Project design document form
(Version 11.0)

BASIC INFORMATION	
Title of the project activity	Choloma Hydroelectric Project
Scale of the project activity	☐ Large-scale ☒ Small-scale
Version number of the PDD	6.1
Completion date of the PDD	15/04/2020
Project participants	Hidroeléctrica Choloma, S.A.
Host Party	Guatemala
Applied methodologies and standardized baselines	AMS-ID: Grid connected renewable electricity generation, version 18.0.
Sectoral scopes	Sectoral scope: 1 Type I. Renewable energy projects < 15 MW Project type: Project supplies electricity to a national/regional grid
Estimated amount of annual average GHG emission reductions	14,542 t CO_2e

SECTION A. Description of project activity

A.1. Purpose and general description of project activity

The purpose of the proposed project activity is to generate renewable electricity using small-scale hydroelectric resources and to sell the generated output to the national grid. The project activity has the capacity to reduce CO_2 emissions by avoiding electricity generation by fossil fuel-fired power plants connected to the grid. In the baseline scenario and the situation existing prior to the implementation of the project activity, the electricity delivered to the grid is generated by the operation of existing grid-connected power plants and by additions of new generation sources, as is reflected in the combined margin to calculate baseline emissions. The project is expected to reduce an average of 14,542 tCO_2/year, totaling 101,794 tCO_2 during the second crediting period.

The project activity consists of the construction and operation of the Choloma Hydroelectric Project, a small-scale hydroelectric power plant with an installed capacity of 9.7 MW[1], which will produce electricity free of greenhouse gases. As per CDM project standard for project activities, it is classified as a small-scale project Type I (Renewable energy projects < 15 MW).
The developer and owner of the project is Hidroeléctrica Choloma, S.A., a company based in Guatemala.

According to the version 18.0 of the AMS-I.D. Grid connected renewable electricity generation, "the spatial extent of the project boundary includes the project power plant and all power plants connected physically to the electricity system[2] that the CDM project power plant is connected to."

The goals of the Choloma Hydroelectric Project are as follows:

1. To produce electricity to be injected into the electric grid of Guatemala, with the purpose of contributing to meet the country´s growing electricity demand. It is estimated that the power plant will produce an average of 36.538 GWh[3] of electricity per year, which will be sold in the Guatemalan energy market. The Guatemalan legal framework, under the Guatemalan General Electricity Law (*Ley General de Electricidad*), allows private investments in the power generation sector with the objective of increasing electricity supply.

2. To increase the use of renewable resources in Guatemala in order to produce clean electric energy and to substitute fossil fuel based generation.

3. To contribute to the sustainable development of Guatemala, utilizing the renewable resources responsibly, and strengthening local synergies to foster the development of the communities in the area of influence of the project activity through the following measures:

- Environmental dimension
    - The project activity avoids the emission to the atmosphere of approximately 14,542 tons of CO_2 per year, through the utilization of renewable resources to generate electric power, thus contributing to the mitigation of global climate change. In addition to CO_2 emissions reductions, the project activity will also mitigate other pollutants, such as SO_2, NO_x, and particles associated with power generation by displacing fossil fuels.
    - It contributes to the preservation of local natural resources of the sub-basin of the Choloma

[1] As per the version 18 of the General Guidelines to SSC CDM methodologies, the installed capacity of the plant is determined by the rated output of the generator, which is 9.7 MW, as per equipment manufacturer data. This information is indicated in the generator nameplate.

[2] Refer to section B.6.1 for definition of an electricity system.

[3] See calculation procedure in section A.4.2 of the PDD (page 7).

River, by means of projects aimed at environmental conservation and protection. In addition to reforestation projects that will be supported, the surrounding area of the project property contains more than 800 hectares (8 million square meters) of natural rainforests, which will be conserved.

- Over the long-term, because of its size and general characteristics (rural area, local electricity needs), this project has a high probability of being replicated in other parts of Guatemala. This fact magnifies the global and local environmental benefits generated by the project activity.

- Economic dimension
  - The project activity contributes to poverty reduction by creating employment opportunities through the construction and operation of the hydroelectric plant and by the implementation of reforestation programs, as well as projects carried out by the sponsoring company´s corporate social responsibility efforts that improve infrastructure, health and educational aspects in the surrounding communities.
  - On a national scale, the project activity provides clean electricity to the power market, thus reducing dependence on fossil fuel imports.

- Social dimension
  - The project participant plans to support community projects that improve the quality of life of people living close to the hydroelectric plant. As part of the project development, a potable water grid for the neighbouring indigenous communities is planned.
  - As part of the social responsibility program of the project activity, projects aimed at improving living standards and economic development of the surrounding indigenous communities will be designed and implemented, including activities such as: Assisting a local health centre, supporting community organization in order for them to be able to access government programs and international aid projects, providing vocational training courses, and in general assisting with education, health, infrastructure (and other) requirements, through the establishment of cooperation agreements between Choloma and various local and international NGOs, and by coordinating and implementing projects directly.

From its inception the project activity considered the reduction of CO_2 emissions and the related revenues to overcome project financial barriers. CDM income (from the sale of CERs) will enable the execution of the Project, thereby contributing to Guatemala’s sustainable development and to global climate change mitigation.

The project participant is anticipating to direct, at a minimum, 10% of the annual revenues generated through the sale of CERs to be invested in social and environmental programmes, with the objective of assisting the local environment and communities in areas such as community organization and leadership, school education, health, infrastructure and sustainable productive projects, as previously described. The main objective in the medium term is for communities to develop self-sustaining and environmentally sound economic activities to improve living standards in general.

A.2. Location of project activity

The Choloma hydroelectric plant is located on the Choloma River, in the Department (State) of Alta Verapaz, Guatemala; around 200 kilometers North-east of Guatemala City. The geographical coordinates of the location are:

Table 1. Coordinates of the Choloma hydroelectric plant (Power plant) location

Latitude	15.41656531

Longitude	- 89.74165110

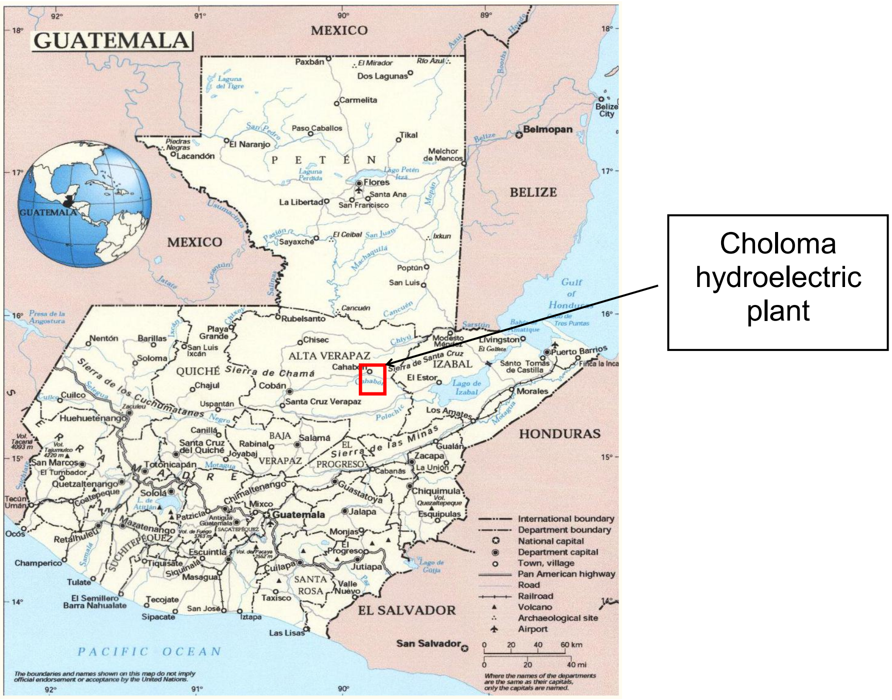


Fig. 1. Choloma Hydroelectric Project location

A.3. Technologies/measures

The project activity is type I (Renewable energy projects < 15 MW), classified as ID category for Grid connected renewable electricity generation, sectoral scope 01. The technology of the small-scale project activity consists of hydro renewable energy generation units, supplying electricity to a national grid.

Electricity from a renewable source will be generated by a small-scale hydroelectric plant with a daily regulation reservoir (tank), which will allow a constant power supply during the daily peak demand hours that in the Guatemalan electric market occur from 6 to 10 pm.

The small-scale hydroelectric plant is located in a region with high variations in the annual hydrologic pattern between the rainy and the dry seasons. The hydroelectric plant is designed as a peaking or daily regulation plant. It includes a small artificial reservoir (water storage tank) that will allow water storage during daily low demand hours, which is then released during daily peak demand hours, thus contributing renewable energy to the power grid at the time of maximum power requirement, which directly results in a greater avoidance of higher levels of fossil fuel based power generation. The power plant, which uses the water flows from the Choloma River and its tributaries Secampana, Secampanita, Golondrinas and Caquipek, is illustrated in Figure 2.

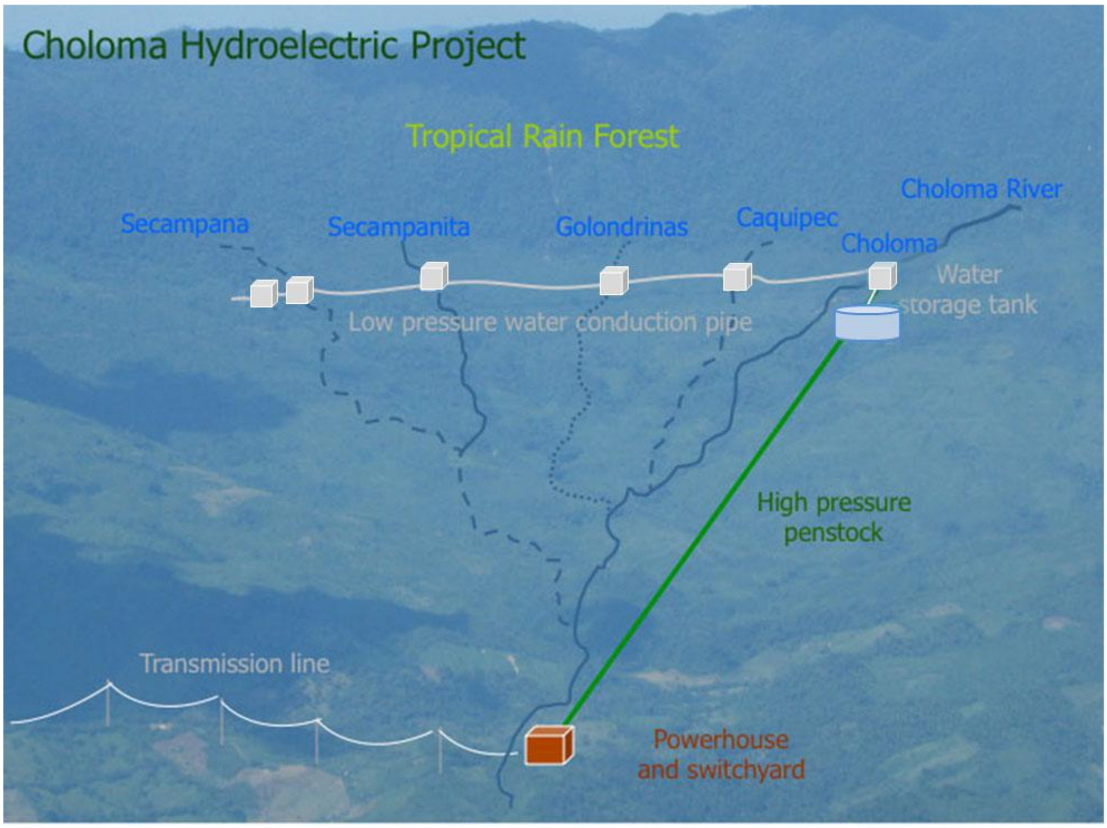


Fig. 2. Layout of Choloma Hydroelectric Project

Project installed capacity and annual energy generation

The Choloma hydroelectric project has a gross head (altitude differential from the maximum water level in reservoir (tank) to the turbine axis elevation) of 461 meters, and has a design flow of 2.5 cubic meters per second. The powerhouse is equipped with a 9.577 MW turbine and a 9.7 MW generator. The yearly average electricity production is expected to be 36.538 Gigawatt hours (GWh), assuming a plant factor of 0.43.

The hydroelectric plant will have a water storage tank with a capacity of 20,000 cubic meters of live storage volume, which will provide power delivery at a capacity of at least 5 Megawatts during peak demand hours year round (6 to 10 pm each day), and up to full capacity in the rainy season due to the increased water flows.

Site geology

The geology of the area is composed mainly of Karst type geologic formations, and Geological and Geotechnical exploration studies were undertaken to establish the design criteria and requirements for an adequate final design, in particular for the powerhouse foundations, the main thrust block (concrete block that holds the high pressure penstock at its connection to the powerhouse), and the tank. In order to ascertain the completeness and adequacy of the geological explorations, the US consulting firm *EES Consulting* issued the “Choloma Hydroelectric Project Geotechnical Investigation Scope of Work.”

The Geologic studies were contracted with the Guatemalan company Rodio-Swissboring (http://www.rodio-swissboring.com/empresa.html), a subsidiary of the Spanish company Rodio (http://www.rodio.com/eng/presentacion.asp). The results from the various studies were used for final designs of the project’s water storage tank, the penstock thrust blocks, machine house and switchyard foundations.

Hydrology and climate

The water flow to be used by the project activity comes from the Choloma River and its four tributaries Secampana, Secampanita, Golondrinas and Caquipec; this system is part of the larger Polochic river basin located in the central Alta Verapaz region. The water flow contributions from the four tributaries will be collected and conducted through a 6.44 kilometre long low-pressure pipeline to a water storage tank to be built next to the Choloma River, where the flow from this fifth and most important river is added to the system.

The average annual rainfall at the project area is approximately 4,050 millimetres. The rainy season starts in early June and ends in late October. Some rainfall during the dry season occurs sporadically, induced by weather systems coming from the Caribbean ocean. Historically, the month with most rainfall is July, while the driest month is April. Daily rainfall records have been collected since 1996.

Using the results obtained from the hydrological study and the water measurements taken over time, the hydroelectric plant has been conceptualized with a design flow of 2.5 m^3/s. Average annual water flow is 1.07 m^3/s, with a minimum daily flow of 0.210 m^3/s occurring in April. The flow duration curve of the power plant is presented next.

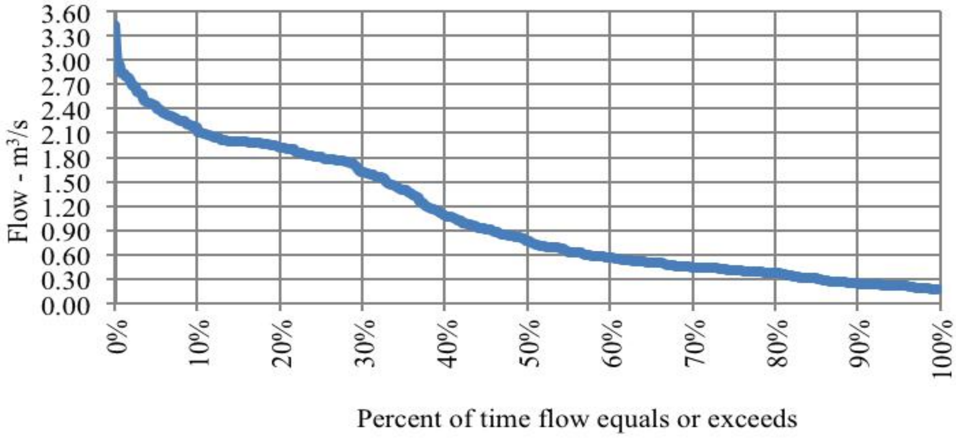


Fig. 3. Flow duration curve

Water intake dams and low-pressure pipeline

Small water diversion dams will be built at each of the four tributaries and on the Choloma River. The diversion dams will divert water from the Choloma River and its tributaries and will form small water bodies, which will not be used as daily regulation reservoirs.

The water will flow into the low-pressure pipes through the intakes, which are constructed with self-cleaning sluiceways and trash-rack covered pipe-inlets in order to keep sediment, leaves and other debris out. The pipes from each intake will merge with a main low-pressure pipeline in order to conduct the combined water to the water storage tank at the Choloma River. The entire low pressure system is 6.45 km long, and most of it will be installed underground, buried next to an existing road, saving the project the high cost, and avoiding the environmental effects, of having to construct a new trench through very difficult terrain.

Water storage tank

The project will have a water storage tank with a live storage volume (water available for power generation) of approximately 20,000 cubic metres, enabling the plant to constantly deliver 5.0 MW during the 4 daily peak demand hours, year round.

The tank will be of steel, with a diameter of 60 meters and a height of 10.6 meters. The geometric shape of the tank is cylindrical; therefore its area is constant at any water level. The innovative and environmentally friendly idea of building a water tank as water reservoir, instead of a dam, is

already being replicated in at least one small hydro project in Guatemala that is currently under construction.

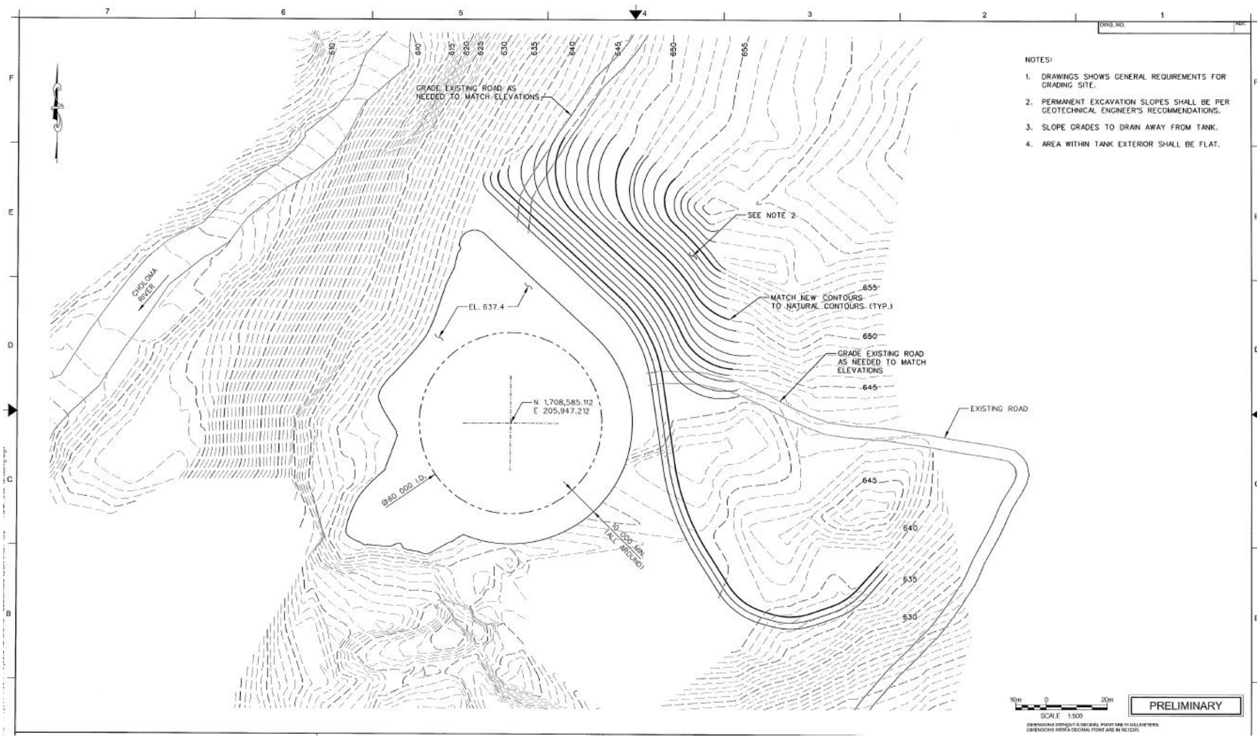


Fig. 4. Footprint and location of the water storage tank

The high-pressure penstock begins at the tank. The controlled turbine output will manage the water level in the tank continuously, so that a full tank can be established daily ahead of the peak demand period during which the complete live storage volume will be released over 4 hours to increase plant output.

