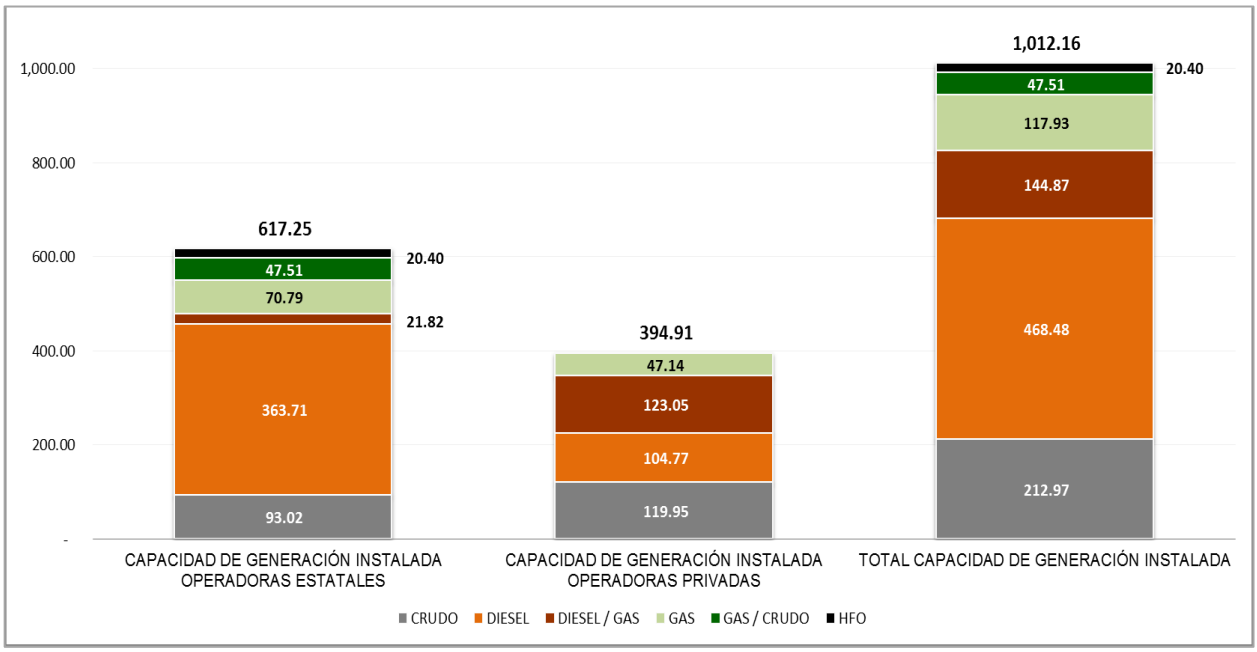
c. There is no reliable means of transportation (read distribution lines) to export from a surplus field to a deficit field.

Under the model that was in place (power generation outline with traditional topology) and considering the projected energy demand for the oil sector, if the OGEE&EE Program is not implemented, the installation of a power generation capacity of approximately 1,500 MW (excluding the requirements for secondary oil recovery) will be necessary.

Of the total installed capacity in the oil sector, 178.03 MW were leased to external suppliers.

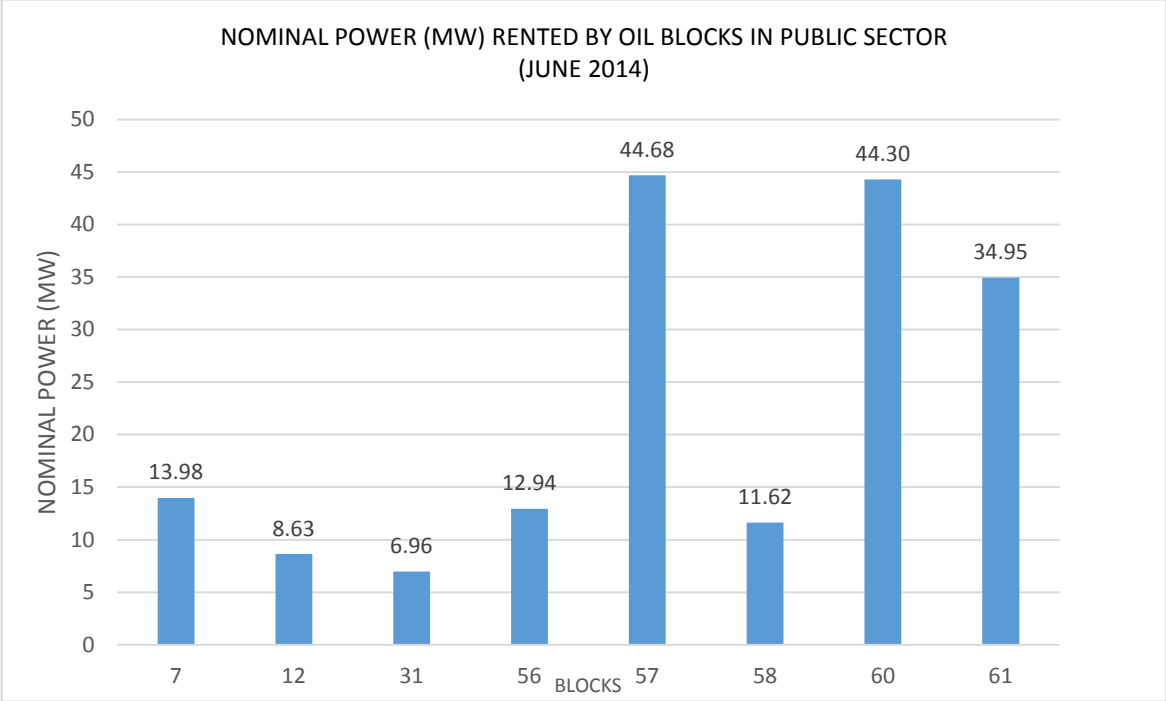
Figure 1 presents a summary of installed capacities by type of operator and type of fuel. Over 60% of installed capacities correspond to State Operators.

Figure 1: Installed Generation Capacity in the Amazon District by Type of Operator and Type of Fuel (until June 2014)



(Source: Petroamazonas EP/ OGE&EE)

Figure 2: Rented Generation Capacity



(Source: Petroamazonas EP/ OGE&EE)

2.2. GHG emissions in the energy sector

According to the preliminary national inventory of GHG that the FOCAM project developed for 2010, emissions are concentrated in the energy sector as well as the agricultural and land-use change and forestry sectors, which amount to 66.5 million tCO2e of the total national emission, which corresponds to 71.7 million; in the key category analysis, the sub-sectors which emit the most are the following: energy industries, transportation, enteric fermentation, agricultural soils (agriculture), agricultural land (land-use change and forestry) and wetlands (FOCAM, 2014).

As for the energy sector, table 1 shows by sub-sectors the emissions for the year 2010.

Table 1: Emissions from the energy sector of INGEI

Combustion of fossil fuels (sectoral approach)	*Total Net Emissions of CO_2 Equivalent (millon of tons)*
Energy industries	12,81
Construction and manufacture industries	4,28
Transport	15,16
Other sectors (comercial/institutional, residential and agriculture/forestry/fishing)	2,92

(Source: FOCAM, 2015)

In the case of energy industries, the emissions are considered in terms of the energy necessarily consumed to carry out their activity, (only burned petroleum is included, refined petroleum is excluded) consumption through thermoelectric power stations, and consumption of autoproducers to generate electricity, as it is the case of the oil sector examined in this paper. In 2010, the main fuel used for electricity generation by autoproducers was diesel with 1.7 million bbl, followed by crude oil with 1.4 million bbl.

2.3. Mitigation of Climate Change in Ecuador's oil sector

Despite the demand for electricity to operate the oil sector, the use of associated gas for electricity generation is not a common practice in Ecuador, neither regionally nor globally. Consequently, over the last 30 years oil extraction has been characterized by gas combustion devices, which burn large volumes of associated gas. This procedure is called “flaring” (World Bank Group, 2006). The World Bank estimates that annually about 110,000 million cubic meters of associated gas are burned and emitted worldwide. In Ecuador, particularly in the Amazon District, it is estimated that the burning of associated gas amounts to over 1,000 million cubic meters per year (World Bank Group, 2006).

Associated gas is a heterogeneous fluid and fuel with characteristics specific to each reservoir. Because of this, there are economic and technical obstacles to overcome to move away from the practice of “flaring” towards the usage of associated gas for the generation of electrical energy, which will be addressed in detail below.

Therefore, the putting to use of associated gas is a clear mitigation action against climate change because not only does it reduce burning, but it also enables the displacement of other fossil fuels commonly used for power generation in this sector.

2.4. Model of Petroamazonas EP

In 2008, Petroamazonas EP intervened in Block 15 (which was posteriorly divided into Block 12 and Block 15) through the allocation of resources for the implementation of projects to promote the use of associated gas under the OGE Project. In 2011, the scope of the OGE Project broadened and the implementation of the Optimization of Electricity Generation and Energy Efficiency within the Amazonian Sector-District was considered (OGE SECTORIAL or OGE D.A.), what is today known as OGE&EE. Thus, on March 31st of 2011 the Interinstitutional Cooperation Agreement between Petroamazonas EP, EP Petroecuador and Rio Napo Operations (ORN) was signed. Pet-

roamazonas EP leads the implementation of the program, for which it established the Management Unit OGE&EE, which in turn is based on the OGE&EE Development Plan 2012-2015 which was updated in 2013 through the OGE&EE Development Plan 2013-2017 (the latter of which was approved on August 22nd of 2013 by the Board of Petroamazonas EP).

Having shown that the implementation of the OGE&EE Development Plan 2013-2017 has a potential for reducing GHG emissions along with sectoral and national benefits, in 2013, the Ministry of Environment and Petroamazonas EP signed a cooperative agreement whose purpose was the conceptualization and design of the OGE&EE Program as a NAMA.

The OGE&EE Program proposes the development of the following power generation measures (see below), allows for the harnessing of associated gas, and guarantees a quality supply of electricity:

- Electricity generation systems using gas (untreated associated gas or residual gas).
- Electricity generation systems using gas/ crude oil.
- Electricity generation systems using crude oil (with the capacity to convert into gas/ crude oil if it is verified that the disposal of associated gas is higher than projected).
- Electricity generation systems capable of using associated gas condensation (heavy hydrocarbons).