High pressure penstock

The high-pressure penstock will be of steel. The pipe diameter ranges from 0.96 to 1.1 metres, and the complete pipeline will be 2.68 kilometres long.

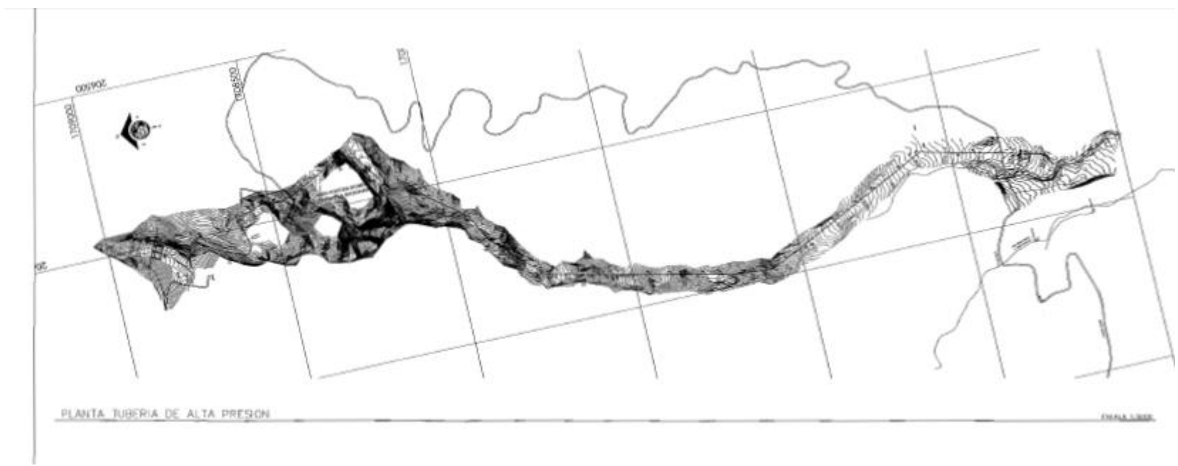


Fig. 5. Top View of high-pressure penstock (2,684 meters)

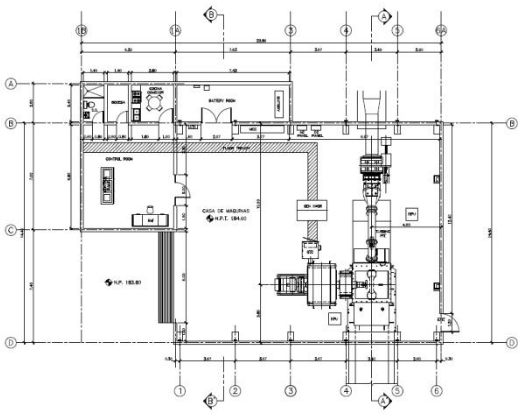
The penstock will be installed in an earthen trench, which will be refilled with the extracted soil as fill-material. Pipe sections will be stored at general staging areas, from where they will be transported and placed into the trench utilizing the developer's own overhead cable-crane, a very

efficient installation method that does not require the construction of extensive and expensive roads and reduces environmental impacts.

Powerhouse (Machine House)

The machine house will be composed of a concrete foundation and a steel structure, covered with metal siding. It will house the turbine, generator, lubrication and hydraulic pump units, switchgear, control and protection equipment. It will contain an overhead travelling crane with sufficient capacity to lift the heaviest parts (oil filled main step-up transformer); the crane will be used for equipment unloading and assembly. Adjacent to the power house will be the operating and control room from where the plant operator will be shielded from the noise and higher temperatures but will be able to observe the power-house floor on one side, and the exterior switchyard on the opposite side. The control room will include all equipment necessary for automatic and manual plant operation and control. Additional rooms adjacent to the powerhouse and control room will contain emergency battery racks, operator kitchenette, restroom, and storage area.

Water discharge from the turbine will flow into a tailrace channel underneath the powerhouse, which will extend out to the original Choloma river basin for water release.



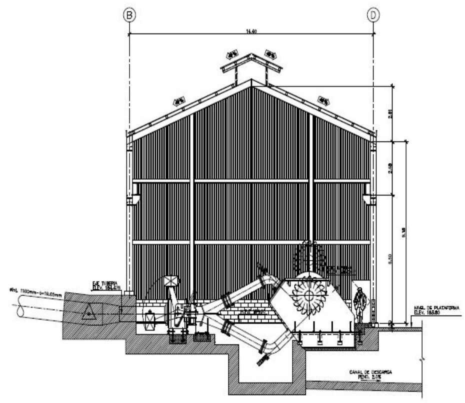


Fig. 6. Machine House Layout and Machine House Side-View

Choloma Switchyard and Transmission Line

Outside of the control room a 180 square meter electrical switchyard will be built. It will contain the main step-up transformer and related switchgear. To prevent environmental damage, an oil trap will be built with the capacity to hold 100% of the transformer oil in the event of leakage/spillage.

A 4-kilometre long 69-kilovolt-transmission line has been installed, which will connect the Choloma substation with the existing Secacao substation. From here, the net electricity produced by the project activity will be delivered to the Guatemalan transmission grid.

The electricity metering equipment will be installed at the Secacao substation and consists of two electricity meters (main and back-up), voltage and current transformers, power supply and a communication system.

In addition to the high-voltage transmission line, an “internal” low-voltage power line has been built which extends from the machine house up to the main Choloma dam and the 5 intakes at the other rivers. This line provides electricity for illumination and gate operation, and will also hold an optical fibre cable to allow data transfer between the dam and the powerhouse for plant monitoring and control.

Project technical data summary[4]

River Basin:	Polochic River (sub-basin: Choloma River)
Main River:	Choloma
Secondary flows:	Secampana, Secampanita, Golondrinas, Caquipek
Installed Capacity[5]:	9.7 MW
Design flow:	2.5 m^3/s
Gross head:	461 m
Turbine:	Single Pelton turbine, twin jets, horizontal shaft, 9.577 MW
Generator:	9.7 MW, 60 Hz, synchronous, enclosed water/air-cooling unit
Water Storage Tank:	Steel, 60 meter diameter, 10.6 meter height; live storage capacity of 20,000 m^3
Low pressure penstock:	6.45 km HDPE[6] pipe with diameters ranging from 0.45 to 1.2 meters
High-pressure penstock:	2.68 km steel penstock, diameters from 0.96 meters to 1.1 meters.
Power House:	Concrete foundation, steel structure with steel siding; approximate area of 336 m^2
Main step-up Transformer:	12.2 MVA, 6.6 to 69 kV
Transmission voltage:	69 kV
Main transmission line:	4 km
Average electricity generation:	36.538 GWh / yr
Plant factor:	43%

A.4. Parties and project participants

Parties involved	Project participants	Indicate if the Party involved wishes to be considered as project participant (Yes/No)
Guatemala (host Party)	Private entity: Hidroeléctrica Choloma, S.A.	No

A.5. Public funding of project activity

Public funding from an Annex I or host country are not used by the project activity.

A.6. History of project activity

The CDM project activity was registered on 28/12/2012. The starting date of the first crediting period indicated was changed and approved by the Executive Board from 01/03/2013 to 01/01/2013.

The present version of the PDD is submitted for the renewal of the crediting period.

In addition, the Project Participant declares that the project activity is not included or has not been deregistered as a component project activity (CPA) in a registered CDM programme of activities (PoA).

[4] As per feasibility studies and final design.

[5] In accordance to generator nameplate data.

[6] High density polyethylene.

A.7. Debundling

According to version 04 of the "Assessment of debundling for small-scale project activities" methodological tool, the Choloma Hydroelectric Project is not a debundled component of large project activity, as there is no registered small-scale CDM project activity or an application to register another small-scale CDM project activity with the same project participants, in the same project category and technology/measure, and registered within the previous two years; and whose project boundary is within one kilometre of the boundary of the proposed small-scale activity at the closest point.

There are two existing hydropower plants, Secacao (16 MW) and Candelaria (4 MW), located next to the boundaries of the project activity, using the flow from the Trece Aguas River. The mentioned hydropower plants began operations in 1998 and 2006, respectively. They are not part of the proposed project activity because Secacao was not registered as a CDM project and Candelaria was registered on November 6, 2006 under UNFCCC, reference number 0604.

Nor are any other CDM projects to be submitted by the project sponsor in the future on the same river and within 1 km of the project boundary of the proposed small-scale activity. Thus, the proposed Choloma Hydroelectric Project is not part of a larger, debundled CDM activity.

SECTION B. Application of methodologies and standardized baselines

B.1. References to methodologies and standardized baselines

AMS-ID: Grid connected renewable electricity generation, version 18.0.[7]

Sectoral scope 1(Energy industries)

Type I. Renewable energy projects.

Project type: Project supplies electricity to a national/regional grid.

Likewise, the tools referenced in this methodology are the Tool to calculate the emission factor for an electricity system (version 7.0) and Assessment of the validity of the original/current baseline and update of the baseline at the renewal of the crediting period (version 3.0.1).

B.2. Applicability of methodologies and standardized baselines

AMS-I.D Small-scale Methodology (Grid connected renewable electricity generation)
Sectoral scope: 01

The project activity qualifies under this category because it fulfills the eligibility criteria of version 18 of AMS I.D methodology.

AMS I.D Eligibility criteria	Application to the Project Activity
This methodology comprises renewable energy generation units, such as photovoltaic, hydro, tidal/wave, wind, geothermal and renewable biomass: *a) Supplying electricity to a national or a regional grid; or* *b) Supplying electricity to an identified consumer facility via national/regional grid through a contractual arrangement such as wheeling.*	The Choloma hydroelectric plant uses water (renewable resource) from the Choloma River. The electric energy produced is delivered to the National Electricity System (grid).
This methodology is applicable to project activities	It is a greenfield plant because it consists of the

[7] https://cdm.unfccc.int/UserManagement/FileStorage/2P7FS6ZQAR84LG3NMKYUH50WI9ODBC

that: (a) Install a new power plant at a site where there was no renewable energy power plant operating prior to the implementation of the project activity (Greenfield plant); (b) Involve a capacity addition; (c) Involve a retrofit of (an) existing plant(s); or (d) Involve a replacement of (an) existing plant(s)	construction of a new power plant at a site where there was no renewable energy power plant operating prior to the implementation of the project activity.
Hydro power plants with reservoirs that satisfy at least one of the following conditions are eligible to apply this methodology: • *The project activity is implemented in an existing reservoir with no change in the volume of reservoir;* • *The project activity is implemented in an existing reservoir, where the volume of reservoir is increased and the power density of the project activity, as per definitions given in the project emissions section, is greater than 4 W/m^2;* • *The project activity results in new reservoirs and the power density of the power plant, as per definitions given in the project emissions section, is greater than 4 W/m^2.*	The facility of the hydroelectric plant includes new multiple reservoirs, with a total area of 3,751.97 m^2 at maximum level and the power densities of each reservoir as well as of the whole power plant are greater than 4 W/m^2. As per the information provided in the project emissions section, the power density of the project activity is greater than 4 W/m^2.
If the new unit has both renewable and non-renewable components (e.g. a wind/diesel unit), the eligibility limit of 15 MW for a small-scale CDM project activity applies only to the renewable component. If the new unit co-fires fossil fuel, the capacity of the entire unit shall not exceed the limit of 15 MW.	The project activity does not include both renewable and non-renewable components; and the project activity does not co-fires any fossil fuels. The project activity includes only a renewable component that does not exceed 15 MW. It consists of the construction and operation of the Choloma hydroelectric plant that has an installed capacity below 15 MW. The capacity of the electric generator is 9.7 MW.
Combined heat and power (co-generation) systems are not eligible under this category.	Not applicable, the project activity is not a combined heat and power (cogeneration) system.
In the case of project activities that involve the addition of renewable energy generation units at an existing renewable power generation facility, the added capacity of the units added by the project should be lower than 15 MW and should be physically distinct from the existing units.	Not applicable, the project activity is a new project; therefore it does not involve the addition of renewable generation units at an existing renewable generation facility.
In the case of retrofit, rehabilitation or replacement, to qualify as a small-scale project, the total output of the retrofitted or replacement power plan/unit shall not exceed the limit of 15 MW.	Not applicable, the project activity is not a retrofit nor a replacement.
In the case of landfill gas, waste gas, wastewater treatment and agro-industries projects, recovered methane emissions are eligible under a relevant Type III category. If the recovered methane is used for electricity generation for supply to a grid then the baseline for the electricity component shall be in accordance with procedure prescribed under this methodology. If the recovered methane is used for heat generation or cogeneration other applicable Type-I methodologies such as "AMS-I.C.: Thermal energy production with or without electricity" shall be explored.	Not applicable. The project activity is not a landfill gas-, waste gas-, wastewater treatment- nor an agro-industries project.
In case biomass is sourced from dedicated plantations, the applicability criteria in the tool "Project emissions from cultivation of biomass" shall apply.	Not applicable. The project activity is not biomass power plant.

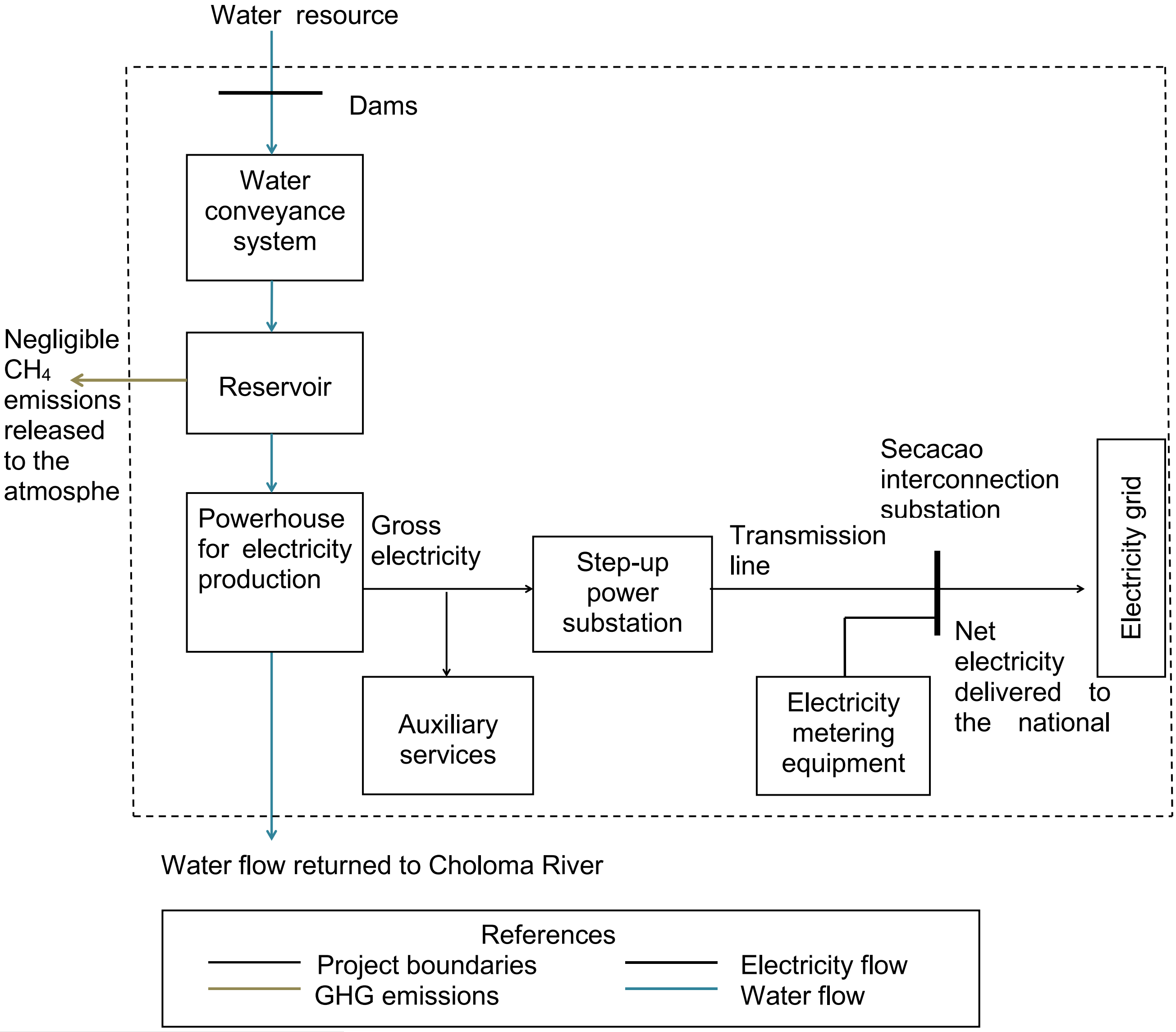
In accordance with the applicable provisions on small-scale project type and eligibility in the CDM project standard for project activities, the project activity qualifies as Type I: Renewable energy project activities with a maximum output capacity of 15 MW, since its installed capacity as indicated by the manufacturer of the equipment (installed capacity of the generator) is 9.7 MW.

B.3. Project boundary, sources and greenhouse gases (GHGs)

According to the version 18.0 of the AMS-I.D. Grid connected renewable electricity generation, "the spatial extent of the project boundary includes the project power plant and all power plants connected physically to the electricity system[8] that the CDM project power plant is connected to."

The power plant includes the area occupied by the components of the hydroelectric plant, which are:

- Water intake structures, conveyance system and daily regulation water storage tank;
- High pressure penstock and powerhouse and;
- Step-up substation.
- A transmission line from the step-up substation to the Secacao interconnection substation[9] that connects to the National Electricity System.
- The electricity metering equipment installed in the 69 kV bus of Secacao interconnection substation to measure the electricity delivered to the grid.



[8] Refer to section B.6.1 for definition of an electricity system.

[9] Secacao interconnection substation is not a component of the Choloma Hydroelectric Plant.

Fig. 7. Boundaries of the project activity

The greenhouse gases and emission sources included in or excluded from the project boundary are shown in the following table.

	Source	GHG	Included?	Justification/Explanation
Baseline	CO_2 emissions from electricity generation in fossil fuel fired power plants that are displaced due to the project activity	CO_2	Yes	Main source. GHG in the baseline are due to carbon and fuel fired plants.
		CH_4	No	Minor source.
		N_2O	No	Minor source.
Project activity	Reservoir	CO_2	No	Minor source
		CH_4	No	Main source. CH_4 emissions are neglected due power density is greater than 10 W/m^2 as per ACM0002.
		N_2O	No	Minor source

B.4. Establishment and description of baseline scenario

Because the project activity is the installation of a new grid-connected renewable power plant, the baseline scenario is the electricity delivered to the grid by the project activity that otherwise would have been generated by the operation of grid-connected power plants and by the addition of new generation sources as AMS-I.D methodology, version 18.0, indicates.

Version 03.0.1 of the methodological tool "Assessment of the validity of the original/current baseline and update of the baseline at the renewal of the crediting period" is used to assess the baseline continued validity and to update the baseline at the renewal of a crediting period. First, baseline is assessed at the time of the PDD registration, then the tool is followed step by step.

I. Baseline at the time of PDD registration was assessed and stated as follows:

1. Legal framework

With the passing of the General Electricity Law by the Guatemalan Congress in 1996, the Electricity Wholesale Market initiated operations and began administrating and dispatching the energy and power transactions between market agents under free market conditions. The electricity market includes energy transactions in the opportunity or spot market, and capacity and energy transactions in the contract market, according to short to long-term contracts between market agents.

Private entities are free to invest in the electricity generation sector in Guatemala. There is no centralized state control/planning for the country´s expansion of the generation system[10]. Nevertheless, the government, through the Ministry of Energy and the Energy Market Regulating Authority (CNEE – Comisión Nacional de Energía Eléctrica), by law must periodically develop long-term projections and establish the country´s "desirable" future investment requirements of the various fuel types for power production (generation matrix). Once established, CNEE attempts to direct or "steer" investments in the desired direction by means of tender procedures through which the country´s power distributors sign long-term contracts with power producers.

[10] Electricity Law, Title I, Chapter I, Article 1, http://www.amm.org.gt/pdfs/AMM-ley-general-electricidad.pdf

Regarding the operation of the countrywide electricity system, the Wholesale Market´s regulatory framework requires that all generating plants be dispatched so as to minimize the cost for the entire electric market.[11] To attain this objective, the Wholesale Market Operator (AMM) coordinates the operation of the generating plants and makes the economic load-dispatch in order of the "merit list" of the available plants (dispatching the system with the least costly mix of generation possible, by dispatching plants from the least expensive to the next least expensive, and so on until demand is met, on a continuous basis).

2. Analysis of the situation at the time of PDD registration

The baseline of the generation system in Guatemala is characterized by a mix of plants that use fossil fuels and renewable resources, and electricity imports have not been significant. According to the Wholesales Electricity Administrator (AMM), capacity additions over the most recent years have been as follows[12]:

Table 2. Capacity additions over the last years (power plants included in the build margin)

Unit power	Starting year	Capacity (MW)	Fuel
Panan	2010	7.320	Hydro
Los Cerros	2010	1.250	Hydro
Covadonga	2010	1.600	Hydro
Jesbon Maravillas	2010	0.750	Hydro
El Prado	2010	0.500	Hydro
Oscana	2010	<5MW	Hydro
Cuevamaría	2009	1.500	Hydro
Kaplan Chapina	2009	2.000	Hydro
La Unión 2	2009	10.000	Biomass
Electrocristal bunker	2009	10.000	Fuel Oil No. 6
Magdalena 5	2008	44.334	Biomass
La Libertad	2008	20.000	Coal
Santa Elena	2008	0.160	Hydro
COENESA	2008	10.000	Diesel
GECSA II	2008	37.800	Fuel Oil No. 6
Amatex 3	2008	24.336	Fuel Oil No. 6
Arizona Vapor 1	2008	12.500	Wasted heat
GECSA	2007	15.744	Fuel Oil No. 6
El Recreo	2007	26.000	Hydro
Montecristo	2006	13.500	Hydro
Trinidad	2006	26.000	Biomass
Palín II	2005	5.800	Hydro
Magdalena 4	2005	30.00	Biomass
Pantaleon II	2005	20.000	Biomass
San Diego	2004	5.000	Biomass

[11] http://www.amm.org.gt/pdfs/AMM-reglamento-amm.pdf . AMM Regulation, page 16.

[12] Projects registered as CDM have been excluded from baseline analysis.

Renace	2004	68.100	Hydro
Arizona	2003	160.000	Fuel Oil No. 6

Source: AMM Statistical Reports and Installed Capacity in the National Electricity System

Over the last years, the investments carried out in power plants using fuel oil No. 6 have been significant. The technology of these generating units is based on internal combustion engines, which require shorter up-front times and lower development/construction costs than power plants using renewable resources.

In the short- and medium-term, important investments in mainly coal and hydroelectric plants are expected, under the objectives of Guatemala´s Energy Policy, which seeks a more diversified energy matrix[13] with the intent of reducing dependence on imported petroleum-based fuels, in order to reduce electricity prices.

As examples of coal fired plants entering the system, a coal-based power plant of 80+ MW is being relocated and installed in Guatemala by Duke Power at the time of this PDD submittal. Previously, in November 2007, CNEE directed an international bid call to Union Fenosa, the owner of two large distribution grids in Guatemala (DEOCSA and DEORSA), through which a contract was issued in order to purchase electricity from a new 275 MW coal plant[14] under a 15-year power purchase agreement. This coal plant project is under development, and will be constructed by Jaguar Energy. It is expected to initiate commercial operation in 2013.

In the near future (within 5 years), CNEE plans to bid out two additional large generation blocks based on coal, with a total capacity of 400 MW, which will begin operations between the years 2014 and 2015. As a result, coal plants are expected to supply approximately 46% of energy demand by the year 2015. The coal-based plants are the most probable electricity generation sources in Guatemala.

Regarding hydroelectric generation, the Xacbal hydroelectric plant (94 MW) began operations in 2010, and the Palo Viejo hydropower plant of 80 MW is expected to initiate operations in 2013. The theoretical capacity additions (under CNEE´s plans) of hydroelectric projects plus electricity imports are similar to the total capacity to be installed in coal-based plants in the long-term, although hydropower in Guatemala is facing growing barriers that make this target unlikely.

As of 2009 Guatemala trades electricity with Mexico through a 400 kV transmission system with a transmission capacity of 200 MW.

In the report “Midterm tendencies for the electricity supply of the National Interconnected System” by CNEE, six generation scenarios are described, considering two hydrological conditions (high and low rainfall) and two conditions for petroleum fuel prices. The results for 2010 through 2015 show that electricity produced by hydroelectric plants will remain at similar to current levels, supplying between 40 to 47% of electricity demand, while the share of coal will strongly increase from 16% to 40% of demand, as the new coal plants will substitute the currently operating older bunker-fuel powered plants, and energy imports.

3. Analysis of national policies and circumstances that determinate future investment tendencies in Guatemala

The central objective of the Energy Policy approved by the Ministry of Energy and Mines is to modify Guatemala´s electric power generation matrix, in order to reduce dependence on power

[13] Comisión Nacional de Energía (CNEE), Tendencies in the midterm for the supplying of electricity of the National Interconnected System (Perspectivas de mediano plazo 2012-15), page 50, http://www.cnee.gob.gt/PEG/Docs/Perspectivas%20PEG.pdf

[14] http://www.cnee.gob.gt/pdf/informacion/licitaciones/LICITACION%20UNION%20FENOSA.PDF

generation by petroleum fuels. The policy states that investments in mainly hydroelectric and coal plants are required, as well as an increase in regional energy exchanges, in order to cover the country´s total electricity demand at reduced prices[15].

The market regulator (CNEE) developed the Generation Expansion Plan 2008-2022[16], which is an indicative plan that outlines the desirable conditions in order to modify the energy matrix towards greater hydro and coal (and potentially other base-load types of generation), away from petroleum fuels. The objective is to reduce petroleum dependence in the long-term, with the utmost objective of reducing electricity prices. In order to diversify the energy matrix and change the baseline conditions, at least 418 MW of hydroelectric plants will need to be added in the mid-term to substitute plants that currently utilize petroleum (bunker) fuel oil No. 6.

To reach the objectives of the Generation Expansion Plan 2008-2022, the Guatemalan government needs to encourage investments in renewable resources, and severe development barriers the projects are currently facing need to be addressed. These barriers include opposition groups (NGOs) to hydropower development, insufficient transmission grid coverage, water resource availability risks as a consequence of climate change and the need to compete with coal fueled generating plants.

Of these barriers, the only one being addressed is the transmission grid coverage, through a large-scale expansion of the grid, a process underway since 2009 expected to be concluded between 2013 and 2014.

Regarding the barrier that refers to coal plants, this circumstance poses a significant risk for mainly small and medium hydropower developments in Guatemala, as coal is being heavily promoted by national authorities, and because the types of plants being built tend to make it difficult for hydropower to be competitive under Guatemala´s market structure due to a series of factors. The plants that are being built are most likely not “clean-coal” and thus pricier technologies. In addition, coal as a fuel type depresses the Guatemalan energy SPOT prices, as the SPOT price is based on a fuel´s related variable production cost only and does not reflect environmental costs nor capital expenditure costs related to plant installation. (Capital expenditures, in the Guatemalan market, are covered by capacity payments separate from energy income, from which base-load generating plants such as coal plants derive most of their revenues.)

As the analyses and simulations carried out by CNEE in order to determine the future scenarios for the Generation Expansion Plan 2008-2022 reflect; hydroelectric plants become competitive and most economical compared to plants using petroleum- and coal-based fuels when the environmental cost is added to these last ones. This cost corresponds to the neutralization of greenhouse emissions that they produce[17].

Consequently, to achieve the targets of the Expansion Plan, the environmental cost has to be transferred as an economical incentive to power plants based on renewable resources, or it has to be charged against high emissions producing power-generating technologies (coal and bunker fueled).

It is concluded that the baseline conditions will prevail during the first crediting period, as investments in technologies using fossil fuels constitute the option with lower up-front times and with less barriers for satisfying electricity demand.

The CDM is critical and decisive in order to modify the baseline tendency in Guatemala and is essential to encourage investments in renewable resources.

---

[15] Comisión Nacional de Energía Eléctrica (CNEE), Expansion Plan of Electricity Generation System 2008-2022, http://www.cnee.gob.gt/PET/Docs/PET%20INGLES.pdf .

[16] Comisión Nacional de Energía Eléctrica (CNEE), Expansion Plan of Electricity Generation System 2008-2022, http://www.cnee.gob.gt/PET/Docs/PET%20INGLES.pdf

[17] Generation Expansion Plan 2008-2022, pages 19 and 20 - CNEE.

II. <u>Application of the methodological tool "Assessment of the validity of the original/current baseline and update of the baseline at the renewal of the crediting period"</u>

Step 1: Assess of the validity of the current baseline for the next crediting period

Step 1.1: Assess compliance of the current baseline with relevant mandatory national and/or sectoral policies

Relevant mandatory national and sectoral policies which have come into effect after the submission of the project activity for validation, and that affect the Project Activity, are reviewed below:

- The National Energy Policy for the 2013-2027 term[18] pursues the sustainable energy development with inclusion and respect to the environment. One of its operative goals is to diversify the energy matrix through the prioritization of renewable resources.
- The General Electricity Law entered into force in 1996, hence is not include in the analysis.

Because hydroelectric projects are not mandatory and the investment in fuel-based technologies is not limited, in the absence of the CDM project activity, the electricity delivered to the grid by the project activity would have otherwise been generated by the operation of grid-connected power plants and by the addition of new generation sources. This is a likely scenario in compliance with the relevant mandatory national and/or sectoral policies. The installed capacity in Guatemala over the last 25 year has had continuous additions in renewable as in fuel-based technologies[19].

As current baseline complies with all relevant mandatory national and sector policies which have come into effect after the submission of the project activity for validation and are applicable at the time of requesting renewal of the crediting period, next step is addressed.

Step 1.2: Assess the impact of circumstances

The baseline scenario identified at the validation of the project activity expected important investments in mainly coal and hydropower plants under the objectives of Guatemala's Energy Policy, seeking for a more diversified energy matrix. These conditions are still valid.
The circumstances of the Project Activity at the renewal of the crediting period are similar to the conditions expected at the registration time.
Circumstance existing at the time of requesting the renewal of the crediting period are the same than those existing at the time of the submission of the project for validation. Thus, the current baseline emissions are not impacted by changes in circumstances.

Step 1.3: Assess whether the continuation of use of current baseline equipment(s) or an investment is the most likely scenario for the crediting period for which renewal is requested.

According to the Tool, this sub-step should only be applied if the baseline scenario identified at the validation of the project activity was the continuation of use of the current equipment(s) without any investment and, the projects proponents or third party (or parties) would undertake an investment later due, for example, to the end of the technical lifetime of the equipment(s) before the end of the crediting period or the availability of a new technology.

Thus, this step does not apply to the project activity.

---

[18] Ministry of Energy and Mines, *Política Nacional de Energía* (Energy National Policy), page 38. http://www.mem.gob.gt/wp-content/uploads/2013/02/PE2013-2027.pdf

[19] CEPAL, Estadísticas de la producción de electricidad de los países del Sistema de Integración Centroamericana (Statistics in Electricity Production of the Countries of the Central America Integration System), page 36. 2015.

Step 1.4: Assessment of the validity of the data and parameters

According to the Tool, if any of the data and parameters that were only determined at the start of the crediting period and not monitored during the crediting period are not valid anymore, the current baseline needs to be updated for the subsequent crediting period.

The emission factor of the grid should be updated in accordance with the latest version of the “Tool to calculate the emission factor for an electricity system” as required by the latest version of the methodology AMS-I.D, using the most recent information of the national grid and the most recent IPCC default values.

Step 2: Update the current baseline and the data and parameters

Step 2.1: Update the current baseline

As indicated in Step 1 and its sub-steps, there are no national and/or sectoral policies or specific circumstances that require an update of the baseline scenario.

Step 2.2: Update the data and parameters

As indicated in Step 1.4, the emission factor of the grid should be updated for the second crediting period, in accordance with the latest version of the “Tool to calculate the emission factor for an electricity system” as required by the latest version of the methodology AMS-I.D.

In section B.6.1 the emission factor of the grid was updated for the second crediting period in this PDD version, in accordance with the latest version of the “Tool to calculate the emission factor for an electricity system”.

B.5. Demonstration of additionality

As per paragraph 280 of the CDM project standard for project activities, for renewal of crediting period of a registered CDM project activity, the project participants are not required to reassess the additionality of the project activity nor update the section of the PDD relating to additionality.

<u>Consideration of CDM in the initial stages of the Project</u>

The most relevant milestones of the project are listed below:

1. Feasibility study was concluded in March, 2009.
2. Hidroeléctrica Choloma, S.A. informed Guatemala´s Designated National Authority and the UNFCCC Secretariat regarding the prior consideration of the CDM, on June 9, 2009.
3. Financial closing took place in June 8, 2010 (Investment decision date).
4. Contract for “Supply, Start-up and Testing of Turbine, Generator, Controls and Associated Equipment” with Gilbert Gilkes & Gordon Ltd. (Gilkes), was signed in June 24, 2010 (Starting date of the project activity).
5. On July 22, 2010 the construction and civil works contract was signed between Choloma and Constructora Nacional, S.A. (CONASA), for the construction of the hydroelectric project.
6. Hidroeléctrica Choloma, S.A. submitted a PDD draft to the DNA on January 27, 2011 and requested the letter of approval for the CDM project.
7. The DNA’s letter of approval was issued on March 23, 2011.
8. The PDD was published on the UNFCCC CDM webpage on May 21, 2011 for global stakeholder consultation.
9. The starting date of the first crediting period is expected to be on March 1, 2013.

Since the project start date is on June 24, 2010, and DNA and the UNFCCC Secretariat were notified on June 9, 2009, prior to project start date, the project meets the condition on prior consideration.

Additionality assessment

Additionality of the Project is demonstrated based on the requirements of the *Guidelines on the Demonstration of Additionality of Small-Scale Project Activities* (EB 68 Annex 27).

Investment barrier

The project activity faces investment barriers due to the possible revenue shortfalls resulting from the variations in electricity production caused by the alteration of the hydrologic cycles. It also faces risks stemming from low-cost coal fired generation plants that depress SPOT market energy prices in the Guatemalan Electricity Market.

The Project´s profitability is evaluated using the Equity Internal Rate of Return (IRR) post-tax method, which is carried out in nominal terms. The Equity IRR post-tax for the project activity is calculated under the following financial assumptions[20]:

General assumptions

	Value	Units	Source and comments
Period of assessment	21	Years	According to Annex 5, Guidelines on the Assessment of Investment Analysis, in general a minimum period of 10 years and a maximum of 20 years will be appropriate for the assessment period.
Residual value	0	$	As per Article 19 of the "*Decreto Número 29-92: Ley del Impuesto Sobre la Rent*a" (Guatemalan Income Tax Law).
Depreciation	5	%/year	As per Article 19 of the "*Decreto Número 29-92: Ley del Impuesto Sobre la Rent*a" (Guatemalan Income Tax Law).
Income tax	31	%	As per "Decreto Número 29-92: Ley del Impuesto Sobre la Renta"(Guatemalan Income Tax Law). Income tax exemption for the first 10 years; the project activity has obtained this authorization by the Ministry of Energy and Mines under the "Incentives Law for Promotion of Renewable Sources of Power;" then, from year 11 on, an income tax rate of 31%.
Value Added Tax	12	%	As per Article 10 of the "*Decreto Número 27-92: Ley del Impuesto al Valor Agregado*" (Guatemalan Value Added Tax Law). On sales (debit) and purchases (credit). As per Article 5 of the Incentives Law for Promotion of Renewable Sources of Power, imported equipment for electricity generation is exemt of VAT.
Inflation rate	4.988	%	Average forecasted inflation rate for Guatemala, published by the IMF for the next five years after the start of the project activity; as per item 7 in the Appendix of the Guidelines on the Assessment of Investment Analysis.
Default value for the expected return on equity	12.5	%	As per paragraph 8 of the Appendix "Default Values for the expected return on equity" of Annex 5 "Guidelines on the Assessment of Investment Analysis

[20] See spreadsheet of the financial calculations for assumptions details.

for energy industries in Guatemala			(Version 05)".
Benchmark (nominal term)	17.488	%	As per paragraph 7 of the Appendix "Default Values for the expected return on equity" of Annex 5 "Guidelines on the Assessment of Investment Analysis (Version 05)", in situations where an investment analysis is carried out in nominal terms, project participants can convert the real term values provided to nominal values by adding the inflation rate.