These systems are modular, i.e. they have the ability to be demobilized and transferred to other sites if there are significant variations beyond the expected ranges. As for the transmission and distribution systems of electric power, the OGE&EE Program plans to build (primarily) underground lines whose objectives are:

- To improve the availability and reliability of the Oil-Extended Interconnected Electric System ("SEIP-E" in Spanish).
- To allow for out of economic merits dispatch.
- To provide infrastructure through which renewables (hydroelectricity surpluses) displace electricity generated with oil and deliver electricity to populations within the area of influence of SEIP-E at a lower cost.

The development of OGE&EE not only contributes to the operations of the existing oil sector but, furthermore, will form part of the central axis for the future development of the Ecuadorian Amazon District through the consolidation of the Oil-Extended Interconnected System (SEIP-E). With these facilities, the following objectives are reachable:

- The interconnection of fields and facilities.
- The dispatch out of economic merits.
- The ensurance of reliable energy at lower costs for urban, agricultural, and industrial development in the Amazon District.

2.5. Summary of the NAMA

To follow, table 2 summarizing the most important information regarding the OGE&EE program from a NAMA's logic may be found.

Table 2: Summary of the OGE&EE NAMA

ITEM	DESCRIPTION
Sector	Energy
Sub-sector	Energy Efficiency
Scope of the NAMA	Providing reliable electric energy to the entire Amazon District, in particular for the oil sector, which is the main consumer of electricity in this region through the development of the Oil - Extended Interconnected Electric System, which optimizes the use of associated gas as an energy source and allows interconnection with the National Interconnected System (SIN) for the use of hydroelectricity surplus.
Objetive	The main objective is the reduction of GHG emissions via the reduction of associated gas flaring and the elimination of diesel consumption for electricity generation, thus allowing the sustainability of the Oil - Extended Interconnected Electric System, to generate economic

	benefits both at the local and national levels.
Measures and activities that have a direct impact on reducing emissions	Assembly and operation of more than 31 gas / crude oil generation plants distributed through 17 blocks of oil production and more than 56 oil fields operated by Petroamazonas EP, Operations Rio Napo (ORN), and other areas concessioned to private companies in an area of approximately 25,000 km2. It comprises more than 120 projects including the development and implementation of more than 31 generation facilities (324.06 MW), 45 substations (13.8, 35, 69 kV), more than 1,000 km of power lines with different capacities (519.70 km of 13.8, 35, 69 kV and 470 km of 138 kV), mainly underground, and 100 km of pipelines.
Measures and activities that have a indirect impact on reducing emissions	-Use of "Low Carbon" technologies, aimed at eliminating the burning of associated gas and its use to produce electricity. -Out of economic merits dispatch. -Construction of the Extended Oil Interconnected Electricity System ("SEIP-E" in Spanish). -Implementation of a MRV using the Management System Energy Efficiency indicators. -Elimination of noise pollution resultant from the removal of isolated diesel generators. -Creating capabilities in generating energy efficient processes.
GHG reduction	15.16 million tCO2e from 2016-2025, 2.08 million tCO2e annual average.

NAMA (Time Limits) - Preparation - Implementation	OGE & EE was implemented in 2008 and since then has already achieved results regarding, among others, the reduction of CO2 emissions, and the shift away from the consumption of fossil fuels. Currently, this initiative is implemented based on the OGE&EE Development Plan 2013-2017; however, its implementation has slowed under the budgetary constraints that the Ecuadorian state faces.
NAMA's implementation and operating costs	In December 2015, a total of USD 640,382,042.26 had been invested out of a total budget of USD 1,152,310,533 for the OGE & EE Development Plan 2013-2017.
Type of NAMA	Supported
Type of support required under the NAMA mechanism	Financial

(Source: FOCAM, 2014)

3. The OGE&EE NAMA: Potential, objective and implementation

Name of the NAMA: Optimization of Power Generation and Energy Efficiency (OGE&EE) in the oil sector in the Amazon District.

Country: Ecuador

Time/ Period of the Nama: 2015-2030

Thematic area: Energy Efficiency

3.1. Potential for transformational change

The OGE&EE NAMA Program seeks to improve the efficiency of the energy model of the oil sector. The oil industry requires electrical power for its operations, mainly for the movement of fluids (crude oil and water) from the artificial lift, the processing phase (separation of water and crude oil), and for the secondary and primary pumps. Without the OGE&EE Program the oil sector would continue using diesel as the main fuel for electricity generation. On one hand, diesel is a fuel that has a production deficit. In 2013, 64% of this fuel was imported, demonstrating how the use of diesel as the primary fuel supply for the oil sector's demands was inefficient in terms of public spending and environmental pollution. On the other hand, with the extraction of oil, associated gas it is also obtained, which, despite being a non-renewable with unstable hydrocarbon volumes, can be harnessed for electricity generation (Petroamazonas EP, 2013).

The OGE&EE Program transforms the customary management of electricity generation in the oil sector in the Amazon District through the implementation of the Oil-Extended Interconnected Electric System (SEIP-E), which can optimize the highest amount of associated gas that is released along with other sources of renewable energy to be included in the National Interconnected system, giving rise to an efficient electric system that ensures the quality of the energy supply and reduces GHG emissions.

The OGE&EE NAMA aims to, among other things:

- Reduce *flaring* by using associated gas as fuel for electricity generation. Typically, associated gas is burned as it is considered waste in the extraction of crude oil.

- Change the oil energy matrix, reducing diesel power generation and increasing the proportion of renewable energy from the National Interconnected System (SIN) through hydroelectricity surplus.
- Develop an efficient Oil-Extended Interconnected Electric System (SEIP-E) for electricity distribution that connects the 17 oil blocks to the population of the area of the Amazon District.

Through the implementation and enforcement of these goals, the OGE&EE NAMA will reduce a total of 15.16 MtCO2e until 2025. A large majority of the reduction of emissions will be consequence of the substantial change in the energy matrix in Ecuador's oil sector (see figures 3 and 4).

Figure 3: Energy Matrix "WITHOUT" the OGE&EE Program

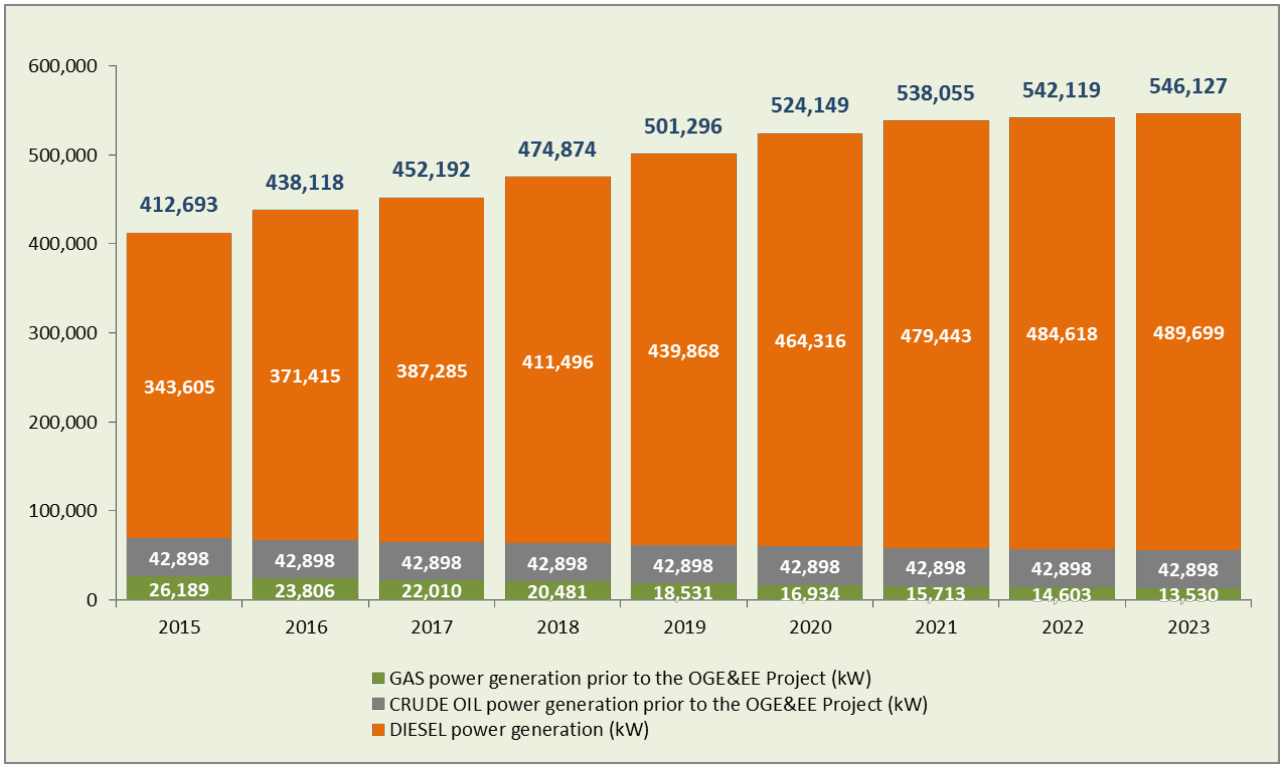
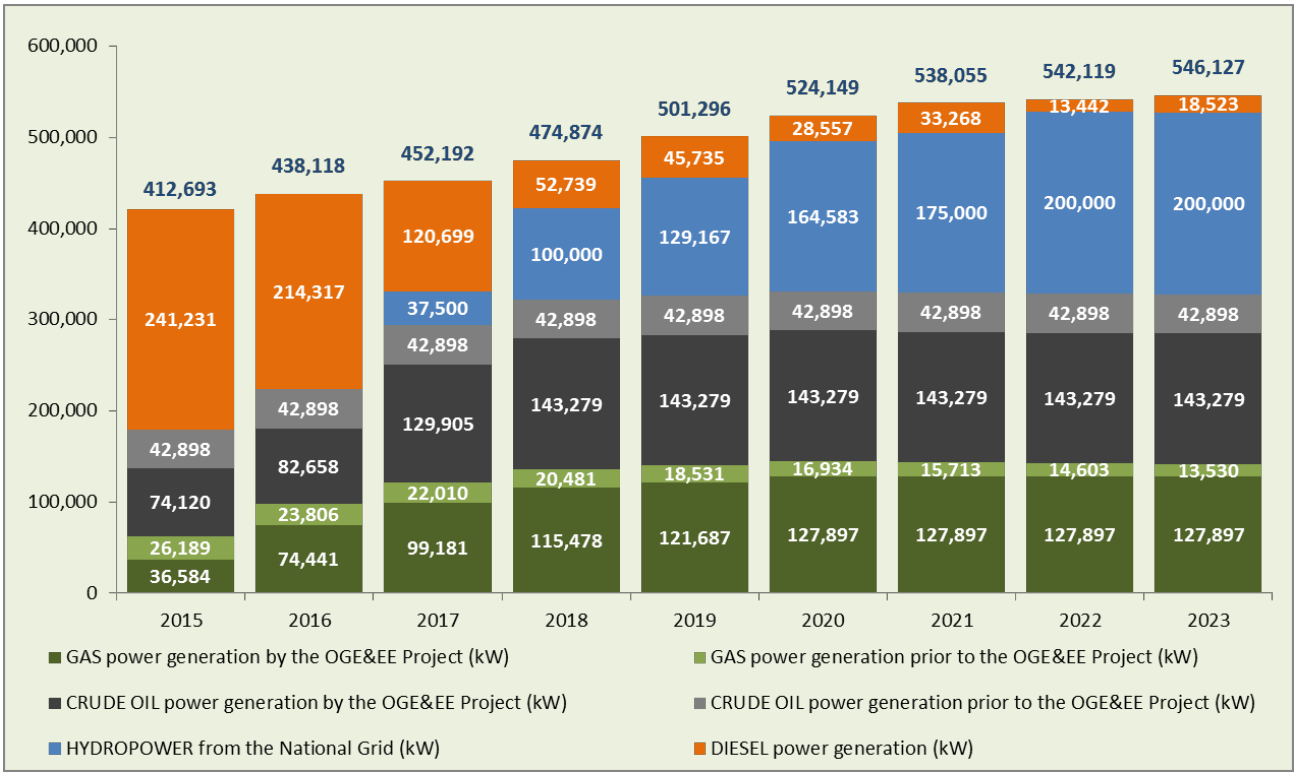