Investment assumptions

	Value	Units	Source and comments
Investment costs	21,878,038	US$	Capital expenditures budget as established in the *Hidroeléctrica Choloma, S.A. "Proyecto Hidroeléctrico Cholomá: Prefactibilidad Técnica y Financiera*" (Technical and Financial Pre-Feasibility Study), March 2009, page 17). Investment costs include studies, designs, construction, equipment and its installation, bank fees, interests and taxes during construction.
Equity	50	%	As per paragraph 18 of the Guidelines on the "Assessment of Investment Analysis" (v.05), a 50% debt and 50% equity financing is assumed as a default, as the benchmark is based on parameters that are standard in the market and information of the typical debt/equity finance structure observed in the sector of the country is not available.
Debt	50	%	
Debt term	10.25	years	Syndicated Loan Term Sheet.
Grace period (from July 2010 through August 2012)	26	months	
Amortizations (principal payments)	33	Quarterly payments	
Interest rate	9.75	%	

Assumptions for revenues estimation

	Value	Units	Source and comments
Installed capacity	9.7	MW	Capacity of the electric generator as per manufacturer data.
Plant Factor	43%	-	Hidroeléctrica Choloma, S.A. "Proyecto Hidroeléctrico Cholomá: Prefactibilidad Técnica y Financiera" (Technical and Financial Pre-Feasibility Study), March 2009, page 12. -available at the time of decision making-
Electricity production	36,538	MWh	As per 9.7MW Installed capacity and 43% Plant factor
Guaranteed power capacity	5.07	MW	Power Purchase Agreement (PPA) Term sheet. It is the capacity guarantee during daily peak-demand hours.
PPA energy price (10yr)	(see Table 4.)	$/MWh	Power Purchase Agreement (PPA) Term sheet. Prices negotiated by the project participant for a 10-year power purchase agreement are shown in the following table:

Table 3. Choloma Power Purchase Agreement Prices

Contract year	1	2	3	4	5	6	7	8	9	10
Min price ($/MWh)	$85	$85	$84	$84	$84	$82	$82	$82	$80	$80
Max price ($/MWh)	$100	$101	$101	$102	$102	$103	$103	$103	$105	$105

			Under the Power Purchase Agreement Term Sheet, an annual energy price range was established for the 10-year period, with a minimum and a maximum price for each year. The project activity will receive the hourly market SPOT price as long as it remains in the range. Should SPOT prices fall below the minimum, then it receives the minimum guaranteed energy price, and when SPOT prices increase above the range, then the buyer has a "ceiling price" as a hedge in case of expensive energy prices (the max price). As the table reflects, the min-max range for the 1st contract year is $85-$100/MWh, with slightly different values each year to end at $80-$105/MWh in year 10.
PPA guaranteed capacity price	7.25	$/kW per month	Power Purchase Agreement (PPA) Term sheet. This price is fixed for the 10-year contract period.
Energy spot price (post-PPA)	80	$/MWh	According to the forecasted price by CNEE for year 2022 and stated in the document "*Plan de Expansión Indicativo del Sistema de Generación 2008-2022*", February 2009, pages 36-38. Energy spot price (post-PPA) is affected by the inflation rate, as of 2023. The graphs, below, show the expected SPOT prices in the Guatemalan energy wholesale market through the year 2022 for two demand-growth scenarios, resulting from CNEE´s plan to promote a significant expansion in coal plants, in addition to other generating plants including ones based on renewable resources:

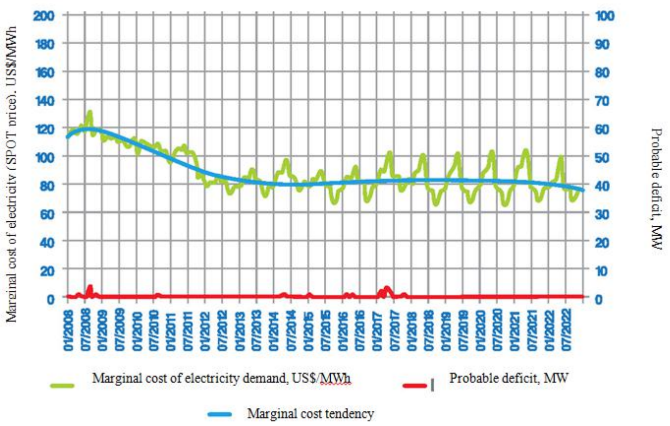


Fig. 8. Expected SPOT prices through 2022, LOW energy-demand scenario
(Source: CNEE - "Indicative expansion plan of the generation system 2008-2022")

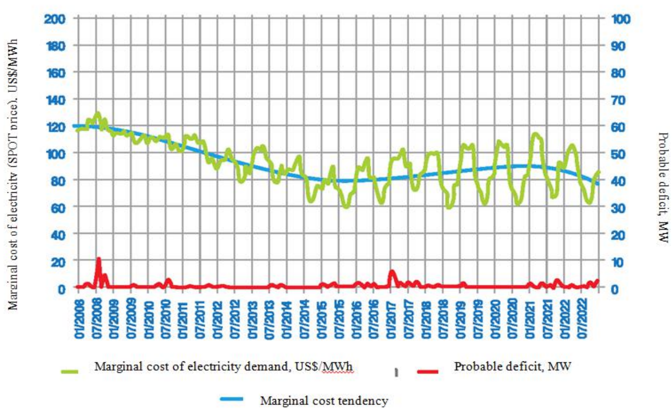


			Fig. 9. Expected SPOT prices through 2022, HIGH energy-demand scenario (Source: CNEE - "Indicative expansion plan of the generation system 2008-2022")
Guaranteed capacity price (post-PPA)	7.25	$/kW per month	Reference: PPA price. Guaranteed capacity price (post-PPA) is affected by the inflation rate, as of 2022.
"Nodal-loss Factor" (Shared 50/50 with PPA offtaker during the 10 yr contract period, as per section 10 of the PPA Term Sheet)	0.9452		As per section 10 "Pérdidas de Transmisión" of the Power Purchase Agreement Term Sheet, parties agree to equally share (50% each) the electrical transmission system losses between the plant and the delivery point. The electrical losses are based on the monthly "Nodal-loss Factors" determined by the Wholesale Electricity Administrator as per Commercial Coordination Norm No.7 ("Norma de Coordinación Comercial No. 7, Factores de Pérdidas Nodales"). For additionality analysis and conservative purposes, the higher annual average (the most conservative value) of nodal-loss factors (Jun'09-May'10) for the period between June 2007 - May 2010 of Secacao Substation (where the project activity is going to be connected to) is used to estimate the electrical losses. Losses, in %, are 1 minus the nodal-loss factor * 100. Electrical losses are applied against revenues.

Assumptions for running costs

	Value	Units	Source and comments
Plant expenses	368,136.00	$	As per Operating Budget. All running costs are affected by the inflation rate, excepting the property tax costs.
Salaries & related worker benefits	184,560.00	$	
O&M	183,576.00	$	
Administrative expenses	117,250.00	$	
Salaries & related worker benefits	9,000.00	$	
Office Expenses	8,250.00	$	
Insurance	100,000.00	$	
Property tax	5,940.00	$	
Transmission toll charges and Wholesale Market (AMM) fee (contract years)	67,714.00	$	
Transmission toll charges and Wholesale Market (AMM) fee (post-contract years)	125,428.00	$	

Investment analysis result

The resulting equity IRR is 12.39%, which is below the Benchmark 17.488%. The resulting equity IRR considering CERs-Income is 13.91% (assuming a CERs price of $14.00 – available at the time of decision making-).

Sensitivity analysis

The Equity Internal Rate of Return (IRR) is calculated under a series of scenarios in order to evaluate the project's financial sensitivity. According to the Guidelines of Investment Analysis, variables that constitute more than 20% of either total project costs or total project revenues are subjected to a variation of +10% and -10%. These variables are: annual power generation, electricity price, total investment costs, capacity price and O&M costs.

The following table presents the Equity IRR results under the various sensitivity scenarios evaluated.

Table 4. Sensitivity Analysis

	Base case -10%	Base case	Base case +10%
Benchmark	17.49%	17.49%	17.49%
Annual Power Generation	10.01%	12.39%	14.73%
Electricity Price	10.01%	12.39%	14.73%
Capacity Price	12.06%	12.39%	12.72%
Total Investment	14.89%	12.39%	10.32%
O&M Costs	12.75%	12.39%	12.02%

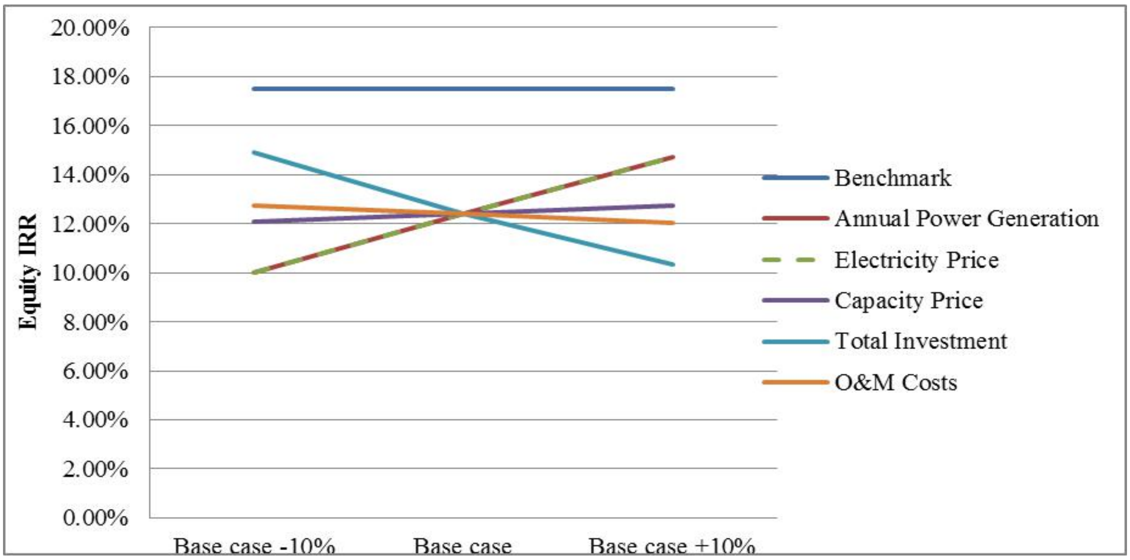


Fig. 10. Sensitivity Analysis

As shown in the Sensitivity Analysis, the benchmark is not matched even with a +/-10% variation of each evaluated parameter. Most variations are very unlikely to occur in a way to positively affect the project's activity, as explained below:

- Analysis of the variation of the annual power generation

For sensitivity analysis, it is assumed that the availability of water and thus plant output for the project activity has 10% variations from the base case. The hydrological regime could be negatively affected by climate change, which affects electricity production directly. The tendency towards greater variations in hydrological cycles (rainfall) affects the water flow availability and consequently energy production. This situation is caused by gradually more intensified global

climatic phenomena like “el Niño” or “la Niña,” and local conditions that include deforestation, increased erosion and river basin degradation[21].

Several studies have analysed the consequences of climate change in Guatemala and its effects on hydrologic cycles. The Economic Commission for Latin America and the Caribbean (ECLAC), in the report “Climate change: a regional perspective,” indicates that climate will have serious consequences in Central America with a significant deterioration in the quality, quantity, and availability of water used for human consumption and agriculture, and a decline in the amount available to generate electricity. The First National Communication on Climate Change, submitted by Guatemala to UNFCCC, concludes that intensified floods and droughts will occur in Guatemala as a consequence of climate change, having negative impacts on basin runoffs. The Communication indicates that basin runoff in general will drop 10% on average with respect to the baseline in the 38 watersheds of the country, under the conditions of the climate scenarios analysed.

On the other hand, the INSIVUMEH[22] has reported that weather has been highly irregular in Guatemala. For example, the *canicula* phenomenon, a recession (interruption) during the rainy season, lasted significantly longer in 2009, causing the worst drought of the last 30 years. Guatemala is located in Central America, where the El Niño phenomenon has implications in weather and rain regimes. The El Niño system, when present, has caused an important reduction in rainfall with implications of reduced availability of water.

The analysis results show that the project´s equity IRR is sensitive to the variations in electricity production caused by the alteration of the flow regime: A 10% reduction in the availability of water flow causes equity IRR to fall to 10.01%. Conversely, an increase of 10% results in an equity IRR of 14.73%, which does not imply a proportional increase in electricity production due to the limitation on the installed capacity of the power plant.

- Analysis of the variation of the electricity price

The base case is considered optimistic due to the high probability of actual price pressure due to the effect of coal plants on SPOT prices in the near and medium term, therefore a +10% variation in electricity prices is considered unlikely.

The CNEE´s “Guatemala´s Electrical Sector Expansion Plans: A Long-Term Perspective” states that the expected level for SPOT prices is low, falling from over $120 to around $80/MWh between 2013 and 2014, and remaining at or close to this level through the year 2022. Based on this information, due to the future “depression” in SPOT prices resulting from significant investments in coal powered generating plants, it is very likely that the project activity will tend to generally receive the minimum contract price throughout the 10-year contract-term.

- Analysis of the variation of the capacity price

Results show that the resulting equity IRR levels are less sensitive to +/-10% variation of this parameter; this parameter would need to be over 150% higher than projected to reach the benchmark.

- Analysis of the variation of the total investment

Based on what is considered an adequate and realistic budget and the high degree of complexity of the project, the likelihood of achieving a lower capital use is very low. Nevertheless, a 10%

[21] According to the National Institute of Forests (Instituto Nacional de Bosques) the deforestation rate is 1.22 % annually in Alta Verapaz directly causing forest cover losses all over the Polochic River Basin and its tributaries (which include the Choloma River and its tributaries).

[22] Instituto Nacional de Sismología, Vulcanología, Meteorología e Hidrología.

savings would produce an equity IRR of 14.89%, whereas a CAPEX cost overrun of 10% would result in 10.32%.

- Analysis of the variation of the O&M costs

Results show that the resulting equity IRR levels are less sensitive to +/-10% variation of this parameter, as even a reduction of 100%, assuming O&M costs are zero, is not enough to reach the benchmark.

The registration of the Choloma Hydroelectric Project as a CDM project will create the necessary and critically important financial benefits from the CERs revenue. This will allow Hidroeléctrica Choloma, S.A. to generate clean electric energy free of GHG emissions.

In conclusion, the equity IRR of the project activity, including the variations reflected in the sensitivity analysis conducted, is under the Benchmark. The Choloma Hydroelectric Project would not be carried out in the absence of CDM revenues. Income from emission reductions helps the project become more attractive to the developers. **Based on this analysis, the project is additional.**

B.6. Estimation of emission reductions

B.6.1. Explanation of methodological choices

1. Calculation of the emission factor

The emission factor of the electrical grid is calculated following the procedures established in the approved "Tool to calculate the emission factor for an electricity system", version 7.0 (hereafter referred to as the Tool).

Step 1. Identification of the relevant electricity systems

Option 2 is chosen to define the project electricity system because Guatemala´s DNA has not published a definition of its delineation. The National Interconnected System (*Sistema Nacional Interconectado*, SNI) is assumed as the project electricity system because scheduling and electricity dispatch in this system is controlled by only one dispatch center, which is operated by the Wholesales Administrator (Administrador del Mercado Mayorista, AMM)[23].

The project electricity system is the spatial extent of the power plants connected to the SNI, which are economically dispatched without significant transmission constraints. See the AMM´s Statistic Report 2018, page 16[24], to check out detail of the diagram of the National Interconnected System.

The Interconnected Central American System is the connected electricity system, which is formed by the electrical grids of El Salvador, Honduras, Nicaragua, Costa Rica, Panama and Mexico. The SNI is interconnected to El Salvador through a 230 kV transmission line and to Mexico through a 400 kV transmission line. At the moment of submittal of the PDD for the first crediting period, the electricity system that interconnects the Central American countries is in the process of being expanded by the Interconnection System for Central America and Mexico (*Sistema de Interconexión Eléctrico para Centroamérica y México*, SIEPAC) in order to increase the international transmission capacity. The construction of the SIEPAC system has not been completed and a transmission line will be constructed to interconnect Guatemala and Honduras.

[23] See AMM´s functions: https://www.amm.org.gt/portal/?page_id=17

[24] https://www.amm.org.gt/portal/?page_id=145

The power system of each country is coordinated independently, while energy exports and imports are coordinated by the Central America Market Operator (Ente Operador Regional, EOR)[25]. National dispatch has priority over the regional Central American dispatch.

Step 2. Inclusion off-grid power plants in the project electricity system

Off-grid power plants are not included in the project electricity system; option 1 is chosen.

Step 3. Selection of a method to determine the operating margin

The calculation of the OM emission factor is based on one of the following methods:

(a) Simple OM; or
(b) Simple adjusted OM; or
(c) Dispatch data analysis OM; or
(d) Average OM

Following the Tool criteria, the method selected is the Simple adjusted OM method because:

- Annual data from each power plant on power generation, fuel type and fuel consumption is available.
- Low-cost/must run resources, including CDM projects, constitute more than 50% of total grid generation on average for the five most recent years. The low-cost/must run resources include hydro, geothermal and biomass (sugar cane bagasse) power plants.
- The generation of the low/cost/must run resources is greater than the average of the lowest annual system loads.
- Hourly loads of the grid in MW are available under request to the Wholesale Electricity Market Administrator.

Low-cost/must-run resources constitute 65% of total grid generation in average of the five most recent years (2014 - 2018), which is above 50%. Therefore, the Simple Adjusted OM method is applied.

For the second crediting period, ex-ante option of the Tool is chosen for data vintage.

Step 4. Calculation of Operating Margin emission factor according to the selected method

The simple adjusted OM method is calculated based on the CO_2 emission factor of the fuel type used and the efficiency of the power unit, because data on electricity generation and fuel types are known (option A2). Option A1 is not used since the amount of fuel consumed by each generating unit is not available publicly.

Assumptions:

- For Operating Margin emission factor calculation, the emission factor of the imports is considered equal to 0 tCO_2 per MWh because the electricity imports come from connected electricity systems in other countries in Central America.
- For the *ex-ante* calculation of the OM emission factor, 2016, 2017 and 2018 data is used, based on the most recent statistics available at the time of PDD submission.
- The cohort of power units for OM includes CDM projects registered.
- The set of power plants m, fuel fired plants, comprises units that burn fuel oil No. 6, coal and diesel. It includes electricity generation of cogenerating power plants during non-harvest (sugar cane bagasse) because they burn fuel oil No.6 and coal during this time-period.

[25] http://www.enteoperador.org/Contexto.jsp

- The low-cost plants are the hydroelectric, geothermal, solar, biogas, wind and cogenerating power plants connected to the grid and also the imports that are modeled as a power plant connected to the grid. Cogenerators are considered low cost plants because burn cane bagasse during sugar cane harvest periods and their variable costs declared to the Wholesales Electricity Administrator are low in comparison to variable costs declared by fuel based power plants.

The Operating Margin emission factor is calculated using Equation 1 and data vintages of the year with the most recent information. It is calculated as the generation-weighted average emissions per electricity units serving the system.

$$EF_{grid,OM-adj,y} = (1-\lambda_y) \bullet \frac{\sum_m EG_{m,y} \bullet EF_{EL,m,y}}{\sum_m EG_{m,y}} \oplus \lambda_y \bullet \frac{\sum_k EG_{k,y} \bullet EF_{EL,k,y}}{\sum_k EG_{k,y}} \qquad \text{Eq. 1}$$

Where:

$EF_{grid,OM-adj,y}$	=	Simple adjusted operating margin CO_2 emission factor in year y (t CO_2/MWh).
y	=	2016, 2017 and 2018
λ_y	=	Factor expressing the percentage of time when low-cost/must-run power units are on the margin in year y.
$EF_{EL.m,y}$	=	CO_2 emission factor of power unit *m* in year *y* and given in tCO_2/MWh. It is determined using Equation 2.
$EF_{EL,k,y}$	=	CO_2 emission factor of power unit *k* in year *y* and given in tCO_2/MWh. It is determined using Equation 2.
$EG_{m,y}$	=	Net quantity of electricity generated and delivered to the grid by power unit *m* in year *y* (MWh). These data are obtained directly from the Generation Report published on AMM´s website, section “Generation”. See Appendix 4.
$EG_{k,y}$	=	Net quantity of electricity generated and delivered to the grid by power unit *k* in the year y (MWh). These data are obtained directly from the AMM´s Generation Report published on AMM´s website, section “Generation”. See Appendix 4.
m	=	All grid power units serving the grid in year *y* except low-cost/must-run power units.
k	=	All low-cost/must run grid power units serving the grid in year *y*.

The emission factor for the subset of power plants, $EF_{EL,m,y}$ and $EF_{EL,k,y}$, connected to Interconnected National System, SNI, is calculated as per option A2 stated in the Tool, using the average CO_2 emission factor of fuel type i used in each generating unit and the default efficiencies, as describes the following equation:

$$EF_{EL\ m,,y} = \frac{EF_{co2,m,i,y} \bullet 3.6}{\eta_{m,y}} \qquad \text{Eq. 2}$$

Where:

$EF_{EL,m,y}$ = Emission factor of power units *m* in year y, given in tCO_2/MWh

$EF_{CO2,m,i,y}$ = Average CO_2 emission factor of fuel type *i,* used in power unit *m* in year *y*, given in tCO_2/TJ.

3.6 = Energy conversion factor, given in TJ/MWh according to the International System Units.