Figure 4: Energy Matrix "WITH" the OGE&EE Program



3.2. Integration of the proposal in national and sectoral strategies, and plans aimed at climate change in Ecuador

The Ecuadorian development model proposed through the National Plan for Good Living 2013-2017 has the following objectives, among others:

- Objective 7: "Ensuring the rights of nature and promoting environmental and territorial sustainability" where it is important to emphasize the following policies and guidelines:
    - Objective 10: "Promoting the transformation of the productive matrix."
    - Objective 11 "Ensuring the sovereignty and efficiency of the strategic sectors for industrial and technological transformation."

In the environmental context, the OGE&EE NAMA will allow the implementation of efficient energy systems that operate with environmental and economic criteria. Hence, NAMA's actions are aligned with the National Plan for Good Living 2013-2017's policies and guidelines:

- Policy 7.7: "Promoting efficiency and the increased participation of sustainable renewable energies as a means of prevention against environmental pollution."
- Policy 7.10: "Implementing mitigation and adaptation actions in relation to climate change to reduce the economic and environmental vulnerability, with an emphasis on priority groups."

In terms of productivity, the government aims at transforming the productive matrix and at diversifying it. To this end, there are two fundamental aspects in which the OGE&EE NAMA contributes: 1. With the implementation of this NAMA, diesel consumption for electricity generation will be reduced, which will reduce the importation of this fuel. 2. It also enables integration in terms of electricity generation among oil operations in the private and public sector. Hence, the actions of the NAMA promote implementation of the National Plan for Good Living 2013-2017, as expressed in the following policy provision:

- 10.1 Policy: "Diversifying and generating higher added value in domestic production;" particularly in the policy that states: "Promoting and strengthening key strategic industries and their production chains, with emphasis on those resulting from the restructuring of the energy matrix, the sovereign management of the strategic sectors, and those stimulating other sectors of the economy in their production processes."

The National Plan for Good Living 2013-2017 in its objective 11 aims to ensure the sovereignty of the strategic sectors for industrial and technological transformation. The oil sector is a key sector for the transformation of the energy matrix as well as for the promotion of industrialization. Efficiency in the oil sector enables an increase in sufficiency of secondary energy given that it reduces the usage of fuels such as diesel, which are primarily imported. Associated gas optimization allows the oil sector to become an efficient and sustainable energy industry because it uses its own resources to meet electricity demand.

3.3. Scope of the OGE&EE NAMA

The OGE&EE NAMA seeks to ensure the efficient use of nonrenewable natural resources in the oil sector through the development and implementation of an innovative management model. It aims at reducing the environmental impact, generating wealth, and setting new standards; the OGE&EE Program is a reference for the national and international oil industries.

It should be noted that one of the main beneficiaries of these measures are the communities surrounding the oil fields due to the construction and consolidation of a power transmission system called Oil-Extended Interconnected Electricity System (SEIP-E) of the Amazon District. The SEIP-E tries to satisfy both electricity demand in the industry processes (pumping crude oil through pipelines, pumping formation water to reinjection wells, the operation of camps) and electricity demand in the communities located within the area of influence of this NAMA (through the local company of electricity distribution).

The SEIP-E is interconnected to the National Interconnected System (National Network of Transmission of Electricity) so that both systems can interact to optimize renewable resources (hydroelectricity surplus) and non-renewables (associated gases), and thus consolidate a robust system of electricity transmission.

The ultimate goal of the OGE&EE NAMA is the low-emission development, consequent of the introduction of energy efficiency measures such as optimizing associated gas, reducing consumption of imported diesel, and crude oil consumption for electricity generation; while, at the same time, using the surpluses consequent of renewable energy generation (hydroelectricity from the national transmission grid).

3.4. General objectives

The aim of the OGE&EE NAMA is the reduction of greenhouse gases (GHGs) by optimizing the use of associated gas and displacing thermal generation, which uses diesel, and the interconnection of the National Interconnected System (SNI) to best utilize the surplus of hydroelectricity.

3.5. Specific objectives

The OGE&EE NAMA objectives are:

- To optimize the existing energy resources (prioritizing those of lower cost and lesser impact on the environment) within the oil industry.
- To optimize the associated gas for electricity generation and LPG production.
- To reduce the use of diesel and crude oil for electricity generation.

- To develop a robust system of transmission/ distribution of electric energy to its diverse users (oil operators and populations within the area of influence) at a lower cost and with a lesser impact to the environment.

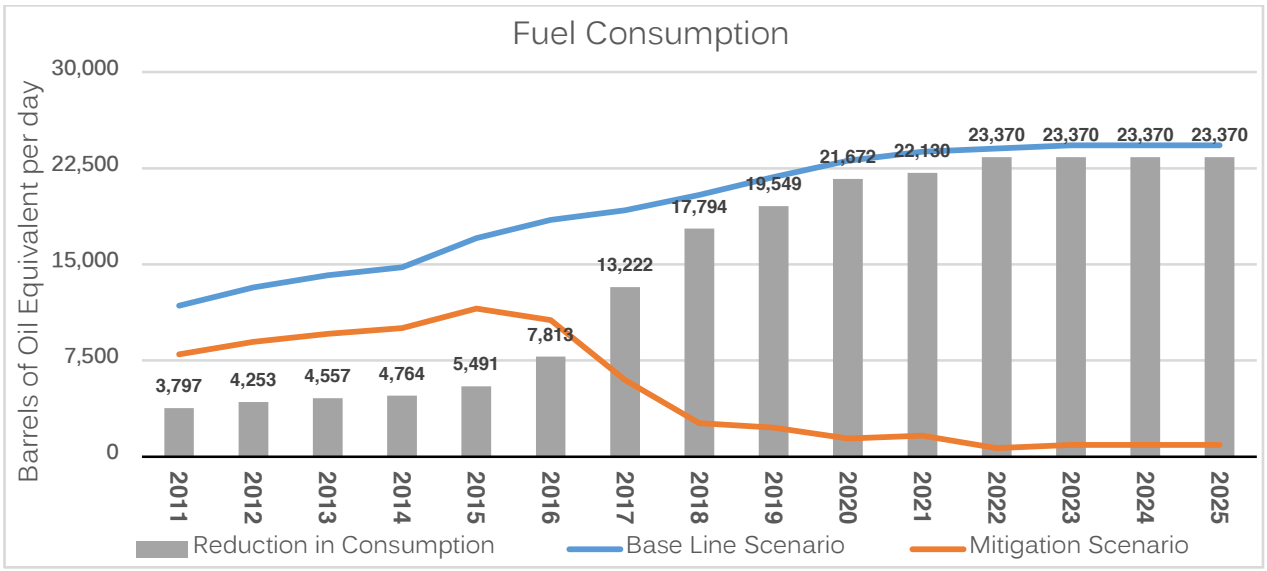
4. Co-benefits associated with the OGE&EE NAMA

The followingCo-benefits are the result of a thorough analysis carried out by the following players: the Ministry of Environment (MAE) and its Project FOCAM, Petroamazonas EP/ Management Unit OGE&EE, and national and international consultants.

4.1. Positive impact on the trade balance

According to the projections of FOCAM based on Petroamazonas EP's data, there is an effort to progressively reduce fuel consumption for electricity generation up to 25,000 barrels of the oil equivalent (BOE) consumed per day from the year 2023 (figure 5), diesel consumption will be the minimum necessary to maintain the stability of the SEIP-E. The main indicator for the evaluation of this joint-benefit is the conservation of fossil fuels in BOE per day as shown in figure 5.

Figure 5: Fuel consumption in BOE per day



(Source: FOCAM based on Petroamazonas EP data, 2015)

In this sense, it is clear that if implemented the OGE&EE Program will save 210,929 BOE per day from 2011 to 2025.

4.2. Electricity supply to communities

Since electricity based on associated gas is obtained at a lower-cost, the program is able to meet industrial demand in the area of SEIP-E, and deliver electricity to the communities within the area

of influence. For example, in September 2014, the first electrical interconnection between the oil sector and the Millennium Pañacocha Community was activated. This project consisted of the development of the following infrastructure:

- 8.4 km of buried line of 13,800 volts.
- North Napo (35 kV) and Yanahurco (15 kV) substations.
- From the beginning of his operation, an average of 29,000 kWh per month has been delivered to this community.

Likewise, the development of the engineering for substations can be found, the process of procurement and bidding for engineering the 15 kV (21 km) line for the interconnection with the Community Millennium Playas de Cuyabeno. Among others, the following activities aimed at providing electricity to communities:

- The derived engineering for the interconnection with the Community of Eden in development.
- The construction of the Substation "El Vergel", whereby the public distribution company CNEL will be able to develop a 13.8 KV feeder that will supply energy to the surrounding communities.

From the above, the following benefits are derived:

- The improvement of the quality of life of the surrounding communities.
- The increase of electricity coverage to remote sites.
- The leveraging of a required investment in the oil sector to meet the basic requirements of surrounding populations.
- Reducing GHG emissions, particularly CO2.

In addition, the Development Plan OGE & EE includes the construction of an infrastructure that can ensure reliable and cheaper energy for urban, agricultural and industrial development in the Amazon District.

4.3. Capacity building

The implementation of the project requires trained and skilled technical staff in the management of associated gas in all its stages, from the capture, transportation, handling, and final usage in the generating units. As part of the project activities, Petroamazonas EP has trained more than 300 technical professionals on issues pertaining to gas management, starting within the operations of Blocks 12 and 15, but that in the future will expand to the entire area of the SEIP-E. During the construction phase of the project, more than 2,000 jobs have been generated.

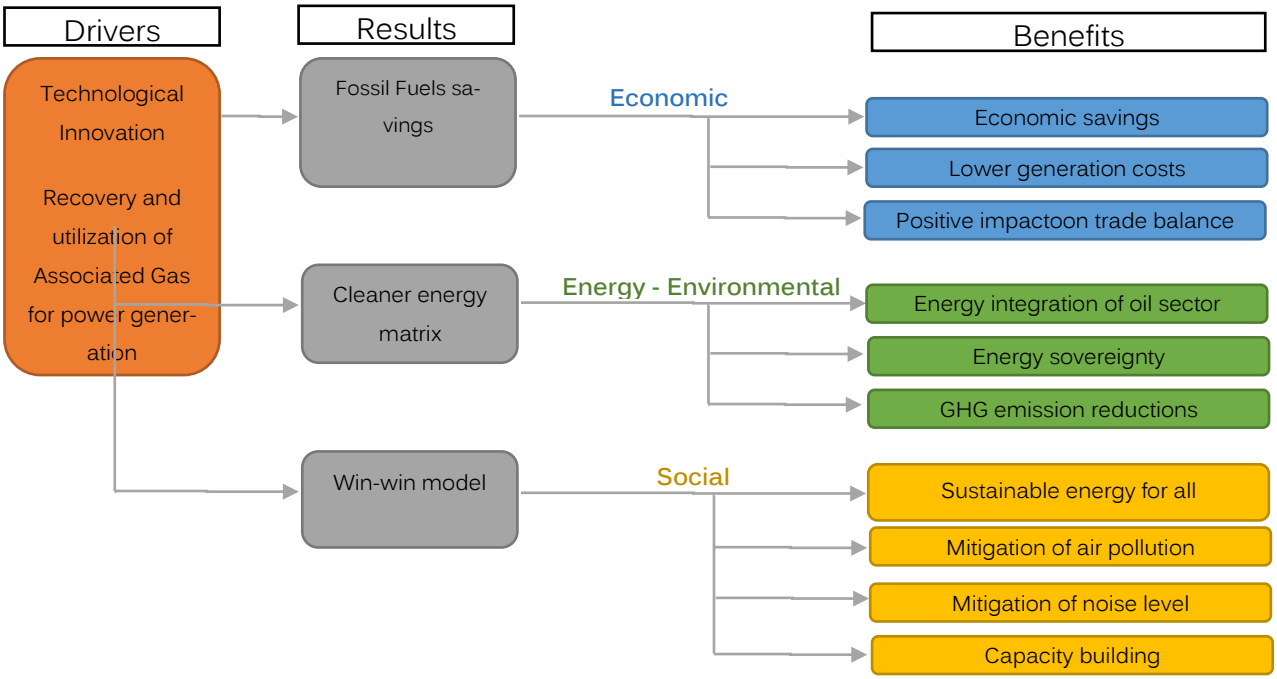
4.4. Reducing noise pollution

Throughout different parts of the Amazon District, the centralized electricity generation facilities that are reconstructed for increased efficiency have enabled the reduction of noise previously existent from the diesel generating units.

4.5. Conceptual framework of the benefits

Figure 6 summarizes the joint-benefits for the economic, energetic-environmental, and social fields.

Figure 6: Conceptual framework of the benefits of the OGE&EE NAMA



(Source: FOCAM, 2014)

5. Scenarios Analysis

The oil sector requires electrical power for its operations (mainly for moving or pumping fluids and for processing them). The oil sector operated with isolated electricity generation systems for over 30 years, which did not employ proper energy dispatch criteria, and the fuel used was primarily diesel, which was mostly imported. In this sense, the initial situation in terms of electricity consumption of the oil sector had clear opportunities for improvement. Whereas associated gas was burned in torches, squandering this resource and generating CO2 emissions.

5.1. General considerations

Having defined and presented the OGE&EE Program as a clear initiative to mitigate climate change. For purposes of assessing impacts on the fight against climate change, this project has defined two scenarios:

- ***Base-line scenario***: it is a scenario which has its start at the beginning of the plan's base year, wherein what would otherwise be new tendencies given the implementation of the OGEEE Program are non-existent, that is to say that the mitigation action does not influence this scenario.
- ***Mitigation scenario***: it is a scenario in which the implementation of the Development Plan OGE&EE is achieved, which was originally planned for the period 2013-2017.

Thereafter, emissions for these two scenarios were analyzed from the base year (2011) and projections of future emissions were made up until 2030. For the formulation of the projections, historical data and information from the OGE&EE Development Plan 2013-2017 were used. Certain assumptions as well as modeling were also used to obtain the projections. For this purpose, Model LEAP (Long-range Energy Alternatives Planning System), developed by the Stockholm Environment Institute (SEI) was used. LEAP is a tool used worldwide to develop energy balances and scenarios for energy planning. LEAP uses macroeconomic projections and integrates information on consumption, production, and extraction of energy resources in all sectors of the national economy. In addition, LEAP allows GHG emissions to be accounted for; for this reason, through this tool, GHG emissions were calculated for each scenario.

5.2. Energy demand in the oil sector

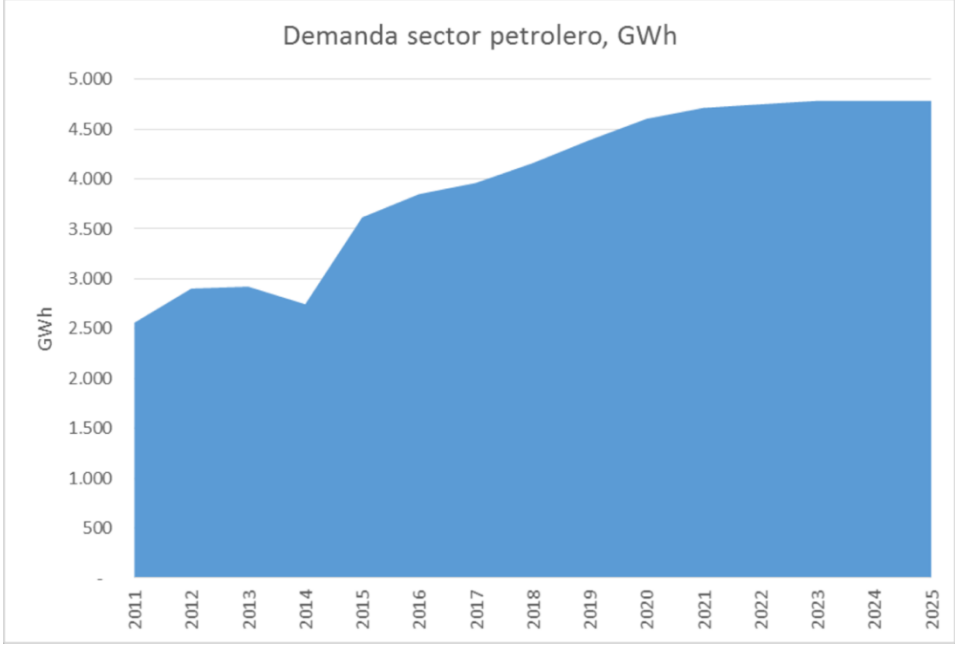
Considering that LEAP makes projections based on energy supply and energy demand, assessment of the demand is essential in the analysis of the scenarios. To do this, the starting point must be from the current demand for electricity in the SEIP-E area. In order to define growth and trends in energy demand, it was used the information from the Tool for Planning and Changing the Energy Matrix (PCME in Spanish) of Petroamazonas EP/ OGE&EE correspondent to a scenario of low investment of Wood Mackenzie (State Operators and Private Operators within the SEIP-E)[3]. It is predicted that there will be a gradual increase in energy demand for electricity. The projected electricity demand for the baseline scenario and the projected electricity demand for the mitigation scenario are the same, and it considers the requirements in the oil fields operated by Petroamazonas EP as well as those operated by private companies. See Table 3 and Figure 7.

Table 3: Energy demand in the oil sector in GWh

Year	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022	2023	2024	2025
Energy Demand SEIP-E (GWh)	2,560	2,908	2,921	2,745	3,615	3,848	3,961	4,160	4,991	4,604	4,719	4,749	4,784	4,784	4,784

(Source: FOCAM based on data from Petroamazonas EP, 2015)

Figure 7: Energy demand in the oil sector



[3] These projections do not include the future possible projections of the Pungarayacu Campos, South East and ITT (Ishpungo Tambococha Tiputini).