$\eta_{m,y}$ = Average net energy conversion efficiency of power unit *m* in year *y* (ratio).

m = All power units serving the grid in year *y* except low-cost/must-run power units

y = 2016, 2017 and 2018

Default CO_2 emissions factor for combustion at a low level of uncertainty are obtained from Table 1.4, chapter 1, 2006 IPCC Guidelines for National Greenhouse Gas Inventories, where oxidation factor is equal 1. The type of fuel for each power unit is obtained from the table “Installed Capacity in the Electric System”, AMM´s website, “Operation Results” section.

Table 5. Effective CO_2 emission factors for fuel types used in Guatemala

	tCO_2/TJ
Diesel or fuel oil No. 5	72.6
Bunker or fuel oil No. 6	75.5
Bituminous coal	89.5

The efficiency factors for power units are considered confidential information in Guatemala, therefore the default values from the version 02.0 tool “Determining the baseline efficiency of thermal or electric energy generation systems” are used, which are indicated in next table. The efficiency factor is selected according the operations starting year and technology of each generating unit, data given by AMM.

Table 6. Default efficiency factors for power plants

Default efficiency factors for power plants Tool 09: Determining the baseline efficiency of thermal or electric energy generation systems			
Generation technolgy	**y≤2000**	**2000<y≤2012**	**>2012**
Coal			
Subcritical	37%	39%	39%
Supercritical	-	45%	45%
Ultra-supercritical	-	50%	50%
IGCC	-	50%	50%
FBS	35.5%	-	-
CFBS	36.5%	40%	40%
PFBS	-	41.5%	45%
Oil/natural gas			
Steam turbine	37.5%	39%	44%
Reciprocal gas engine	33%	40%	49%
Open cycle	30%	39.5%	42%
Combined cycle	46%	60%	62%
Biomass			
IGCC	40%		
Other	35%		
Cogeneration			
Steam turbine	83.5%		
Gas turbine	78.8%		

Reciprocal engine	88.8%
Microturbine	77.7%

Finally, the denominator of the Operating Margin Equation is:

$\sum_{m} EG_{m,y}$ = The summation of electricity generation from each relevant power source m (MWh), during the year *y,* expressed in MWh.

$\sum_{k} EG_{k,y}$ = The summation of electricity generation from each relevant power source k (MWh), during the year *y,* expressed in MWh.

Lambda is defined as follow:

$$\lambda(\%) = \frac{Number\ of\ low-\cos t/must-run\ sources\ are\ on\ the\ margin\ in\ year\ y}{8760\ hours\ per\ year}$$

Eq. 3

The approach 2 is chosen to calculate lambda and the step wise procedure in appendix 4 of the tool is used.

The resulting values of lambda used are indicated in the next table:

Table 7. Lambda results

Parameter		2016	2017	2018
No. hours low cost / must-run power plants are on the margin + imports	Hours	1,114	3,986	2,353
λ	%	0.127	0.455	0.269
1 - λ	%	0.873	0.545	0.731

<u>Step 5. Calculation of Build Margin emission factor</u>

The Build Margin emission factor represents the tendency of the mix of power generation and is calculated similarly to the Operating Margin emission factor, considering the group of power units whose generation is at least 20% of total generation.

Assumptions:

- For the second crediting period, the build margin emission factor is calculated ex-ante, including those units built up to 2018.

- For the *ex-ante* calculation of the BM emission factor, 2018 data is used, based on the most recent statistics available at the time of PDD submission.

- The set of power plants selected for the build margin are selected according to the following premises:
    - Power units registered as CDM project activities are excluded from the cohort of power plants: Hidro Xacbal, El Canada, Matanzas, San Isidro, Las Vacas, Candelaria, Ortitlan Limitada (Amatitlan Geothermal Project), San Antonio El Sitio Wind Farm, Palo Viejo Hydroelectric Plant and Vertedero Trebol.

- The selection of the set of power plant/unit is according to the following steps:

- Identification of the set of five power units, excluding CDM project activities, which started to supply electricity to the grid most recently. See tables of Appendix 4.
- Calculation of the total annual generation of the project electricity system (AEGtotal), excluding CDM project activities.
- Identification of the sample group of power plants/units used to calculate the build margin that consists of the set of power plants in the electricity system that comprise 20% of the generation system and have been built most recently, see Appendix 4.
- The group of power plants/units used is the group that comprises the 20% of the generation system because the electricity generation from this group is larger than the group of the five power plant/units.

The build margin is calculated using the following equation:

$$EF_{grid,BM,y} = \frac{\sum_{m} EG_{m,y} \bullet EF_{EL,m,y}}{\sum_{m} EG_{m,y}} \quad \text{Eq. 4}$$

Where:

$EF_{grid,BM,,y}$	=	Building Margin CO_2 emission factor in year *y* (t CO_2/MWh)
$EF_{EL,m,y}$		CO_2 emission factor of power unit *m* in year *y* (tCO_2/MWh). It is determined using equation 2 according to option A2 of the Tool.
y	=	2018
$EG_{m,y}$		Net quantity of electricity generated and delivered to the grid by power unit *m*, during the year *2018*, given in MWh. See Appendix 4.
m	=	Power units included in the build margin

Step 6. Calculation of the combined margin emission factor

The emission factor of the electrical system is calculated as following equation:

$$EF_{grid, CM, y} \text{ (t } CO_2\text{/MWh)} = EF_{grid, OM, y} \bullet W_{OM} + EF_{grid, BM, y} \bullet W_{BM} \quad \text{Eq. 5}$$

Where:

$EF_{OM\,y}$	=	Operating Margin emission factor (t CO_2/MWh)
$EF_{BM\,y}$	=	Building Margin emission factor (t CO_2/MWh)
W_{OM}	=	Weighting of operating margin emissions factor (%)
W_{BM}	=	Weighting of build margin emissions factor (%)

The default values are chosen for the weighting factors, $w_{OM} = 0.25$ and $w_{BM} = 0.75$ for the second and third crediting period. The emission factor of the grid shall allow the calculation of the baseline emissions and the calculations of the emissions reduced by the project activity.

2. Estimation of project emissions

According to the version 18 of the AMS I.D. methodology, the project emissions due to hydro power plants may be emitted from the reservoirs; which is proven through the power density calculation.

The equation to calculate power density (PD) according to the version 19 of the ACM0002 is described in next equation and if the result of this calculation is greater than 10 W/m², then the project emissions are equal to zero:

$$PD = \frac{Cap_{PJ} - Cap_{BL}}{A_{PJ} - A_{BL}} \qquad \text{Eq. 6}$$

Where:

PD	=	Power density of the project activity (W/m²)
Cap_{PJ}	=	Installed capacity of the hydro power plant after the implementation of the project activity(W)
Cap_{BL}	=	Installed capacity of the hydro power plant before the implementation of the project activity (W). For new hydro power plants, this value is zero.
A_{PJ}	=	Area of the single or multiple reservoirs measured in the surface of the water, after the implementation of the project activity, when the reservoir is full (m²).
A_{BL}	=	Area of the single or multiple reservoirs measured in the surface of the water, before the implementation of the project activity, when the reservoir is full (m²). For new reservoirs, this value is zero.

The project reservoirs consist of the small water bodies resulting from the diversion dams and the reservoir-tank used for the daily regulation.

The reservoir-tank of the project activity has a cylindrical shape with a radius of 30 m. Therefore, the surface area is equal to:

$$A_{PJ} = \pi r^2 \qquad \text{Eq. 7}$$

Where:

A_{PJ} = Area of the single or multiple reservoirs measured in the surface of the water, after the implementation of the project activity, when the reservoir is full (m²). (Area of the tank-reservoir measured in the surface of the water)

π = Pi (3.14159265)

r = radius of the water storage tank

The surface area is considered at a full tank-reservoir level. Due to the cylindrical shape of the tank, the area is constant at any water level (see description in Section A of the PDD).

Power density of the multiple reservoirs will be monitored in order to assure that project emissions will remain zero during the crediting period(s).

3. Estimated leakage

As per the version 18 of the AMS I.D. methodology, leakages, LE_y, are not considered because energy generating equipment is not transferred from another activity.

4. Calculation of baseline emissions

Because the project activity is the installation of a new grid-connected renewable power plant/unit at a site where no renewable power plant was operated prior to the implementation of the project activity, then, the baseline emissions reductions per year are calculated using the following equation as the version 18 of the AMS I.D. methodology states:

$BE_y = EG_{PJ,y} \bullet EF_{grid,y}$	Eq. 8

Where:

BE_y = Baseline emissions in year y (t CO_2)

$EG_{PJ,y}$ = Quantity of net electricity generation that is produced and fed into the grid as a result of the implementation of the CDM project activity in year *y* (MWh)

$EF_{grid,y}$ = Combined margin CO_2 emission factor for grid connected power generation in year *y* calculated using the latest version of the "Toll to calculate the emission factor for an electricity system" (t CO_2/MWh)

5. Calculation of emission reductions

Emission reductions are calculated according to the version 18 of the I.D. methodology as follow:

$ER_y = BE_y - PE_y - LE_y$	Eq. 9

Where:

ER_y = Emission reductions in year *y* (t CO_2/y)
BE_y = Baseline Emissions in year *y* (t CO_2/y)
PE_y = Project emissions in year *y* (t CO_2/y)
LE_y = Leakage emissions in year *y* (t CO_2/y)

B.6.2. Data and parameters fixed ex ante

Information regarding the parameters described in the following tables will be available at validation.

Data/Parameter	Cap_{BL}
Data unit	W
Description	Installed capacity of the hydro power plant before the implementation of the project.
Source of data	Project site
Value(s) applied	zero
Choice of data or measurement methods and procedures	
Purpose of data	
Additional comment	

Data/Parameter	A_{BL}
Data unit	m2
Description	Area of the reservoir measured in the surface of the water, before the implementation of the project activity.
Source of data	Project activity site
Value(s) applied	zero
Choice of data or measurement methods and procedures	
Purpose of data	
Additional comment	

Data/Parameter	$EF_{grid,,y}$
Data unit	t CO_2e/MWh
Description	CO_2 emission factor of the grid electricity in year *y*
Source of data	• Electricity generation data per power plant, fuel types, and demand curve: AMM´s reports, www.amm.org • Default values for emission factors of fossil fuels: IPCC Guidelines 2006. • Default efficiencies values for power plant/unit: Tool for 'Determining the baseline efficiency of thermal or electric energy generation systems'.
Value(s) applied	0.398
Choice of data or measurement methods and procedures	Annual calculation of the combined margin (CM), consisting of the combination of operating margin (OM) and build margin (BM) according to the procedures prescribed in the 'Tool to calculate the emission factor for an electricity system'.
Monitoring frequency	At the beginning of the second crediting period.
Purpose of data	Baseline emissions calculation
Additional comment	It is calculated as indicated in Section B6.1 and is fixed during the second crediting period.

Data/Parameter	$EG_{m,y}$ and $EG_{k,y}$
Data unit	MWh

Description	Net electricity generated by power plant/unit in years 2016, 2017 and 2018.
Source of data	Electricity generation data per power plant/unit: AMM´s (Wholesales Market Administrator) Generation Reports, www.amm.org .
Value(s) applied	See Appendix 3
Choice of data or measurement methods and procedures	Electricity is measured through the measurement equipment installed in each plant according to AMM´s norms of commercial measurement system.
Monitoring frequency	At the beginning of the second crediting period
Purpose of data	Baseline emissions calculation
Additional comment	It is calculated as indicated in Section B6.1 and is fixed during the second crediting period.

Data/Parameter	**$EF_{CO2,m,i,y}$**
Data unit	tCO_2/TJ
Description	CO_2 emissions factor of fuel type *i,* used in generating units *m and k.*
Source of data	IPCC Guidelines 2006, chapter I, volume 2 (Energy)
Value(s) applied	See table 6 of the PDD
Choice of data or measurement methods and procedures	Default values for emission factors of fossil fuels at the lower limit of the uncertainty at 95% of confidence interval are used annually during the crediting period for the relevant year, in accordance to the 'Tool to calculate the emission factor for an electricity system'.
Monitoring frequency	At the beginning of the second crediting period.
Purpose of data	Baseline emissions calculation
Additional comment	It is determinated as indicated in Section B6.1 and is fixed during the second crediting period.

Data/Parameter	$\eta_{m,y}$ and $\eta_{k,y}$
Data unit	Not applicable
Description	Average net energy conversion efficiency of power unit m or k in years 2016, 2017 and 2018
Source of data	These values are determined annually during the crediting period for the relevant year in accordance to the 'Tool to calculate the Emission Factor for an electricity system'.
Value(s) applied	See table 7 of the PDD
Choice of data or measurement methods and procedures	Default efficiencies values for power plant/unit are used as per the tool: 'Determining the baseline efficiency of thermal or electric energy generation systems'.
Monitoring frequency	At the beginning of the second crediting period
Purpose of data	Baseline emissions calculation
Additional comment	It is determinated as indicated in Section B6.1. It is fixed during the second crediting period.

B.6.3. Ex ante calculation of emission reductions

The combined emission factor of the grid is calculated *ex-ante* according to equation 5, described in Section B.6.1, as follow:

$$EF_{grid,,y} \quad (t\ CO_2/MWh) \quad = \quad 0.25 \bullet 0.536 \quad + \quad 0.75 \bullet 0.352 \ = \ 0.398\ t\ CO_2/MWh$$

Where, 0.536 represents the value of the operation margin adjusted and 0.352 the building margin. Please see Appendix 4 for more details.

Substituting the annual energy estimated for the power plant and the value of the emission factor for the grid in equation 8, results in an *ex-ante* calculation of baseline emissions of the following values:

Table 8. Estimation of baseline emissions for the second crediting period

Variable	$EG_{PJ,facility,y}$	$EF_{grid.,y}$	BE_y
Description	**Net electricity supplied by the project activity to the grid**	**Emission factor**	**Baseline emissions**
Unit	**MWh**	**t CO_2/MWh**	**t CO_2**
Definition	**A**	**B**	**A*B**
2020	36,538	0.398	14,542
2021	36,538	0.398	14,542
2022	36,538	0.398	14,542
2023	36,538	0.398	14,542
2024	36,538	0.398	14,542
2025	36,538	0.398	14,542
2026	36,538	0.398	14,542

Power density is calculated to determinate the project emissions due to the reservoirs formed by the derivation dams and the reservoir tank. Since the project activity results in multiple reservoirs, the power density of each single reservoir and of the whole power plant is calculated using equation 6.

Table 9. Power density of each reservoir and power plant

Reservoir	Area of the reservoir (m^2)	Power density calculation	Power density (w/m^2)
Secampana I	137.21	$(9.7 \text{ X } 10^6 \text{ W} – 0 \text{ W}) / (137.21 \text{ m}^2 – 0 \text{ m}^2)$	70,694.56
Secampana II	145.01	$(9.7 \text{ X } 10^6 \text{ W} – 0 \text{ W}) / (145.01 \text{ m}^2 – 0 \text{ m}^2)$	66,891.94
Secampanita	85.95	$(9.7 \text{ X } 10^6 \text{ W} – 0 \text{ W}) / (85.95 \text{ m}^2 – 0 \text{ m}^2)$	112,856.31
Caquipec	43.93	$(9.7 \text{ X } 10^6 \text{ W} – 0 \text{ W}) / (43.93 \text{ m}^2 – 0 \text{ m}^2)$	220,805.83
Golondrinas	115.2	$(9.7 \text{ X } 10^6 \text{ W} – 0 \text{ W}) / (115.20 \text{ m}^2 – 0 \text{ m}^2)$	84,201.39
Choloma	397.23	$(9.7 \text{ X } 10^6 \text{ W} – 0 \text{ W}) / (397.23 \text{ m}^2 – 0 \text{ m}^2)$	24,419.10
Reservoir-tank	2827.44	$(9.7 \text{ X } 10^6 \text{ W} – 0 \text{ W}) / (2827.44 \text{ m}^2 – 0 \text{ m}^2)$	3,430.67
Power plant	**3751.97**	$\mathbf{(9.7 \text{ X } 10^6 \text{ W} – 0 \text{ W}) / (3751.97 \text{ m}^2 – 0 \text{ m}^2)}$	**2,585.31**

Thus, it is proven that the project emissions are zero because the power densities result greater than 10 W/m^2 for each reservoir and for the whole power plant.

Therefore, the ex-ante calculation of emission reductions is calculated using equation 9, where project emissions and leakages are equal to zero; then the emissions reductions due to the project activity are equal to the baseline emissions as is indicated in Table 12.

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

The ex-ante estimation of the emissions reductions for the second crediting period is summarized in the following table:

Emissions reductions estimated for the second crediting period

Year	Baseline emissions (t CO_2e)	Project emissions (t CO_2e)	Leakage (t CO_2e)	Emission reductions (t CO_2e)
Definition	***B***	***A= 0 because power density > 10 W/m^2***	***C***	***A - B - C***
2020	14,542	0	0	14,542
2021	14,542	0	0	14,542
2022	14,542	0	0	14,542
2023	14,542	0	0	14,542
2024	14,542	0	0	14,542
2025	14,542	0	0	14,542
2026	14,542	0	0	14,542
Total	101,794	0	0	101,794
Total number of crediting years	21			
Annual average over the crediting period	14,542	0	0	14,542

B.7. Monitoring plan

B.7.1. Data and parameters to be monitored

Data and parameters monitored during monitoring

Data/Parameter	**$EG_{PJ,facility,y}$**
Data unit	MWh
Description	Quantity of net electricity supplied to the grid in year y.
Source of data	Electricity meters
Value(s) applied	36 538
Measurement methods and procedures	• The monitoring of the parameter is conducted through the authorized metering equipment by the Wholesale Electricity Administrator (Administrador del Mercado Mayorista, AMM). The meters (main and back-up) fulfill Norms IEC 687 o ANSI/IEEE 12.20 or an updated standard, according to AMM´s Commercial Norm No.14. For example, accuracy certificates from manufacturer could be used as evidence during verification. • According to Norm No. 14, the meters has to be provided with a function to integrate real-time measured values in programmable intervals and with a non-volatile internal memory to save measured data for at least 37 days. • The measurement methods and procedures applied are according to the AMM´s market Norm on Commercial Measuring Systems (Norm NCC-14). - Monitoring data: All monitoring data of the electricity delivered and consumed from the grid is monitored continuously and automatically by the main and back-up electricity meters authorized by AMM. - Measurement data: The measured data is downloaded from the meters monthly by means of an interface device and measured data is saved in an hourly basis. - Recording data: Data downloaded from meters is recorded monthly in an electronic form. - Storing data: All data collected as part of monitoring should be archived in electronic and hard formats, and be kept at least for 2 years after the end of the last crediting period. • Emergency procedures in case a calibration audit is delayed If during verification of a certain monitoring period, the calibration has been delayed and the calibration has been implemented after the monitoring period in consideration, the following conservative approach is adopted in the calculation of emissions reductions: (a) If the results of the delayed calibration do not show any errors in the measuring equipment, or if the error is smaller than the maximum permissible error, the maximum permissible error of the instrument to the measured values is applied, or (b) If the error is beyond the maximum permissible error of the main and back-up measuring equipment, the error identified in the delayed calibration is applied. The error shall be applied for all measured values taken during the period between the scheduled date of calibration and the actual date of calibration. • Emergency procedures in case of erroneous measurement In case of a meter failure, erroneous or lost data the following procedure is followed (as per Commercial Coordination norm 14 AMM (NCC-14)): (a) If main meter fails then data recorded by the back-up meter is used. When both meters fail, AMM uses the average of the historical information registered during the last six months.
Monitoring frequency	Monthly

QA/QC procedures	• A quality management system will be implemented and procedures will be followed. The procedures will describe the following information: - Name of the procedure - Description of the procedure - Responsible person - Monitoring frequency - Data registration • A cross-check procedure will be followed: - The monitored data will be compared monthly with the commercial data (electricity invoices or AMM´s Monthly Transactions Report) - The monitored data will be compared with the data registered manually by the plant operator • Equipment calibration and/or audits: - Electricity meter is calibrated initially by the manufacturer. For example, accuracy certificates from manufacturer could be used as evidence. - The equipment accuracy audits are carried out annually by a third party authorized by the AMM.
Purpose of data	Baseline emissions calculation.
Additional comment	

Data/Parameter	**Cap_{PJ}**
Data unit	W
Description	Installed capacity of the hydro power plant after the implementation of the project activity.
Source of data	Generator nameplate
Value(s) applied	9.7×10^6
Measurement methods and procedures	The installed capacity will be confirmed annually by a visual verification of the generator nameplate on site.
Monitoring frequency	Annually
QA/QC procedures	• To assure quality a procedure will be followed. The procedure to check the nameplates will describe the following information: - Name of the procedure - Description of the procedure - Responsible person - Monitoring frequency - Data registration • A cross-check procedure will be followed: The installed capacity can be confirmed by generator nameplate, or by generator manufacturer declaration of true final installed capacity (if different).
Purpose of data	Project emissions calculation
Additional comment	Data from manufacturer and equipment manuals will be stored in duplicated files, in the power plant and in headquarters.

Data/Parameter	**A_{PJ}**
Data unit	m^2
Description	Area of the multiple reservoirs measured in the surface of the water, after the implementation of the project activity, when the reservoir is full (m^2)
Source of data	Power plant site
Value(s) applied	The sum of the areas of the multiple reservoirs and the reservoir-tank is 3751.97

Measurement methods and procedures	The area of the multiple reservoirs formed by the diversion dams in the surface of the water, when the reservoirs are full, will be checked using the design maps with level curves and borders of each reservoir. The surface area of the tank-reservoir is simple to establish as this structure is a circular tank of known dimensions (60 meter diameter), therefore their geometrical dimensions are checked. The surface area of the reservoirs will be checked annually in order to assure that the power density is greater than 10 W/m^2.
Monitoring frequency	Annually
QA/QC procedures	• To assure quality a procedure will be followed. The procedure to check the reservoir area will describe the following information: - Name of the procedure - Description of the procedure - Responsible person - Monitoring frequency - Data registration
Purpose of data	Project emissions calculation
Additional comment	

B.7.2. Sampling plan

Not applicable.

B.7.3. Other elements of monitoring plan

The monitoring plan comprises the compilation and filling of all the relevant data needed to estimate the emissions reductions by the plant as specified in the decision 17/CP.7, document FCCC/CP/2001/13Add.2.

Objective:

The objective of the monitoring plan is to assure the complete, consistent, clear, and accurate monitoring and calculation of the emissions reductions, within the project activity boundaries, during the crediting period.

Methodology:

Monitoring will be according to the version 18 of the Simplified baseline methodologies for selected small-scale CDM project activity (AMS-I.D).

Boundaries

The boundaries of the project activity will remain constant during the entire crediting period and comprise the spatial extent of the project boundary including the project power plant and all power plants connected physically to the electricity system that the CDM project power plant is connected to.

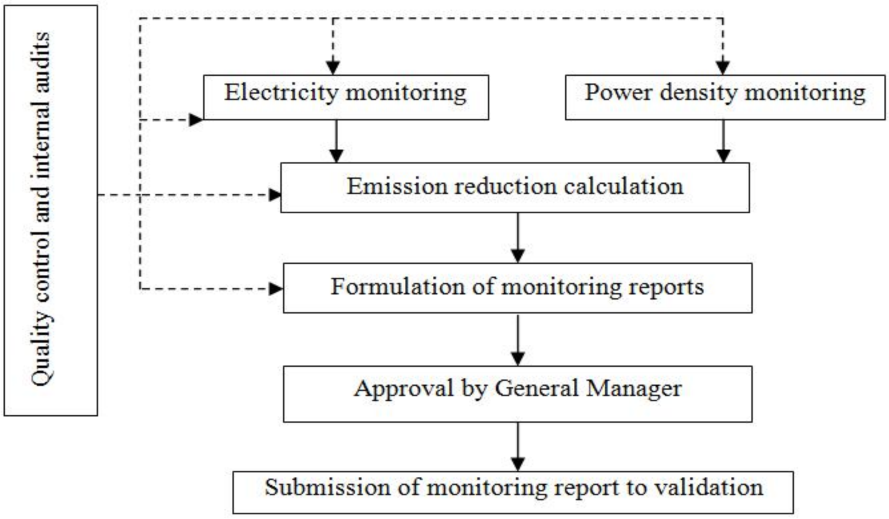


Fig. 11. Operational structure of the monitoring plan

Monitoring plan involves different processes. Each process is fed by an input and consists of a series of activities that produce a result or output. The following chart illustrates how the monitoring processes are interrelated.

Responsible personnel

The following table describes the responsibilities assigned to the personnel in charge of the monitoring process.

Table 10. Description of monitoring responsibilities

Personnel	Responsibilities
General Manager	• Responsibility of the monitoring plan. • Authorization to submit monitoring plans to DOE. • Authorization to contract CDM consultants for training, validation and verification activities. • Assignment of the personnel in charge of quality control and internal audits. • DOE and consultants contracting.
CDM coordinator	• CDM process coordination: assessment of CDM training requirements, planning of CDM training activities, coordination of meetings to revise process, etc. • Revision of monitoring parameters data. • Calculation of baseline emissions, project activity emissions and emission reductions. • Formulation of monitoring reports. • Documentation of monitoring processes for verification audits. • Data storing in hard and electronic.
Plant chief	• Parameters monitoring in power plant site. • Data registration. • Assignment of monitoring activities to plant personnel and commissioned personnel.
Commercial analyst	• Review of data from electricity meters against the AMM´s commercial data.
Internal auditor	• Annual review of CDM process. • Revision of monitoring reports before submittal to DOE

Quality control

The quality control and quality assurance procedures observed during the monitoring stage involve:

- Establishment of clear and defined procedures for data monitoring, downloading/reading and recording.
- Establishment of clear and defined procedures for baseline emissions and emissions reductions calculations.
- The General Manager appoints an officer to assure quality. A non-conformance and corrective/prevention actions procedure will be established in order to reduce the remaining uncertainties of the monitored emissions reductions.
- The monitoring process is reviewed once a year, including any non-conformance and corrective actions and whether these have been satisfactorily closed or not. The monitoring report is also reviewed before submission to a DOE for verification.

Data registration

The CDM coordinator is responsible that a file is kept, electronically and as a hard copy, during the crediting period plus two years, including:

- Electronic files containing data downloaded from electricity meters.
- All documents and information generated during each monitoring process.
- If the monitoring plan is modified or improved, the CDM coordinator will file the versions submitted to the Executive Board.
- Non-conformity reports where there is full detail of each non-conformity, from the moment of appearance to final closing.
- Information generated during training activities.

Training

Personnel in charge of the Monitoring Plan are trained as is indicated in the annual training plan. New personnel undergo a training program and are formed in the specific skills required to carry out the Monitoring Plan.

The CDM Project Manager is responsible for:

- Drafting and planning the training activities.
- Carrying out the training activities in accordance with the approved plans.
- Hiring of experts when necessary.
- Training of new personnel.

SECTION C. Start date, crediting period type and duration

C.1. Start date of project activity

24/06/2010

Starting date of the project activity is fixed by the date when the contract for “Supply, Start-up and Testing of Turbine, Generator, Controls and Associated Equipment” with Gilbert Gilkes & Gordon Ltd. (Gilkes) was signed.

C.2. Expected operational lifetime of project activity

30 years (as per equipment operational lifetime).

C.3. Crediting period of project activity

C.3.1. Type of crediting period

Renewable crediting period.
7 years and 0 months.

C.3.2. Start date of crediting period

01/01/2020

C.3.3. Duration of crediting period

7 years and 0 months.

SECTION D. Environmental impacts

D.1. Analysis of environmental impacts

Plant design blueprints, Environmental Impact Study, hydrological study, geological and geophysical studies, topographical mappings, electric stability and interconnection studies, have all been completed. No significant negative impacts are reported in these studies.

Environmental Legislation

The Guatemalan Political Constitution (1985) establishes that the State must promote social, economical and technological development to prevent environmental degradation and maintain ecological balance. In its Article 97 it states: *"all necessary norms to guarantee the rational utilization and usage of the fauna, flora, soil and water shall be dictated."*

The specific environmental norm that regulates these matters is the *Law of Protection and Improvement of the Environment* (Decree 68-86 of Congress), which seeks to contribute to the protection, conservation and improvement of the natural resources of the country, as well as the prevention of the deterioration and misuse or destruction of the resources and of the environment in general. Article 8 of this Law establishes that prior to the development of any project it is necessary to present an Environmental Impact Assessment Study (EIA) to the National Commission of Environment (CONAMA).

In the year 2000 Congressional Decree 90-2000 created the Ministry of Environment and Natural Resources, which replaced CONAMA. In 2003, through the Governmental Accord 23-2003[26], a new Regulation for Environmental Evaluation, Control and Follow-up was approved, which contains the guidelines for the preparation and presentation of the Environmental Impact Assessment Studies (EIA).

The Ministry of Environment and Natural Resources (MARN - by its abbreviation in Spanish) established an official list[27] of projects, industries and activities that must comply with EIA studies, classifying them into categories according to their characteristics, nature, level of potential environmental impact and environmental risk. This list classifies all hydroelectric projects as having "high environmental impact," which therefore requires such projects to present an EIA study for approval by the Ministry.

Environmental Impact Assessment Study

The project participant commissioned the consulting firm "Asesoría Manuel Basterrechea Asociados, S.A." (AMBA) to develop the Environmental Impact Assessment Study of the project activity.

The objectives of the EIA are to evaluate the impacts to the physical, biological and socioeconomic environment that the development of the project might cause, and to establish negative impact mitigation measures where necessary.

Identification of Impacts

As specified in the Environmental Impact Assessment rules of the Ministry of Environment (MARN), the aspects that have to be taken into consideration when identifying and valuing the various impacts are as follows: *i) air quality, ii) noise and vibrations, iii) superficial and underground water,*

[26] This Governmental Accord was reformed by the Governmental Accord 431-2007.

[27] Governmental Accord 23-2005.

iv) soil and subsoil, v) flora, fauna, aquatic and terrestrial biotopes, vi) historical and cultural resources, vii) landscape, viii) occupational health and safety, ix) socio-economic factors.

For each of the project phases, next table shows the potential impacts that are evaluated.

Table 11. Impacts during the project phases

Construction	Operation and Maintenance	Abandonment
• Air quality • Noise • Soil and subsoil • Superficial and underground water • Flora, fauna, and aquatic and terrestrial biotopes Historical and cultural resources • Landscape • Occupational health and safety • Socio-economic factors	• Air quality • Noise • Soil and subsoil • Superficial and underground water • Flora, fauna, and aquatic and terrestrial biotopes • Landscape • Occupational health and safety • Socio-economic factors	The project is expected to have a useful life of 50 years, so that the abandonment phase will occur in the long term.

After identifying these impacts, a baseline is developed in order to have the information for future monitoring activities, taking into consideration that all activities will be developed on a private property. An estimate of how much the baseline will change by the impacts generated by the different phases of the project is made. Finally, a valuation (measurement of significance) of the impacts is assessed.

Valuation of Impacts

This valuation of impacts is performed with the intention of estimating their magnitude and, when necessary, selects the corrective measures that will have to be incorporated into the project. First the project is evaluated without considering any mitigating measures, in order to evaluate the sufficiency of those measures and analyze if it is necessary to include new corrective measures.

Mitigating Measures

The Environmental Impact Assessment Study includes an Environmental Management Plan, which includes the mitigating measures to be implemented during the construction and operation phases of the hydroelectric project, in order to prevent, control and mitigate the impacts to the physical, biotical and socio-economic environment and to maximize the significant positive impacts that will originate from the project construction.

EIA approval

The Environmental Impact Assessment for the Choloma Hydroelectric Project was approved by The Ministry of Environment and Natural Resources, MARN, according to resolution 1744-2008/ECM/MFG on April 4, 2008.

D.2. Environmental impact assessment

No significant negative environmental impacts are expected by the development and implementation of the project activity.

SECTION E. Local stakeholder consultation

E.1. Modalities for local stakeholder consultation

As previously indicated, the Choloma Hydroelectric Project will be located in the San Antonio Senahú area, Department of Alta Verapaz, in northeastern Guatemala. The nearby communities include Nuevo San Carlos, La Montañesa, Santa Lucía Secacao, Candelaria Secacao, Santa Elena Secacao, Miralvalle Secacao, Las Margaritas Semococh.

The properties where the project activity will be located are privately owned, no municipal or communal lands are used. The project participants have undertaken several presentation meetings with representatives from the neighboring communities, in order to explain the project activity and to invite questions and comments.

Because the project participants have experience in the area through two existing hydroelectric plants[28], before the project activities were initiated informative meetings were held with representatives from the local communities, as follows:

1. First Stage of Information

On June 8th 2007, project executives held a meeting with 39 representatives from the Nuevo San Carlos, La Montañesa, Santa Lucía Secacao and Las Margaritas Semococh communitites. The objective of this meeting was to inform these representatives about the Choloma hydroelectric project. The presentation included a description of the existing Secacao and Candelaria hydroplants and a description of the activities and objectives of the related reforestation company "Reforestadora Polochic, S.A." [29]

During the meeting a survey was taken in order to obtain opinions regarding the development and construction of the new Choloma hydroelectric project.

On July 30th 2007 the project executives presented the Choloma Hydroelectric Project to the members of the Municipal Board, including the Mayor, of the Municipality of the Senahú Township. The Municipal Decree No. 30-2007, dated July 30th 2007, issued the construction approval for the Choloma Hydroelectric plant.

2. Second Stage of Information

With the intention of corroborating and enriching the information previously obtained, the consultant in charge of the undertaking of the project´s Environmental Impact Assessment Study held meetings with the legally established Community Councils for Development – COCODES (by their abbreviation in Spanish), which are community councils of the nearby communities. In addition, authorities from the Municipality of San Antonio Senahú participated.

On September 13th 2007, a meeting with leaders of COCODES took place. This meeting was attended by representatives of the Nuevo San Carlos, La Montañesa and Santa Lucía Secacao communities. Table 15 below shows the name and council position of the attendees.

Table 12. Meeting attendance

Community	Name	Council Position
Nuevo San Carlos	Martín Coc	President

[28] Secacao and Candelaria Hydroelectric Plants.

[29] Company in charge of reforestation activities.

	Jorge Chub Jaal	Coordinator
	Mario Cac Coc	Secretary
	Lorenzo Cac	Treasurer
	Santiago Choc	Board Member
La Montañesa	José Choc	President
	Alejandro Chuc Col	Coordinator
	Emilio Chu	Secretary
Santa Lucía Secacao	Juan Rax	President
	Raúl Pérez Tox	Coordinator
	Mardoqueo Maquín	Secretary
	Pedro Choc	Board Member
	Santiago Maquí	Board Member
Choloma Project Representatives	Rudolf Jacobs	Executive
	Javier Luengo	Executive
	Rodrigo Tormo	Executive
	Rodrigo Lux	Translator Castilian-Q'eqchi
Basterrechea Asociados, S.A.	Manuel Basterechea	Study coordinator
	Carlos Quezada	Sociologist
	Hugo Enríquez	Biologist
	Roberto Sagastume	Cartographer

On September 18th 2007, a meeting with members of the Municipal Board was held in the Municipality of San Antonio Senahú. The EIA consultant explained that the objective of the meeting was to gather opinions of the board members regarding the development of the Choloma hydroelectric project. The Municipality representatives confirmed that they had prior knowledge of the project, and that they had been informed about the project details in due course. Table 16 below shows the attendee list of this meeting.

Table 13. Meeting attendance

Name	Municipality Position
José Salvador Buenafé Reyes	Councillor I
Mario Eduardo Hassen Ovalle	Councillor V and Mayor in functions
Alejandro Argueta	Municipal Secretary

In addition, a series of random interviews were performed, Table 17 lists the names of the persons that were interviewed.

Table 14. People randomly interviewed

Name
Alfredo Xixel
Eduardo Mú
Mariano Díaz
Haroldo Toch Chen
Julio Chum

Domingo Tot

The documentation that supports this information, such as meeting minutes, lists of participants / attendees, surveys, etc., is included in the EIA (Environmental Impact Assessment study) of the project.

3. Third and Final Stage of Information

Finally, on February 17th, 2011, a Stakeholder Consultation to representatives from several nearby communities was undertaken. This consultation intended to collect comments from leaders and representatives from local communities.

Invitations were sent out for this event, and 65 attendees from seven nearby communities participated, as documented in the attendance sheet. Ing. Raúl Castañeda, from the Guatemalan Designated National Authority (DNA), participated as an observer.

The event included a presentation by Mr. Rodrigo Tormo and Ms. Laura Ruiz, General Manager and CDM Assistant, respectively, of Hidroeléctrica Choloma, S.A. (project participant), a comments/questions session with the registration of written comments, a guided plant-tour to project installations of the existing Secacao hydroelectric plant, a demonstration of how a hydroelectric plant functions with the help of a miniature model (see photos), and a closing luncheon.

E.2. Summary of comments received

Comments received during the ***first and second information stages*** are presented in the table below.

Table 15. Stakeholders' comments

Stakeholder	Comments
COCODES	• Community representatives were aware of the development of the project and were agreeable with the plans to develop it. • The project roads contribute to the mobilization of the nearby communities. • Because meeting participants were familiar with hydroelectric energy generation they were neither concerned nor worried about being affected. Mr. Mario Cac indicated that "jobs have been generated, we see no problems. Also, trees are being planted." • Representatives asked for support in the construction of water tanks. • Various representatives were thankful for having been invited and heard. • Representatives expressed support and acceptance regarding the construction of the Choloma project.
Municipality	• Representatives requested for the Company to collaborate with the supply of road materials for the rehabilitation or nearby municipal access roads. • The Municipal authorities thanked the project developers for their visit and expressed being in agreement with the project construction.
Inhabitants	• These kinds of projects benefit our communities by offering jobs, building new and fixing old roads, assisting with access to electricity and by reforesting the area. In favor regarding the construction of the Choloma hydroelectric project.

The comments received from local stakeholders during the ***third information stage and consultation process*** of Feb. 17th, 2011 are presented next, in a summarized and graphical form. Comments were, for the most part, very positive. Local stakeholders expressed that the Choloma

Hydroelectric Project will bring benefits to their communities, generate new jobs and increase electricity generation from a non-polluting source.

Local stakeholders also stated that the project activity will not only generate clean electricity but will also improve the labour and health conditions of the area through reforestation efforts, providing better environmental conditions for the local communities.

Comments received during the stakeholder consultation (17.02.2011): 51 attendees registered their comments, on 45 comment sheets (forms):

1 Based on the available information and your knowledge regarding the Environment, Climate Change, Kyoto Protocol and Clean Development Mechanism, briefly express your opinion about the Choloma Hydroelectric Project.