5.3. Emission under BASE Scenario

Considering the projected energy demand, the baseline scenario consists in the maintaining of the initial installations without considering any measures to reduce emissions, i.e. without the consideration of the implementation of the OGE&EE Program. Here, the demand is met mainly with diesel, as indicated in Table 4.

Table 4: Energy demand in the oil sector in GWh. Base scenario

Year	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022	2023	2024	2025
CRUDE oil generation installed before OGE & EE Program (GWh)	159	178	190	199	209	209	193	179	162	149	138	128	119	119	119
GAS generation installed before OGE & EE Program (GWh)	260	291	312	326	376	377	376	376	376	377	376	376	376	376	376
Diesel generation installed before OGE & EE Program (GWh)	2,142	2,434	2,419	2,220	3,010	3,263	3,393	3,605	3,853	4,079	4,200	4,245	4,290	4,290	4,290
Energy demand SEIP-E (GWh)	2,560	2,903	2,921	2,745	3,615	3,848	3,961	4,160	4,391	4,604	4,713	4,749	4,784	4,784	4,784

(Source: FOCAM base on data from Petroamazonas, 2015)

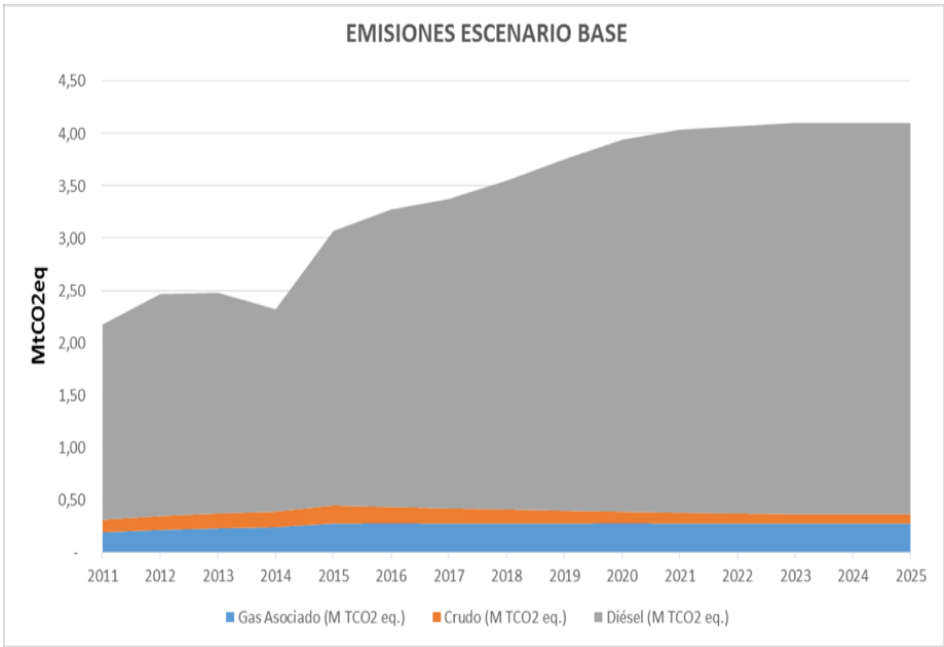
To calculate emissions, IPCC emission factors were considered:

- Crude oil emission factor: 72.5 tCO2 / TJ
- Associated gas emission factor: 55.8 tCO2 / TJ
- Diesel emission factor: 72,6TCO2 / TJ

On the other hand, the conversion rate from TJ to GWh is 1TJ = 0.27795 GWh.

According to the above, emissions up until the year 2025 for electricity generation for the SEIP-E area would be 4.10 MtCO2e (Figure 8 and Table 5).

Figure 8: GHG emissions under the Baseline Scenario



(Source: FOCAM based on data from Petroamazonas EP, 2015)

Table 5: GHG emissions in the BAU scenario

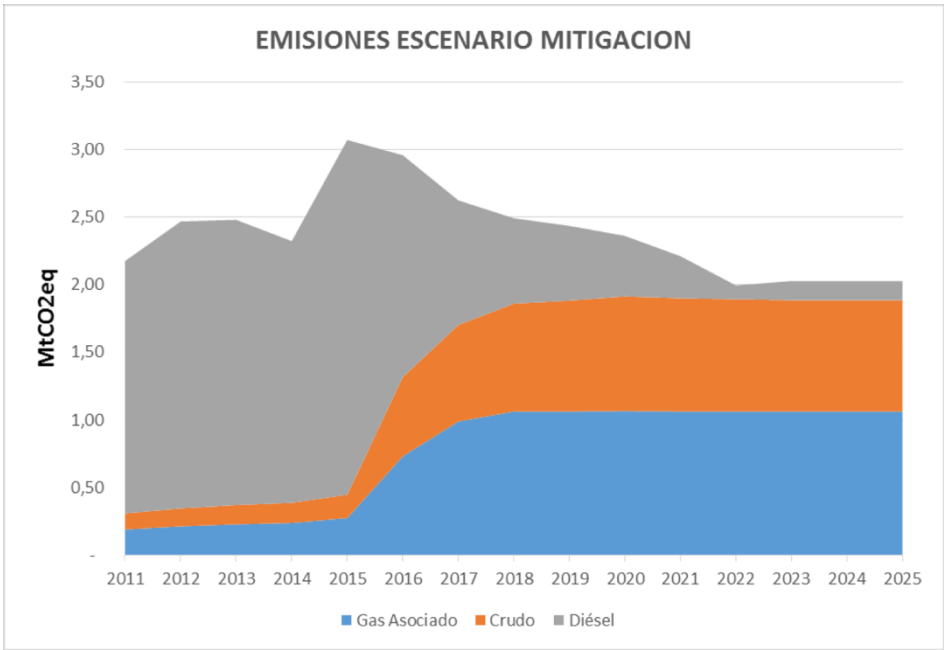
	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022	2023	2024	2025
Gas Asociado (M TCO2 eq.)	0,19	0,21	0,23	0,24	0,27	0,28	0,27	0,27	0,27	0,28	0,27	0,27	0,27	0,27	0,27
Crudo (M TCO2 eq.)	0,12	0,13	0,14	0,15	0,17	0,16	0,14	0,13	0,12	0,11	0,10	0,10	0,09	0,09	0,09
Diésel (M TCO2 eq.)	1,87	2,12	2,11	1,93	2,62	2,84	2,96	3,14	3,36	3,55	3,66	3,70	3,74	3,74	3,74
Total	2,18	2,47	2,48	2,32	3,07	3,28	3,38	3,55	3,75	3,94	4,04	4,07	4,10	4,10	4,10

(Source: FOCAM based on data from Petroamazonas EP, 2015)

5.4. Mitigation Scenario

The mitigation scenario corresponds to the implementation of the OGE&EE Program; energy demand is the same as in the baseline scenario, however, the difference comes from the use of fuels. Thanks to new generation facilities, (internal combustion engines with gas and internal combustion engines with associate gas/ crude oil) the use of associated gas is optimized to produce electricity and reduce significantly the use of diesel. From 2017, the SEIP-E is interconnected to the SNI. These measures reduce "flaring" and consequently also the release of GHG emissions into the atmosphere. Emissions up until the year 2025 for electricity generation for the SEIP-E area would be 2.03 MtCO2e (Figure 9 and Table 6).

Figure 9: GHG emissions under the Mitigation Scenario



(Source: FOCAM based on data from Petroamazonas EP, 2015)

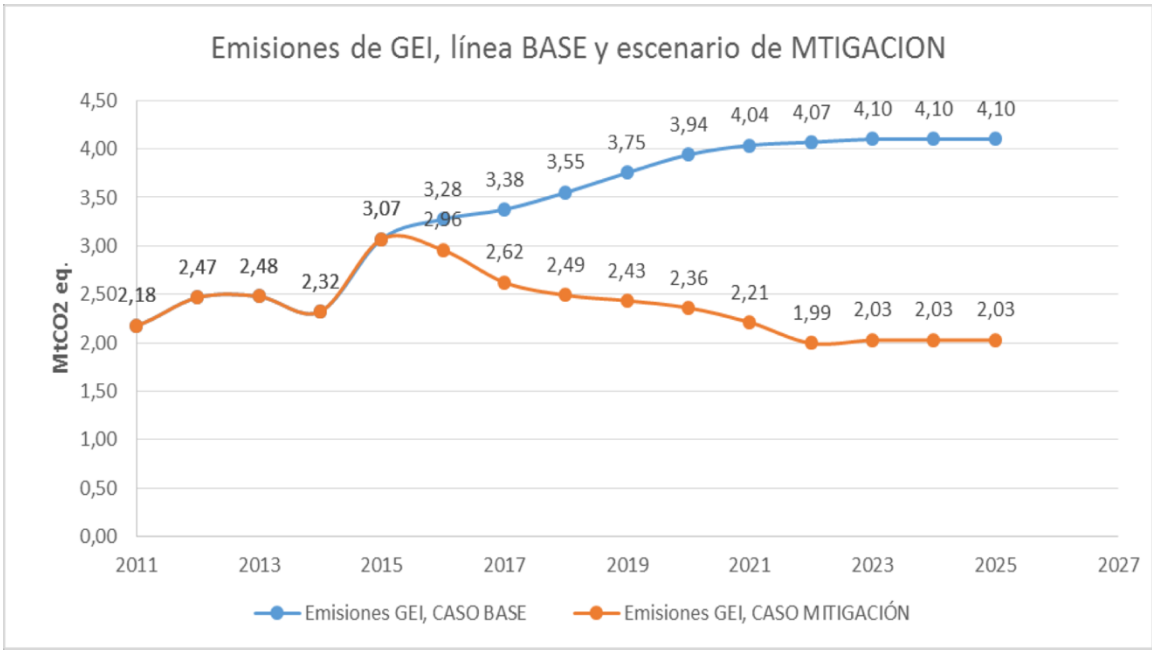
Table 6: GHG emissions under the Mitigation Scenario

	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022	2023	2024	2025
Gas Asociado (M TCO2 eq.)	0,19	0,21	0,23	0,24	0,27	0,73	0,99	1,06	1,06	1,06	1,06	1,06	1,06	1,06	1,06
Crudo (M TCO2 eq)	0,12	0,13	0,14	0,15	0,17	0,59	0,71	0,80	0,82	0,85	0,84	0,83	0,82	0,82	0,82
Diésel (M TCO2 eq.)	1,87	2,12	2,11	1,93	2,62	1,64	0,92	0,63	0,55	0,45	0,31	0,10	0,14	0,14	0,14
Total	2,18	2,47	2,48	2,32	3,07	2,96	2,62	2,49	2,43	2,36	2,21	1,99	2,03	2,03	2,03

5.5. Potential for reduction of GHG emissions

The potential for reducing GHG emissions is simply the difference in emissions between the baseline scenario (without the implementation of Program OGE&EE) and the mitigation scenario once the entire OGE&EE Program is implemented up until the interconnection of the SEIP-E and the SNI. The OGE&EE NAMA would achieve a sustainable reduction of emissions; figure 10 shows the potential of reduction: the reduction of emissions in the area between the curve of emissions under the baseline scenario and the mitigation scenario. Hence, a reduction of 2,08 MtCO2e can be achieved annually from 2022, which is the result of the difference in emissions between the baseline scenario and the mitigation scenario.