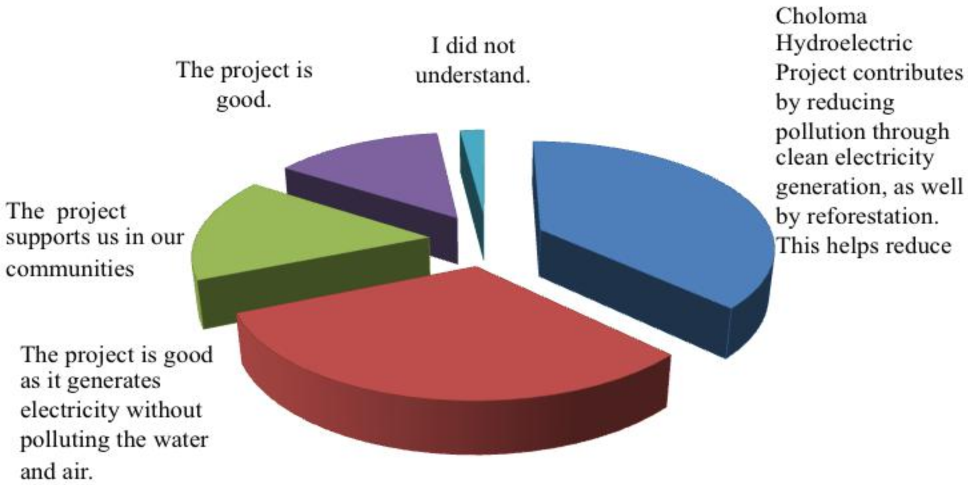


Fig. 12. Comments on Choloma Hydroelectric Project

2 Would you recommend private companies, governmental authorities or other organizations to develop projects of this kind: electricity generation from renewable resources as a contribution to the mitigation of climate change?

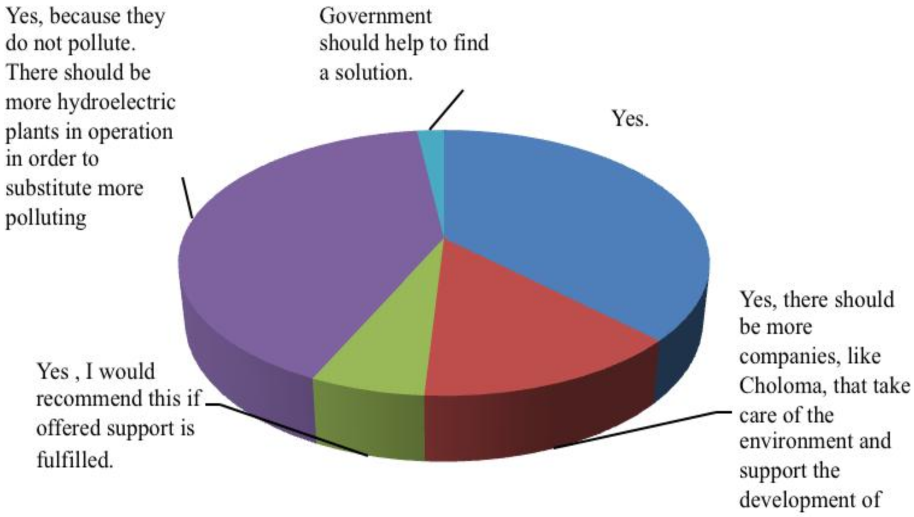


Fig. 13. Comments on electricity generation from renewable resources

3 Do you believe that Choloma Hydroelectric Project will contribute to the environmental, social and economic development (sustainable development) of the region and of Guatemala?

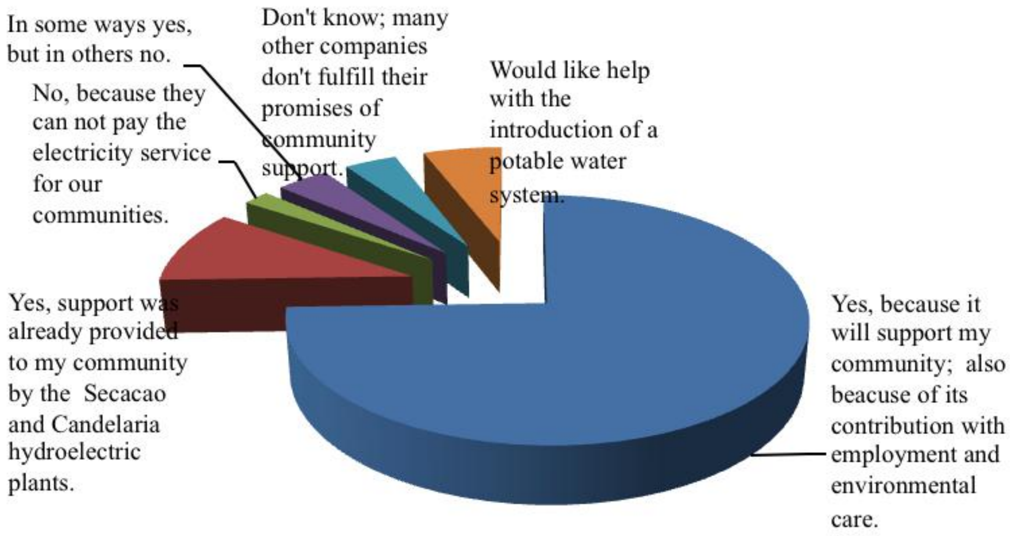


Fig. 14. Comments on contribution of the project to sustainable development

4 Express any additional comments.

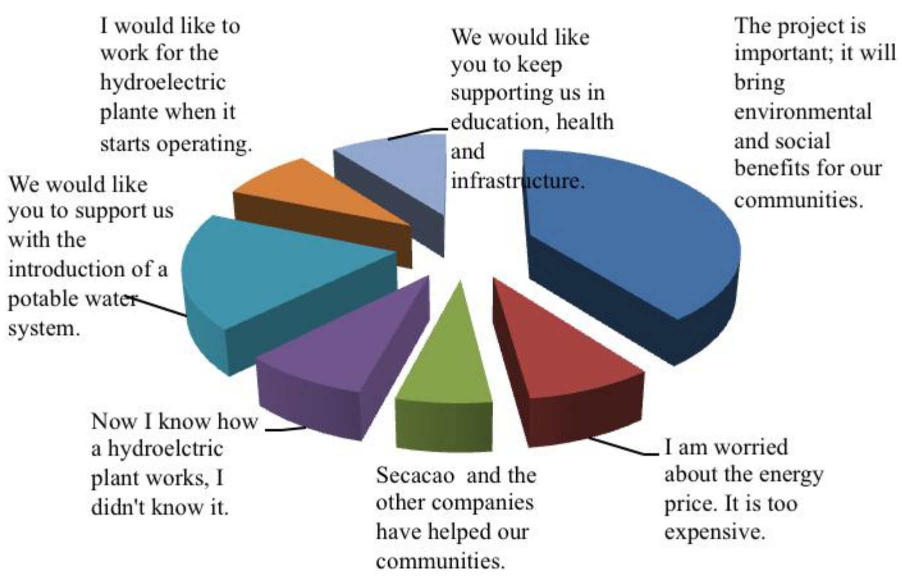
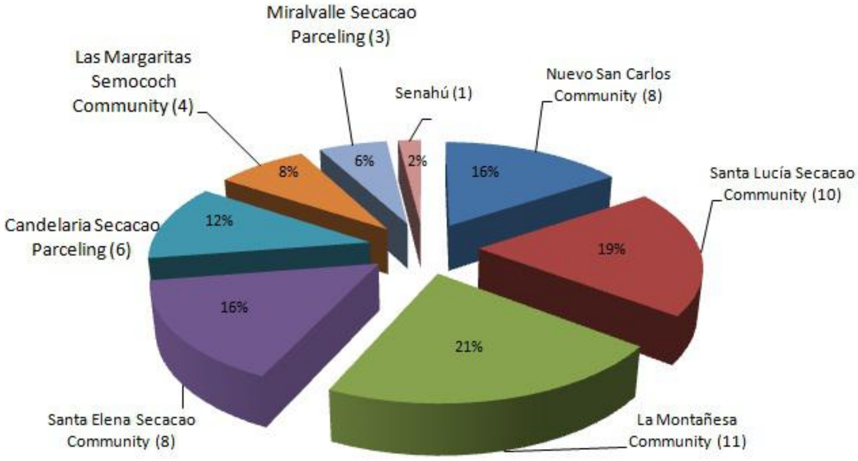


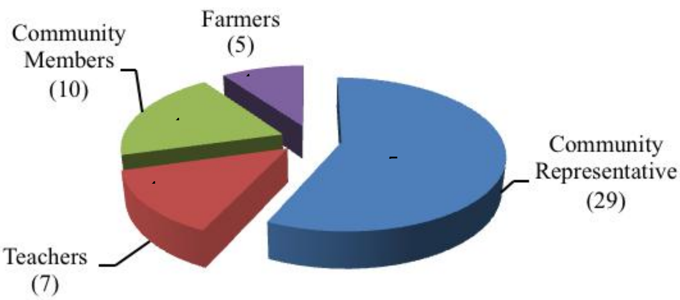
Fig. 15. Additional comments

*** General information**

a Community Representation:



b Position / profession:



c Attendees:

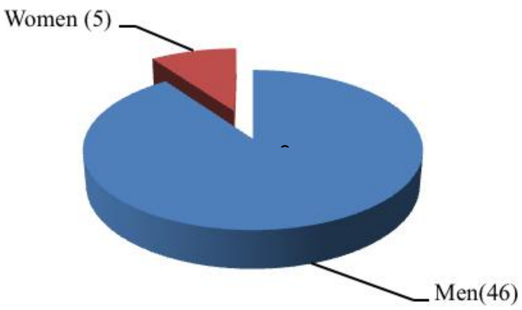


Fig. 16. Characterization of stakeholders consulted

E.3. Consideration of comments received

Community infrastructure:

Regarding the expressed and observed need that local communities have with the lack of adequate water distribution systems, and the absent action by the local and national governments (Municipality of Senahú and Federal Government ministries), the project participant is evaluating different alternatives on how to assist, recognizing the strong and direct relationship that exists between inadequate water and elevated health problems, general child development and lower living standards due to time and effort required to collect water.

For three neighboring communities, a quantification of water sources and volumes present in the dry season are being identified and measured. With this information and a mapping of the distribution of houses in these communities, including population per house density (and population growth in a design period of 20 years), a water distribution system is being evaluated, and if feasible, is to be designed and constructed. The final goal is to present to the communities the resulting designs, and to seek to establish a mutual cooperation agreement where, in essence, the project activity would assist with the design and construction of the system, with contributions by the community members with respect to labor and a long-term commitment by the community organizations and members to maintain and administer their water system to guarantee its functionality and longevity.

Community support:

As part of the capital investment into the project activity, a new ambulance will be put into service, which will be operated by the sponsors and will tend to health emergencies that require transportation to better equipped medical centers, that usually lie from a few to several hours away from the neighboring communities.

In addition, the project activity will join the efforts with the existing Secacao and Candelaria hydroelectric power companies, in maintaining and stocking a community health center that was built by these companies to tend to the nearby population (of 4,000+) regarding non-emergency health care, including pregnancy and child-birthing assistance.

The project participant, on its own land area that surrounds the physical project components, will implement reforestation projects, aimed at job-creation, water resource management and general ecosystem recovery. As part of this effort, the project activity will, on a long-term basis, tend to the conservation and protection of the natural tropical forests that cover the higher project areas where the water resources used by the project come from.

General infrastructure:

Continuous assistance is provided to the Municipality of Senahú, and the local communities, especially with respect to providing road construction and maintenance materials (sand, fill, rock, etc.), in particular when these maintenance programs are focused on the general roads that serve and connect the surrounding communities. Often construction equipment is also provided.

SECTION F. Approval and authorization

Letter of approval from Guatemala (March 23, 2011) is available and can be accessed at the UNFCCC website:
https://cdm.unfccc.int/filestorage/u/r/48DBE7Y6TG139XMK0HOZ5CAVQLRIPS.pdf/Letter%20of%20National%20Approval.pdf?t=Uk98cHc2a2NsfDBN1wpt25LbaZlEWFJ6GmJ3

Appendix 1. Contact information of project participants

Organization name	Hidroeléctrica Choloma, S.A.
Country	Guatemala
Address	29 avenida 2-85 Zona 15,, Guatemala City, Guatemala, Central America
Telephone	+(502) 2313-8383
Fax	+(502) 2313-8383
E-mail	rtormo@gruposecacao.com
Website	www.gruposecacao.com
Contact person	Rodrigo Tormo

Appendix 2. Affirmation regarding public funding

No public funding from parties included in Annex I is available to the project activity.

Appendix 3. Applicability of methodologies and standardized baselines

Standardized baselines are not used. See sections B1 and B2 for more information about the methodology applied.

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

a. Information Sources for Baseline Calculation

Variable	Description	Units	Source
	Name of the power plant/unit connected to the grid		Wholesale Electricity Market (www.amm.org.gt), "Operation results" section, “Annual Reports” sub-section, table "Installed Capacity "
	Available capacity of the power units connected to the grid	MW	Wholesale Electricity Market (www.amm.org.gt), "Operation results" section, “Annual Reports” sub-section, table "Installed Capacity "
	Starting year of the power units connected to the grid		Wholesale Electricity Market (www.amm.org.gt), "Operation results" section, “Annual Reports” sub-section, table "Installed Capacity "
$EGm_{,2010}$	Energy produced by plants/units m in 2016-2018	(MWh)	Wholesale Electricity Market (www.amm.org.gt), "Operation results" section, “Annual Reports” sub-section, table "Annual Generation per Plant "
i	Fuel Type of power units		Wholesale Electricity Market (www.amm.org.gt), "Operation results" section, “Annual Reports” sub-section, table "Installed Capacity "
$EF_{CO2,m,i,y}$	Average emission factor of fuel type i	(t CO_2/TJ)	IPCC, 2006, Inventory Workbook

	Conversion factor of power units	TJ/MWh	Conversion factor from the International System of Units
η_m	Default efficiency factors of power units	%	Tool 09 for Determining the baseline efficiency of thermal or electric energy generation systems
$EF_{EL,m,y}$	Emission factor of unit m in 2016 - 2018	t CO_2/MWh	Calculated
	CO_2 emissions 2016 - 2018 of power units	t CO_2	Calculated

b. Selection of set of power plants *m* for operating margin calculation

Power units *m* in 2016

Name of the power plant/unit (clasified by technology)	Starting year	$EG_{m,2016}$	i	$EF_{CO2,m,i,y}$		η_m	$EF_{EL,m,y}$	
	Starting year	Energy produced 2016	Fuel Type	Average emission factor of fuel type i	Conversion factor	Default efficiency factors	Emission factor of unit m	CO_2 emissions 2016
		(MWh)		(t CO_2/TJ)	TJ/MWh	%	t CO_2/MWh	t CO2
	AMM	AMM	AMM	Inventory Workbook (IPCC, 2006)	Conversion factor from the International System of	Meth tool 09, appendix	Calculated	Calculated
Coal		**2,484,764**						**2,099,349.08**
SAN JOSE	2000	1,042,421	Bituminous coal	89.50	3.6	37%	0.871	907,751.26
LA LIBERTAD	2008	80,903	Bituminous coal	89.50	3.6	39%	0.826	66,838.67
PALMAS 2	2012	298,342	Bituminous coal	89.50	3.6	39%	0.826	246,476.48
COSTA SUR	2013	171,708	Bituminous coal	89.50	3.6	39%	0.826	141,857.50
SANTA LUCÍA	2014	120,884	Bituminous coal	89.50	3.6	39%	0.826	99,868.81
JAGUAR	2015	575,226	Bituminous coal	89.50	3.6	39%	0.826	475,224.99
SAN ISIDRO	2016	195,280	Bituminous coal	89.50	3.6	39%	0.826	161,331.37
Combined cycle		**4,311**						**0.0**
ARIZONA VAPOR 1	2008	4,311	Waste Heat	0.0	3.6	0%	-	0
GAS TURBINES		**5,429**						**4,730.15**
TAMPA	1995	4,212	Diesel	72.6	3.6	30%	0.871	3,669.19
STEWART & STEVENSON	1995	299	Diesel	72.6	3.6	30%	0.871	260.76
ESC.GAS No.3	1976	-	Diesel	72.6	3.6	30%	0.000	-
ESC.GAS No.5	1985	918	Diesel	72.6	3.6	30%	0.871	800.19
LAGUNA GAS 2	1978	-	Diesel	72.6	3.6	30%	0.871	-
Internal combustion motors		**981,350**						**740,691.38**
ARIZONA	2003	341,550	Fuel Oil No.6	75.5	3.6	40.0%	0.680	232,083.47
LA ESPERANZA	2000	330,609	Fuel Oil No.6	75.5	3.6	33.0%	0.824	272,301.25
PQPLLC	1993	19,909	Fuel Oil No.6	75.5	3.6	33.0%	0.824	16,397.69
LAS PALMAS 1	1998	15,612	Fuel Oil No.6	75.5	3.6	33.0%	0.824	12,858.68
LAS PALMAS 2	1998	4,932	Fuel Oil No.6	75.5	3.6	33.0%	0.824	4,062.54
LAS PALMAS 3	1998	15,030	Fuel Oil No.6	75.5	3.6	33.0%	0.824	12,379.61
LAS PALMAS 4	1998	11,314	Fuel Oil No.6	75.5	3.6	33.0%	0.824	9,318.35
LAS PALMAS 5	1998	4,926	Fuel Oil No.6	75.5	3.6	33.0%	0.824	4,057.54
GENOR	1998	55,641	Fuel Oil No.6	75.5	3.6	33.0%	0.824	45,827.60
Sidegua	1995		Fuel Oil No.6	75.5	3.6	33.0%	0.824	-
TEXTILES B1	1996	58,390	Fuel Oil No.6	75.5	3.6	33.0%	0.824	48,092.06
TEXTILES B2	2003	31,528	Fuel Oil No.6	75.5	3.6	40.0%	0.680	21,423.05
TEXTILES B3	2008	52,821	Fuel Oil No.6	75.5	3.6	40.0%	0.680	35,891.63
ELECTROGENERACIÓN	2003	34,360	Fuel Oil No.6	75.5	3.6	40.0%	0.680	23,347.33
GENERADORA PROGRESO	1993	-	Fuel Oil No.6	75.5	3.6	33.0%	0.824	-
GECSA	2007	-	Fuel Oil No.6	75.5	3.6	40.0%	0.680	-
GECSA 2	2008	-	Fuel Oil No.6	75.5	3.6	40.0%	0.680	-
COENESA	2008	6	Diesel	75.5	3.6	40.0%	0.680	4.26
INTECSA	2016	-	Fuel Oil No.6	75.5	3.6	48.5%	0.560	-
GENOSA	2013	4,546	Fuel Oil No.6	75.5	3.6	48.5%	0.560	2,547.72
ACTUN CAN	2016	176	Fuel Oil No.6	75.5	3.6	48.5%	0.560	98.59
Cogenerators (fossil fuel)		**597,673**						**218,841.86**
CONCEPCION	1994	0	Fuel Oil No.6	75.5	3.6	83.5%	0.326	0
PANTALEON	1991	45,305	Bituminous coal	89.50	3.6	83.5%	0.386	17,482
SANTA ANA	1995	138,031	Bituminous coal	89.50	3.6	83.5%	0.386	53,262
MAGDALENA	1994	200,936	Fuel Oil No.6	75.5	3.6	83.5%	0.326	65,407
LA UNION	1995	6,403	Fuel Oil No.6	75.5	4.6	83.5%	0.416	2,663
MADRE TIERRA	1996	1,708	Fuel Oil No.6	75.5	5.6	83.5%	0.506	865
TULULA	2001	844	Fuel Oil No.6	75.5	3.6	83.5%	0.326	275
TRINIDAD	2011	109,878	Bituminous coal	89.5	3.6	83.5%	0.386	42,398
EL PILAR	2012	0	Fuel Oil No.6	75.5	3.6	83.5%	0.326	0
PALO GORDO	2014	94,058	Bituminous coal	89.50	3.6	83.5%	0.386	36,294
GENERADORA DEL ATLÁNTICO	2014	510	Bituminous coal	89.50	3.6	83.5%	0.386	197
	Σ	**4,073,528**					**Σ**	**3,063,612**