Figure 10: Potential of reducing emissions from the OGE&EE project



(Source: FOCAM based on data from Petroamazonas EP, 2015)

6. Description of the planned activities for the implementation of the OGE&EE NAMA

As it is mentioned above, since 2008 there has been an ongoing effort to implement the OGE&EE Program, which represents a clear action to mitigate climate change. Since 2013, the Ministry of Environment has given priority to actions that have the potential to develop as a NAMA, such as the OGE&EE Program. Below it is presented the overall development schedule of the NAMA that is laid-out according to the OGE&EE Development Plan 2013-2017. For this reason, it shows the components of infrastructure implementation as well as the managerial components related to the conceptualization of the OGE&EE Program as a NAMA.

Table 7: Planned activities for the implementation of the NAMA OGE&EE

Components of the OGE&EE NAMA		2008-2011	2012	2013	2014	2015	2016	2017
Defining the OGE & EE Management Unit		■						
Development Plan: Infrastructure	Improving Existing Facilities		■	■	■			
	Implementation of Generation Facilities with oil and associated gas				■	■		
	Implementation of Facilities of Associated Gas Management					■	■	■
	Implementation SEIP-E						■	■
	Interconnection SNI							■
Identification of the OGE & EE Development Plan as a NAMA				■				
Development of the OGE & EE NAMA Document					■	■		
Implementation of the MRV (SGI-EE)					■			
Registration of the OGE & EE NAMA before the NAMA national authority							■	
Registration of the NAMA before the UNFCCC							■	
Comprehensive MRV improvements							■	■

(Source: FOCAM based on data from Petroamazonas EP, 2015)

7. Finance for NAMA: investment and funding sources

Once the OGE&EE Management Unit within Petroamazonas EP was established, the planning for the development of the OGE&EE Program was established; initially this occured with the OGE&EE Development Plan 2012-2015; later it was updated with the OGE&EE Development Plan 2013-2017. Through this planning, investments have been made both in management and in infrastructure for the optimal implementation of the OGE&EE Program. Based on this planning, investments and savings have been studied and evaluated[4].

Within the comprehensive development budget for the OGE&EE Program, the largest investments are made for the construction of electricity generation facilities using associated gas, crude oil, and gas/ crude oil, capture facilities and transportation of associated gas, and the implementation of the Oil-Extended Interconnected Electricity System. In addition, minor investments have been made for research and development, plan improvement, and other management activities.

7.1. Partial results of the OGE&EE Program

Thus far, the results of the OGE&EE program are the following:

- Up until December 2015, 640.38 million USD have been invested of a total budget of 1152.3 million USD in the OGE&EE Development Plan 2013-2017.
- With the investment mentioned above, the following facilities have been put into operation to reduce *flaring*:
    - **Generation Facilities**: 17 generating facilities with a combined nominal power capacity of 180,160 kW; i.e. 56% of the target set in the Development Plan 2013-2017.
    - **Distribution Facilities**: 157.70 km of electric lines with capacities ranging from 13.8 kV to 69 kV; i.e. 30% of the target set in the Development Plan 2013-2017.
    - **Capture, Transportation, and Handling of Associated Gas Facilities**:
        - Phase 1 Gas Management System CPF.

[4] This planning may be subject to change based on approved annual budget allocation and may vary. Hence, the current year's cuts due to the availability of resources allotted by the Ministry of Finance.

- Gas Accumulation System (Lung Gas) CPF.
- Gas Management System EPF.
- Re-powering Gas Management System Secoya.
- Interconnection Pipeline Sacha Norte-CIS and Limoncocha-CPF to increase the volume of gas in Block 15 CPF (pending commissioning).
- Gas Management System Limoncocha.
- Gas Management System Paka Sur.
- Pipeline Drago-CIS (however, this project was suspended for lack of funds).

- The implemented infrastructure has saved 237.73 million gallons of diesel and has reduced 780,950.22 tons of CO2 emissions.

Figure 11: Volume of diesel saved by the OGE&EE Program (2009-2015)

(Millon of gallons)

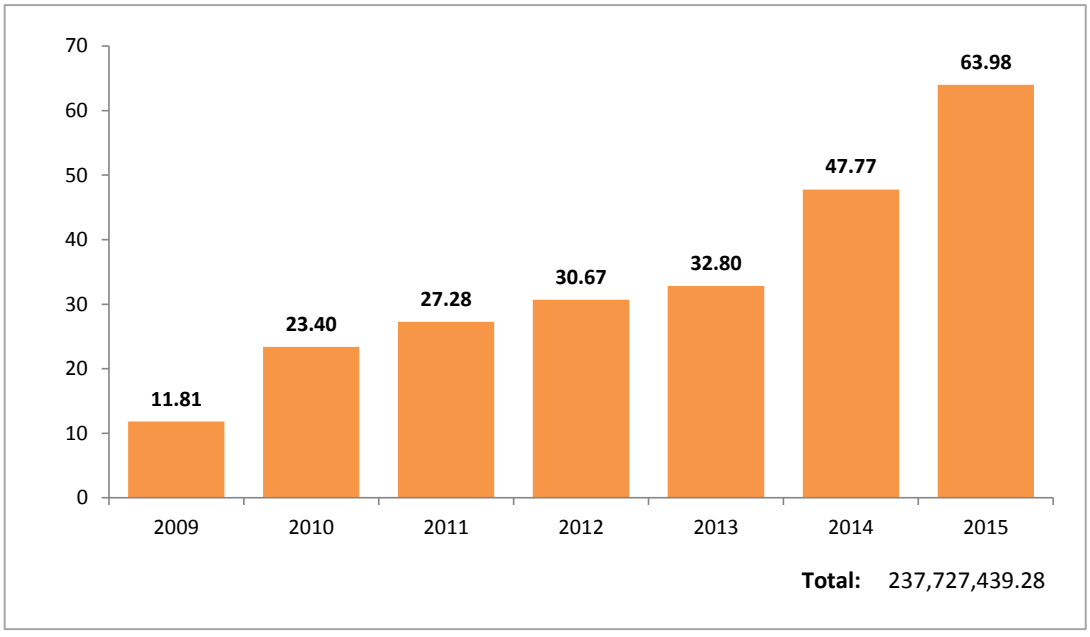
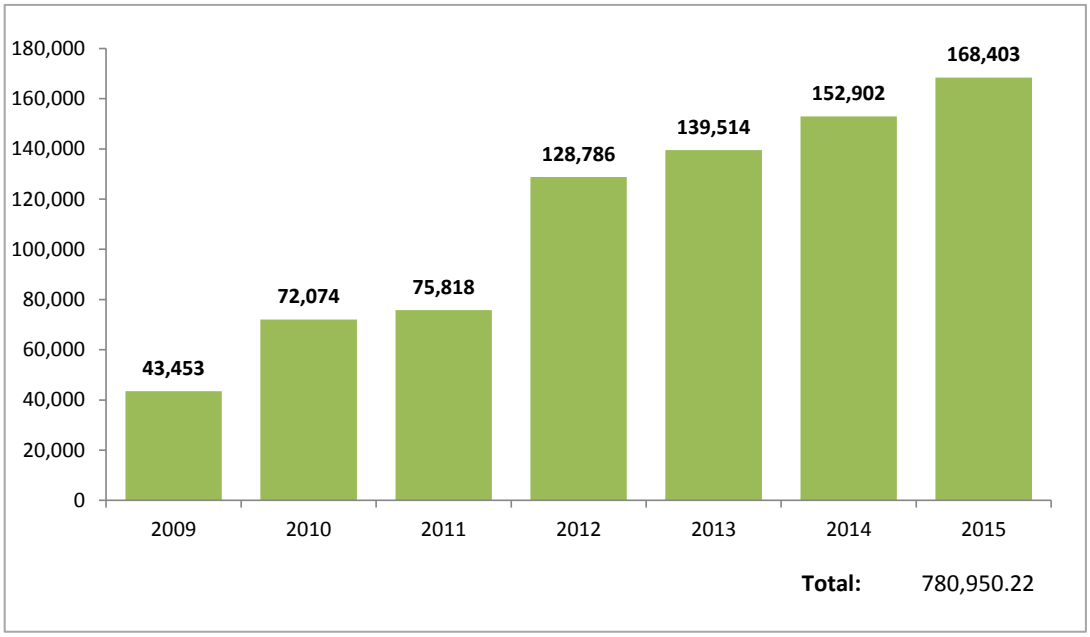


Figure 12: Reduction of emissions by OGE & EE Program (2009-2015)

(Tons of CO_2)



7.2. Financial Mechanisms

Since 2014, the OGE&EE program has suffered budget cuts that have limited the implementation of the activities planned in the OGE&EE Development Plan 2013-2017. For example, the budget for 2015 was USD 276,667,021.18; however, ultimately only USD 70,000,000 were available. It is worth mentioning that by the end of 2014, $50,000,000 out of these $70,000,000 were already secured through contractual instruments.

However, in response to these cuts, an Operational OGE&EE Strategic Plan 2015-2016 was developed which aims to:

- Generate savings for Petroamazonas EP and the state in the shortest possible time, attracting domestic and international investments; among these, climate finance.
- Achieve the objectives of the OGE&EE Project, as set out in the OGE&EE Development Plan 2013-2017.

The Strategic Action Plan holds that the pending projects to be developed by the OGE&EE Execution Unit will be executed in the form of Project Finance. Project Finance is a financial mechanism used in large investments and it is based on: (i) the project's ability to generate cash flows to meet the repayment of loans; and (ii) contracts between various stakeholders to ensure the prof-

itability of the project. They are also projects characterized by having the involvement of vastly mature technologies.

The increase of large investments in infrastructure and the tendency of governments to reduce their budget deficit levels have been a fundamental fact in the development of Project Finance. This financial mechanism allows both public administration and private stakeholders to undertake projects whose capital investment is significantly high.

Project Finance is a mechanism widely used in the implementation of the telecommunications sector (mobile telephony, cable TV, etc.). However, today it has gained prominence in other sectors such as the electricity or transportation sector, shifting away large investments from the public sector to the private sector.

Finally, it is worth mentioning the importance of the coverage ratio, which clearly indicates the "health" of the project, showing the ability of the generated cash flows to repay debt.

The main features of this mechanism are the following:

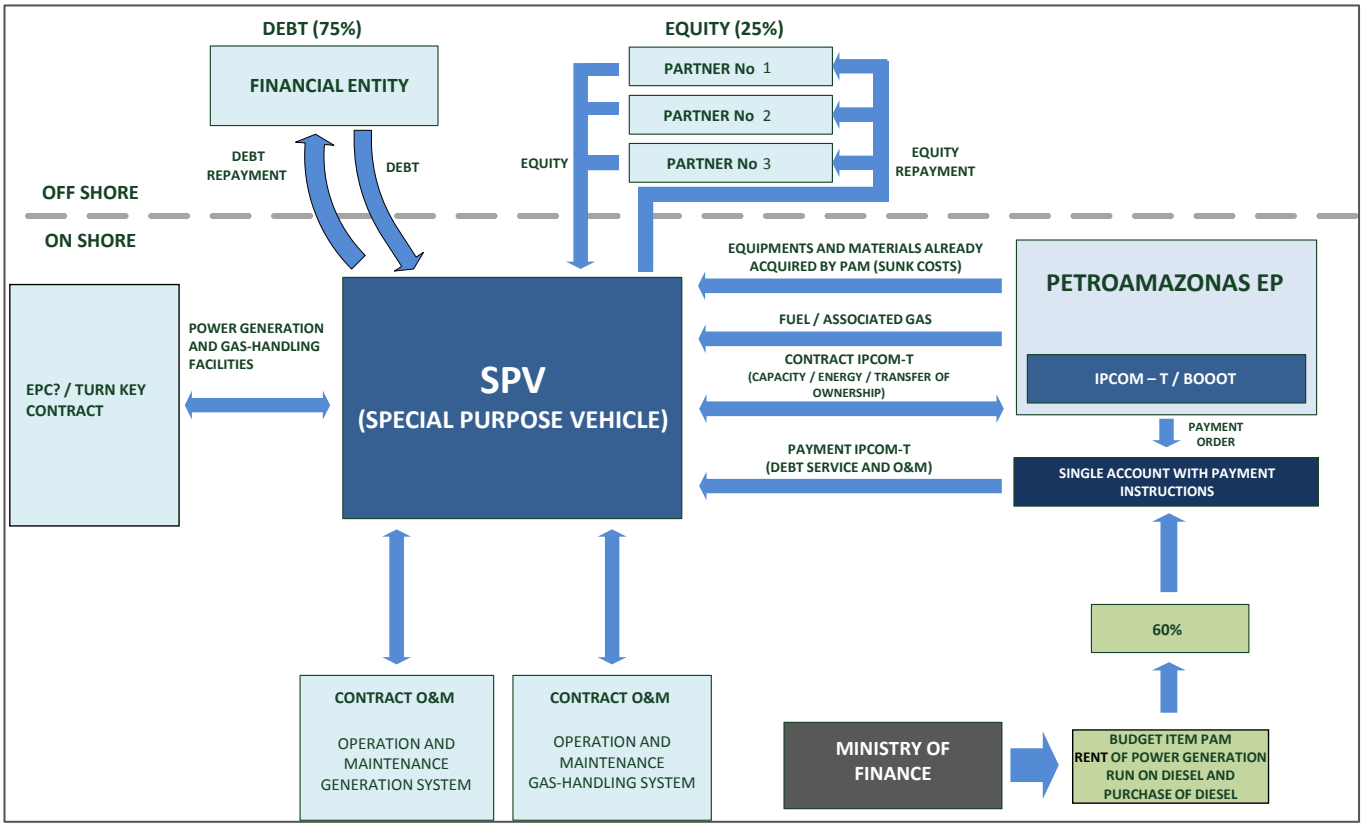
- An independent vehicle or legal entity is created as a financial instrument for the project, which in current literature is denominated "Special Purpose Vehicle (SPV)."
- The manager or project sponsor can provide most of the capital of the SPV, linking project funding to project management.
- The SPV holds contracts with various parties: manufacturer, supplier, customer and financial institution, among others.
- The SPV operates at a high level of debt to equity ratio, so that lenders have limited possibilities to claim in case of default.
- The demand in contracts of guarantee enables the project to be profitable, and thereby capable of satisfying the interests of the participants. In addition, these requirements are higher in the initial phase of the project (design and construction). This is because the costs of this phase are very high and the project does not generate income yet. As a counterpart, it is a common practice to take as collateral the contracts of machinery construction and power purchase agreements, among others.

- Creation of a reserve fund constituted from surpluses in cash flows in order to cover the possible negative contingencies during the project lifecycle.

Power Generation Projects

Figure 13 presents the Project Finance model to be applied for developing Power Generation Facilities.

Figure 13: Financial mechanism for power generation facilities



For the implementation of this financial mechanism, two outlines have been identified:

- ***IPCOM-T Model:*** it considers a contract of "Integrated Services with Financing for Engineering, Procurement, Construction, Operation and Maintenance under charge rate." Through this outline, Petroamazonas EP delivers the "long delivery time" equipment such as generating units, electrical equipment, processing facilities, etc., conceptual/ basic engineering and design and construction criteria while the contractor (strategic partner)

closes the engineering phase, it performs the additional procurement and builds and operates the facilities.

It is worth indicating that at this time, Petroamazonas EP is negotiating the development of 52.1 MW of electricity generation using gas/ crude oil with a private consortium under this outline. The consortium is supported by the Inter-American Investment Corporation (IIC) of the Inter-American Development Bank (IDB) that has channeled funding for this project (among other funding also derived from climate funds).

- ***BOOT Model (Build, Own, Operate, Transfer):*** it considers a contract of "Integrated Services with Financing for the Development of Generating Facilities." Under this outline the Contractor assumes the integral development of the facilities, where Petroamazonas EP can deliver minor components for developing the facilities.

It should be mentioned that for the development of either of these two financial mechanisms it is necessary that Petroamazonas EP ensures the source of payment for the service, which in this case, they are the OPEX budgets of income generation with diesel and fuel used in electricity generation.

In the case of electricity distribution projects, with slight variations and specifications, the same mechanism of Project Finance for its development could be applied.

8. Assessment of barriers and risks

To ensure the positive implementation of the OGE&EE Program, an analysis to identify barriers and risks has been carried out in order to propose possible solutions for overcoming them.

8.1. Prioritization and assessment of barriers

Below, Table 8 shows information regarding the prioritized barriers, the proposed solutions with their respective evaluation.

Table 8: Prioritization and assessment of barriers

#	BARRIERS/ SOLUTIONS	MEASURES
Barrier 1	Prioritization of funds for conventional oil operations **Solution**: Allocation of sufficient and incremental budget for Energy Efficiency projects	Petroamazonas EP prioritizes budget for Energy Efficiency
		Increase in net production volume due to the implementation of the OGE&EE Program, which generates greater volume of currency to Ecuador
		The company performance is also evaluated based on resource optimization and efficiency
		Petroamazonas EP implements new technologies for power generation
Barrier 2	Insufficient financial incentives **Solution**: Availability of resources and financial incentives	To design, development and implementation of standards for energy efficiency; there are available funds and resources for compliance
		It should be developed or identified new mechanisms and strengthen existing mechanisms for financing energy efficiency projects. Lines of credit, and financing mechanisms for cooperation
Barrier 3	Scarcity of resources (availability of labor) **Solution**: Increasing availability of skilled labor	To promote skills development focused on the needs of strategic sectors
		To increase the level of employee commitment to the company / project
		Personnel involved in the project remains longer and share experience and know-how to achieve the project objectives
Barrier 4	Risk of losses in assets (stranded assets) **Solution**: Using assets efficiently throughout its life-time	To include schemes in the design criteria to mitigate the risk of changes in production profiles, for example in the SEIP-E, modular generation facilities, flexible generation with gas, oil, gas / oil and condensate, as well as the development of capture and transport projects to increase the availability of associated gas for power generation and the reduction in sunk costs by 14% (pipelines)
Barrier 5	Lack of resources at the country level (state budget) **Solution**: Available resources for funding the project or part of it	To promote the Program and to create mechanisms to guarantee the financial resources to achive the comprehensive scope of the project or part of it (e.g. Project transmission line of 138 kV for the SEIP-E) such as financing the supply of the 138kV line, BOOT contract scheme (build, own, operate, and transfer), identification and management of alternative financing mechanisms (international climate regime) and joint technological development with suppliers of equipment

#	BARRIERS/ SOLUTIONS	MEASURES
Barrier 6	Reliability of electricity generated **Solution**: Reliable Energy with SEIP-E, flexible generation schemes, modular systems, portable systems G-MPUs, MPUs, R&D power generation using condensates	Development of flexible technological solutions
		Comprehensive evaluation of power generation projects with various technologies in order to comprehensively consider investments and expenditure to be incurred (capital cost, operating cost and fuel cost)
		It is necessary to install facilities for the handling of associated gas (processing, storage, etc.)
		To implement design criteria to improve the level of reliability of the electrical system
Barrier 7	Technical and operational limitations / administrative limitations to reach agreements and arrangements with communities **Solution**: Technical and Operational Facilities/ Administrative Facilities	To review and to propose a fair and equitable update in fees with DINAC (National Valuations and Cadastre)
		Hiring a specialized team on issues of community relations to audit the management of a third party hired to manage and negotiate the rights of way
		Design of contractual instruments for services of surveying and plats
		Conduct a survey of existing rights of way to verify status of them.
		Within the legal department of PAM EP there must be a group dedicated to carry out the legal procedures to reach the final agreement

9. Recommendations on the Monitoring, Reporting and Verification System (MRV)

A System of Monitoring, Reporting and Verification (MRV) integrates an information management system that enables the assessment of the implementation of the NAMA to show both performance in reducing GHG emissions and the joint-benefits of it. Currently, the OGE&EE Management Unit has a Management System of Energy Efficiency Indicators (SGI-EE) based on the operation of a technology platform and a management outline with defined players and roles. It also has a process that indicates the flow of information from registration, validation and publication.

The parameters measured as primary inputs for the SGI-EE are:

- Energy dispatched with gas (MWH) and energy dispatched with crude oil (MWH)
- Gas consumption (MCF) and oil consumption (BBLS)

By measuring these parameters, the reduction in GHG emissions and the resultant savings may be calculated. Thus, daily, monthly and annual reports are elaborated; furthermore, an executive summary is elaborated, which goes through a validation process of the information gathered. All these reports are prepared according to guidelines.

Additionally, there are other reporting mechanisms such as the Result-oriented Government System (GPR in Spanish) from which the Ministry of Hydrocarbons reports on the results of OGE&EE in a government platform in order to track projects and strategic programs in Ecuador. Additionally, Petroamazonas EP annually presents Management Reports and Sustainability Reports showing achievements in these issues.

Below, some relevant aspects should be taken into account for the design of an MRV system.

9.1. Responsibilities of the institutions involved

The overall responsibility for the design and implementation of the MRV system lies with Petroamazonas EP as the OGE&EE Program developer from which the NAMA is derived. However, an MRV system requires measurement and monitoring activities, reporting and verification activities. Table 8 shows the public institutions involved in the responsibilities regarding the OGE&EE NAMA.

Table 9: Institutions involved in the MRV system of the OGE&EE NAMA

INSTITUTION	RESPONSIBILITIES
MEASUREMENT	
Petroamazonas EP/ OGE&EE	Responsible for the implementation of the Oil Development Plan in their fields. It is the public oil company. Responsible for the OGE&EE Programme.
National Center for Energy Control (CENACE)	Responsible for sorting the energy dispatch from the electricity generation plants of the National Interconnected System (SNI).
Electricity Regulation and Control Agency (ARCONEL)	Responsible for drafting the Electrification Master Plan, which is mandatory for the public sector and serves as the benchmark for the private sector. It is the regulatory and monitoring entity in the electricity system. It provides technical information and it represents the Ecuadorian State in signing the contracts for electricity generation.
REPORTING	
Petroamazonas EP/ OGE&EE	Petroamazonas EP develops reports periodically; for example the year-end balances of the annual management, which includes the performance of the NAMA activities. These activities are indicative for national mitigation reports (e.g. biennial update reports and national communications). Petroamazonas EP has been reporting the progress of the OGE&EE Program and the compliance with requirements of the adopted standards for project design (e.g. engineering, energy efficiency).
Ministry of Environment (MAE)	By decree, MAE is the national environmental authority, thus it is responsible for registering mitigation actions. Instrument: Ministerial Agreement of the National Authority NAMA (AN-NAMA in Spanish), AM 89. Under Secretary for Climate Change.
Ministry of Hydrocarbons (MH)	Responsible for promoting and leading the oil development scenario. Wherein its actions are founded in Hydrocarbons Law.
Ministry Coordinator of Strategic Sectors (MICSE)	Responsible for managing the policies and actions of the institutions within strategic sectors, and, in practice, regularly monitoring the progress and performance of the OGE&EE NAMA.
VERIFICATION	
Institutions and accreditation requirements depend on the negotiations between Petroamazonas EP and the OGE & EE Program, and NAMA's sponsors. Validation of the third part of the MRV system subject to the aforementioned negotiation framework.	

(Source: FOCAM, 2014)

9.2. Monitoring

Petroamazonas EP, through the SGI-EE system, already has a monitoring, reporting, and verification system for the measuring the performance in terms of emission reductions. This system is based on the Clean Development Mechanism (CDM methodology AM0009). In this chapter, the type of methodology is reenforced as well as the emphasis on measuring GHG emissions.

9.2.1. Suggested methodology

To calculate emission reductions, the difference between the emissions amounts from a baseline scenario in which oil, diesel, and gas are used as primary energy to generate electricity and meet electricity demand should be evaluated; and the amount of emissions from the OGE&EE scenario in which the amount of associated gas increases, shifting away from diesel. The CDM incorporates a methodological tool for calculating CO2 emissions from fossil fuel consumption. "The tool to calculate project or leakage CO2 Emissions from fossil fuel combustion V. 02" is referenced by several approved CDM methodologies, which assures its consistency and methodological rigor. Following a revision of the indicated tool, it follows that the fundamental variables and suggested variables for calculating emission reductions are: PEFC, FC, j, y, and i;

$$PE_{FCj,y} = \sum_{i} FC_{i,j,y} \; X \; COEF_{i,y}$$

Where:

PEFCj, y = CO2 emissions in the combustion process j during year y (tCO2/ year)

FCi, j, y = the amount of fuel type i used in the combustion process j during year y (unit of mass or volume/ year)

COEFi, y = the coefficient of CO2 emissions of fuel type i in year y (tCO2/ unit of mass or volume)

In the case of the OGE & EE NAMA, i = 3 (diesel, associated gas and crude oil), j = 3 (generation using gas, generation using diesel and generation using crude oil), and the amounts of fuel will result from the annual compilation for each case.

COEFi,y emission coefficient will be calculated based on net calorific value and CO2 emission factor of each fuel type i, in the following way:

$$COEF_{i,y} = NCV_{i,y} \cdot EFCO2_{i,y}$$

Where:

$COEF_{i,y}$ = CO2 emission coefficient of fuel type i in year y (tCO2 / unit of mass or volume)

$NCV_{i,y}$ = the weighted average of heat capacity of fuel type i in year y (GJ/ unit of mass or volume)

$EFCO2_{i,y}$ = the weighted average CO2 emission factor of fuel type i in year y (tCO2/ GJ)

The data needed to complete the proposed outline is $FC_{i,j,y}$, $NCV_{i,y}$, and $EFCO2_{i,y}$. This implies having knowledge of certain data that is available in annual publications in the country, while other data should be taken from international default values. Below, table 9 shows the relationship between the required data and the available data. It is noteworthy that Petroamazonas EP has developed a set of indicators as part of its market intelligence activities that entail field data collection.

Table 10: Relationship between generated data and required data for Measurement

Required data	NAMA implication	Definition	Source
$FC_{i,j,y}$	Amount of associated gas used in the generating system	Daily consumption of associated gas to generate electricity (MSCF)	SGI-EE
	Amount of crude oil used in the generating system	Daily consumption of crude oil and or reduced crude oil to generate electricity (bbl).	SGI-EE
	Amount of disel used in the generating system	N/D	-
$NCV_{i,y}$	Weighted average of heat capacity of associated gas in generating electricity	LHV = 950 BTU/scf	OGE&EE Development Plan 2013-2017
	Weighted average of heat capacity of crude oil in generating electricity		IPCC Guides

	Weighted average of heat capacity of diesel in generating electricity	NCV = 41.8 (TJ/1000 ton)	Emission factor SNI 2012
EFCO2, i, y	Emision Factor of CO2 from associated gas when used to generate electricity	Highly variable	-
	Emision Factor of CO2 from crude oil when used to generate electricity		
	Emision Factor of CO2 from diesel when used to generate electricity	FE = 72,600 (kgCO2/TJ)	Emission factor SNI 2012
SGI-EE: Management System of Energy Efficiency Indicators of Petroamazonas EP SNI: National Interconnected System LHV: Lower Heating Value N/D: Not available			

(Source: self-compiled data)

9.3. Reporting

After measuring the reduction in emissions, it should be reported in a clear and transparent manner to key stakeholders. In the case of the OGE&EE NAMA, the report will have its origin in Petroamazonas EP and will be addressed by the Ministry of Environment (MAE) as NAMA's National Authority. In addition, the report should consider the guidelines and timelines necessary to harmonize the results with the National Communications and Biennial Update Reports to the UNFCCC. The report being elaborated by Petroamazonas EP will have as its objective reporting the activity: The replacement of fossil fuel in the electricity generation process of "upstream" oil (diesel) and the usage of a byproduct (associated gas) frequently considered a waste in the industry as a measure of energy efficiency, the reduction of CO2 emissions being the ultimate objective of this report.

Regarding the methodology, the report should explain the methodology used in calculating the reduction in emissions, the data sources used, the assumptions made in the calculation and control procedures, and quality assurance data. It should indicate the sources and levels of uncertainty that are used in the calculation, as well as the methodology for determining the outcomes.

9.4. Verification

The verification process will depend on whether the NAMA is conducted unilaterally or with support. If the NAMA is supported, the supporting institution may disclose information for the verification activities. In the case of being unilaterally conducted, the Ministry of Environment would determine the verification process, and would consider verification activities such as data validation and data checking, through comparisons with data from activities conducted in other projects in the oil sector. Emission factors will be reviewed, and in the case that they are national or country specific (tier 2) they may be compared with IPCC's emission factors (tier 1).

References

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