Power units *m* in 2017

Name of the power plant/unit (clasified by technology)	Starting year	EGm_{2017} Energy produced 2017	i Fuel Type	$EF_{CO2,m,i,y}$ Average emission factor of fuel type i	Conversion factor	η_m Default efficiency factors	$EF_{EL,m,y}$ Emission factor of unit m	CO_2 emissions 2017
		(MWh)		(t CO_2/TJ)	TJ/MWh	%	t CO_2/MWh	t CO2
	AMM	AMM	AMM	Inventory Workbook (IPCC, 2006)	Conversion factor from the International System of	Meth tool 09, appendix	Calculated	Calculated
Coal		######### #						**1,989,137.02**
SAN JOSE	2000	890,196	Bituminous coal	89.50	3.6	37%	0.871	775,191.89
LAS PALMAS II	2012	222,686	Bituminous coal	89.50	3.6	39%	0.826	183,973.01
LA LIBERTAD	2008	33,723	Bituminous coal	89.50	3.6	39%	0.826	27,860.19
GENERADORA COSTA SUR	2013	115,995	Bituminous coal	89.50	3.6	39%	0.826	943,467.94
JAGUAR ENERGY	Aug 2015	1,142,000	Bituminous coal	89.50	3.6	39%	0.826	57,501.41
SAN ISIDRO	may-16	69,601	Bituminous coal	89.50	3.6	39%	0.826	1,142.57
Combined cycle		**1,383**						**0.0**
ARIZONA	2008	1,383	Waste Heat	0.0	3.6	0%	-	0
GAS TURBINES		**4,948**						**4,310.65**
TAMPA	1995	2,901	Diesel	72.6	3.6	30%	0.871	2,527.11
STEWART & STEVENSON	1995	733	Diesel	72.6	3.6	30%	0.871	638.22
ESCUINTLA GAS 3	1985	-	Diesel	72.6	3.6	30%	0.871	-
ESCUINTLA GAS 5	1985	1,315	Diesel	72.6	3.6	30%	0.871	1,145.33
Internal combustion motors		**393,682**						**283,851.39**
ARIZONA	2003	200,117	Fuel Oil No.6	75.5	3.6	40.0%	0.680	135,979.43
LA ESPERANZA	2000	67,959	Fuel Oil No.6	75.5	3.6	33.0%	0.824	55,973.72
PQP	1993	3,961	Fuel Oil No.6	75.5	3.6	33.0%	0.824	3,262.06
LAS PALMAS	1998	11,692	Fuel Oil No.6	75.5	3.6	33.0%	0.824	9,630.37
GENOR	1998	5,262	Fuel Oil No.6	75.5	3.6	33.0%	0.824	4,334.31
TDL B1 (6,7,8,12)	1998	32,709	Fuel Oil No.6	75.5	3.6	33.0%	0.824	26,940.15
TDL B2 (3,4,9)	2003	17,264	Fuel Oil No.6	75.5	3.6	40.0%	0.680	11,730.63
TDL B3 (10,11,13)	2008	26,194	Fuel Oil No.6	75.5	3.6	40.0%	0.680	17,798.95
ELECTROGENERACIÓN	2003	18,615	Fuel Oil No.6	75.5	3.6	40.0%	0.680	12,648.88
GENOSA	2013	1,801	Fuel Oil No.6	75.5	3.6	48.5%	0.560	1,009.18
TERMICA B + TERMICA B2	2017	5,733	Fuel Oil No.6	75.5	3.6	48.5%	0.560	3,212.71
ELECTRO CRISTAL BUNKER	2016	2,375	Fuel Oil No.6	75.5	3.6	48.5%	0.560	1,331.00
COENESA	2008	-	Diesel	75.5	3.6	40.0%	0.680	-
Cogenerators (fossil fuel)		**109,568**						**39,836.97**
CONCEPCION	1994	15	Fuel Oil No.6	75.5	3.6	83.5%	0.326	5
PANTALEON B1	1991	18	Fuel Oil No.6	75.5	3.6	83.5%	0.326	6
PANTALEON B3	jul-16	1,242	Bituminous coal	89.50	3.6	83.5%	0.386	479
SANTA ANA	1995	5	Fuel Oil No.6	75.5	3.6	83.5%	0.326	2
SANTA ANA B2	2015	15,456	Fuel Oil No.6	75.5	4.6	83.5%	0.416	6,429
MAGDALENA	1994	47,860	Fuel Oil No.6	75.5	3.6	83.5%	0.326	15,579
LA UNION B1	1995	0	Fuel Oil No.6	75.5	3.6	83.5%	0.326	0
MADRE TIERRA	1996	36	Fuel Oil No.6	75.5	3.6	83.5%	0.326	12
GENERADORA SANTA LUCÍA	2014	6,095	Bituminous coal	89.50	3.6	83.5%	0.386	2,352
TULULA B1	2001	32	Fuel Oil No.6	75.5	3.6	83.5%	0.326	10
TULULA B4	2013	0	Bituminous coal	89.50	3.6	83.5%	0.386	0
TRINIDAD B3	2011	186	Fuel Oil No.6	75.5	3.6	83.5%	0.326	61
TRINIDAD B4	2015	0	Bituminous coal	89.50	3.6	83.5%	0.386	0
TRINIDAD B5	oct-16	24,155	Bituminous coal	89.50	3.6	83.5%	0.386	9,321
EL PILAR B3	2012	0	Fuel Oil No.6	75.5	3.6	83.5%	0.326	0
PALO GORDO B2	2014	14,263	Bituminous coal	89.50	3.6	83.5%	0.386	5,503
GENERADORA DEL ATLÁNTICO (GDR)	2014	206	Bituminous coal	89.50	3.6	83.5%	0.386	79
	Σ	**2,983,782**					Σ	**2,317,136**

Power units *m* in 2018

Name of the power plant/unit (clasified by technology)		$EG_{m,2018}$	i	$EF_{CO2,m,i,y}$		η_m	$EF_{EL,m,y}$	
	Starting year	Energy produced 2018	Fuel Type	Average emission factor of fuel type i	Conversion factor	Default efficiency factors	Emission factor of unit m	CO_2 emissions 2018
		(MWh)		(t CO_2/TJ)	TJ/MWh	%	t CO_2/MWh	t CO2
	AMM	AMM	AMM	Inventory Workbook (IPCC, 2006)	Conversion factor from the International System of	Meth tool 09, appendix	Calculated	Calculated
Coal		**######### #**						**2,705,794.14**
SAN JOSE	2000	911,775	Bituminous coal	89.50	3.6	37%	0.871	793,983.51
LAS PALMAS II	2012	99,291	Bituminous coal	89.50	3.6	39%	0.826	82,029.45
LA LIBERTAD	2008	94,668	Bituminous coal	89.50	3.6	39%	0.826	78,210.46
GENERADORA COSTA SUR	2013	156,349	Bituminous coal	89.50	3.6	39%	0.826	813,273.80
JAGUAR ENERGY 1	2015	984,410	Bituminous coal	89.50	3.6	39%	0.826	806,983.86
JAGUAR ENERGY 2	2015	976,796	Bituminous coal	89.50	3.6	39%	0.826	130,354.19
SAN ISIDRO	2016	157,784	Bituminous coal	89.50	3.6	39%	0.826	958.88
Combined cycle		**1,161**						**0.0**
ARIZONA VAPOR	2008	1,161	Waste Heat	0.0	3.6	0%	-	0
GAS TURBINES		**1,855**						**1,616.13**
TAMPA	1995	1,403	Diesel	72.6	3.6	30%	0.871	1,222.60
STEWART & STEVENSON	1995	292	Diesel	72.6	3.6	30%	0.871	254.26
ESCUINTLA GAS 5	1985	160	Diesel	72.6	3.6	30%	0.871	139.27
Internal combustion motors		**377,816**						**271,922.92**
ARIZONA	2003	228,320	Fuel Oil No.6	75.5	3.6	40%	0.680	155,143.60
PQP	1993	3,490	Fuel Oil No.6	75.5	3.6	33%	0.824	2,874.48
LAS PALMAS	1998	27,563	Fuel Oil No.6	75.5	3.6	33%	0.824	22,701.53
GENOR	1998	11,252	Fuel Oil No.6	75.5	3.6	33%	0.824	9,267.25
TDL B1 (6,7,8,12)	1998	33,569	Fuel Oil No.6	75.5	3.6	33%	0.824	27,648.59
TDL B2 (3,4,9)	1998	17,835	Fuel Oil No.6	75.5	3.6	33%	0.824	14,689.97
TDL B3 (10,11,13)	1998	23,046	Fuel Oil No.6	75.5	3.6	33%	0.824	18,981.88
ELECTROGENERACIÓN	2003	18,982	Fuel Oil No.6	75.5	3.6	40%	0.680	12,898.37
GENOSA	2013	2,704	Fuel Oil No.6	75.5	3.6	49%	0.560	1,515.53
TERMICA	2017	2,229	Fuel Oil No.6	75.5	3.6	49%	0.560	1,249.10
TERMICA B2	2017	6,693	Fuel Oil No.6	75.5	3.6	49%	0.560	3,751.08
ELECTRO CRISTAL BUNKER	2016	2,058	Fuel Oil No.6	75.5	3.6	49%	0.560	1,153.52
COENESA	2008	73	Diesel	72.6	3.6	40%	0.653	48.02
Cogenerators (fossil fuel)		**607,493**						**223,158.92**
CONCEPCION	1994	26	Fuel Oil No.6	75.5	3.6	83.5%	0.326	9
PANTALEON B1	1991	38	Fuel Oil No.6	75.5	3.6	83.5%	0.326	12
PANTALEON B3	2016	62,205	Bituminous coal	89.50	3.6	83.5%	0.386	24,003
SANTA ANA	1995	11	Fuel Oil No.6	75.5	3.6	83.5%	0.326	3
SANTA ANA B2	2015	88,682	Fuel Oil No.6	75.5	4.6	83.5%	0.416	36,885
MAGDALENA	1994	226,772	Fuel Oil No.6	75.5	3.6	83.5%	0.326	73,816
LA UNION B1	1995	3,599	Fuel Oil No.6	75.5	3.6	83.5%	0.326	1,172
MADRE TIERRA	1996	125	Fuel Oil No.6	75.5	3.6	83.5%	0.326	41
GENERADORA SANTA LUCÍA	2014	59,486	Bituminous coal	89.50	3.6	83.5%	0.386	22,954
TULULA B1	2001	36	Fuel Oil No.6	75.5	3.6	83.5%	0.326	12
TULULA B4	2013	73	Bituminous coal	89.50	3.6	83.5%	0.386	28
TRINIDAD B3	2011	-	Fuel Oil No.6	75.5	3.6	83.5%	0.326	-
TRINIDAD B4	2015	36,645	Bituminous coal	89.50	3.6	83.5%	0.386	14,140
TRINIDAD B5	2016	57,999	Bituminous coal	89.50	3.6	83.5%	0.386	22,380
EL PILAR B3	2012	0	Fuel Oil No.6	75.5	3.6	83.5%	0.326	0
PALO GORDO B2	2014	71,169	Bituminous coal	89.50	3.6	83.5%	0.386	27,462
GENERADORA DEL ATLÁNTICO (GDR)	2014	628	Bituminous coal	89.50	3.6	83.5%	0.386	242
	Σ	**4,369,398**					Σ	**3,202,492**

c. Selection of set of power plants *k* for operating margin calculation

Power units *k* in 2016

Name of the power plant/unit (clasified by technology)	Starting year	$EG_{k,2016}$	i	$EF_{CO2,k,i,y}$		η_k	$EF_{EL,k,y}$	
		Energy produced 2016	Fuel Type	Average emission factor of fuel type i	Conversion factor	Default efficiency factors	Emission factor of unit k	CO_2 emissions 2016
		(MWh)		(t CO_2/TJ)	TJ/MWh	%	t CO_2/MWh	t CO2
	AMM	AMM	AMM	Inventory Workbook (IPCC, 2006)	Conversion factor from the International System of	Meth tool 09, appendix	Calculated	Calculated
Geothermal		**289,139**						0
ORZUNIL	1999	125,153	Geothermal steam	0	-	0	0	0
ORTITLÁN	2007	163,986	Geothermal steam	0	-	0	0	0
Hydroelectrics		**3,724,240**						0
CHIXOY	1983	980,005	Water	0	0	0	0	0
AGUACAPA	1982	259,420	Water	0	0	0	0	0
JURUN	1970	255,799	Water	0	0	0	0	0
ESCLAVOS	1966	41,696	Water	0	0	0	0	0
PEQUEÑAS HIDRO	1938-1926	44,687	Water	0	0	0	0	0
RIO BOBOS	1995	38,496	Water	0	0	0	0	0
SECACAO	1998	95,883	Water	0	0	0	0	0
PASABIEN	2000	38,691	Water	0	0	0	0	0
POZA VERDE	2000	35,960	Water	0	0	0	0	0
LAS VACAS	2002	86,953	Water	0	0	0	0	0
EL CANADÁ	2003	160,419	Water	0	0	0	0	0
MATANZAS + SAN ISIDRO	2002	54,224	Water	0	0	0	0	0
RENACE	2004	260,459	Water	0	0	0	0	0
PALIN II	2005	13,307	Water	0	0	0	0	0
MONTECRISTO	2006	44,053	Water	0	0	0	0	0
CANDELARIA	2006	24,434	Water	0	0	0	0	0
EL RECREO	2007	104,232	Water	0	0	0	0	0
HIDROXACBAL	2010	302,268	Water	0	0	0	0	0
PANAN	2010	19,944	Water	0	0	0	0	0
SANTA TERESA	2011	59,366	Water	0	0	0	0	0
CHOLOMA	2011	25,165	Water	0	0	0	0	0
PALO VIEJO	2012	110,365	Water	0	0	0	0	0
VISIÓN DE AGUILA	2013	7,710	Water	0	0	0	0	0
EL MANANTIAL	42036	46,934	Water	0	0	0	0	0
EL CÓBANO	42036	29,131	Water	0	0	0	0	0
OXEC	nov.2015	58,582	Water	0	0	0	0	0
RENACE 2	Ab.2016	374,515	Water	0	0	0	0	0
LAS FUENTES II	May.2016	23,025	Water	0	0	0	0	0
EL CAFETAL	May.2016	29,392	Water	0	0	0	0	0
RAAXHA	May.2016	15,972	Water	0	0	0	0	0
FINCA LORENA	Aug.2016	10,554	Water	0	0	0	0	0
RENACE 3	Nov.2106	58,060	Water	0	0	0	0	0
RECREO 2	Oct.2016	14,542	Water	0	0	0	0	0
Distribuited generation		**248,045**						0
SANTA ELENA	2008	2,209	Water	0	0	0	0	0
KAPLAN CHAPINA	2009	1,384	Water	0	0	0	0	0
CUEVAMARÍA	2009	20,708	Water	0	0	0	0	0
LOS CERROS	2010	4,322	Water	0	0	0	0	0
COVADONGA	2010	5,303	Water	0	0	0	0	0
JESBON MARAVILLAS	2010	-	Water	0	0	0	0	0
EL PRADO	2010	2,009	Water	0	0	0	0	0
OSCANA	2010	3,089	Water	0	0	0	0	0
HIDRO HDMM	2011	13,327	Water	0	0	0	0	0
LA PERLA	2011	9,517	Water	0	0	0	0	0
SAC-JA	2011	13,797	Water	0	0	0	0	0
SAN JOAQUIN 2	Jan 2012	4,738	Water	0	0	0	0	0
LUARCA	jun-12	490	Water	0	0	0	0	0
CERRO VIVO	2012	7,919	Water	0	0	0	0	0
LAS VICTORIAS	2013	2,646	Water	0	0	0	0	0
EL LIBERTADOR	2013	2,160	Water	0	0	0	0	0
EL IXTAL	2014	6,004	Water	0	0	0	0	0
CORALITO	2013	8,591	Water	0	0	0	0	0
EL ZAMBO	2013	3,324	Water	0	0	0	0	0
MONTE MARÍA	2014	2,323	Water	0	0	0	0	0
AGUNA	2014	9,417	Water	0	0	0	0	0
FOTOVOLTAICA SIBO	2014	12,371	Water	0	0	0	0	0
GDR LA PAZ	2014	5,232	Water	0	0	0	0	0
GDR GUAYACÁN	2014	4,736	Water	0	0	0	0	0
PUNTA DEL CIELO	2014	3,598	Water	0	0	0	0	0
SANTA TERESA	Jan 2015	8,364	Water	0	0	0	0	0
PANAL	feb-15	4,500	Water	0	0	0	0	0
PACAYAS	March 2015	17,497	Water	0	0	0	0	0
VERTEDERO EL TREBOL	Ap 2015	4,931	Water	0	0	0	0	0
SAMUC	may-15	6,033	Water	0	0	0	0	0
HIDRO CONCEPCIÓN	jul-15	1,110	Water	0	0	0	0	0
HIDRO SAN JOSÉ	jul-15	1,029	Water	0	0	0	0	0
GAVIOSA	jul-15	3,692	Water	0	0	0	0	0
HIDROELÉCTRICA PEÑAFLOR	oct-15	999	Water	0	0	0	0	0
SANTA ANITA	dic-15	1,879	Water	0	0	0	0	0
GDR MAXANAL	Feb.2016	4,304	Water	0	0	0	0	0
HIDROELECTRICA LA LIBERTAD CINCO M	Feb.2016	23,528	Water	0	0	0	0	0
LAS UVITAS	Ap 2016	5,476	Water	0	0	0	0	0
EL CONACASTE	May.2016	11,511	Water	0	0	0	0	0
EL BROTE	Aug 2016	2,343	Water	0	0	0	0	0
MOPA	Nov.2016	465	Water	0	0	0	0	0
LOS PATOS	Nov.2016	1,170	Water	0	0	0	0	0
Wind and photovoltaic		**394,500**						0
FOTOVOLTAICA HORUS	Feb/Jul 2015	179,431	Solar	0	0	0	0	0
EOLICA SAN ANTONIO EL SITIO	Ab 2015	148,261	Wind	0	0	0	0	0
EOLICA VIENTO BLANCO	Dec 2015	66,809	Wind	0	0	0	0	0
Cogenerators (biomass)		**2,148,452**						0
CONCEPCION	1994	63,713	Biomass	0.0	0	0%	0	0
PANTALEON	1991	272,915	Biomass	0.0	0	0%	0	0
SANTA ANA	1995	306,869	Biomass	0.0	0	0%	0	0
MAGDALENA	1994	755,347	Biomass	0.0	0	0%	0	0
LA UNION	1995	169,005	Biomass	0.0	0	0%	0	0
MADRE TIERRA	1996	97,294	Biomass	0.0	0	0%	0	0
TULULA	2001	50,517	Biomass	0.0	0	0%	0	0
TRINIDAD	2011-2012	246,624	Biomass	0.0	0	0%	0	0
EL PILAR	2012-2013	31,996	Biomass	0.0	0	0%	0	0
PALO GORDO	2014	153,713	Biomass	0.0	0	0%	0	0
GENERADORA DEL ATLÁNTICO	2013	458	Biomass/biogas	0.0	0	0%	0	0
Imports		568,985		0				0
	Σ	**7,373,361**					Σ	**0**

Power units *k* in 2017

Name of the power plant/unit (clasified by technology)	Starting year	$EG_{k,2017}$ Energy produced 2017	i Fuel Type	$EF_{CO2,k,i,y}$ Average emission factor of fuel type i	Conversion factor	η_k Default efficiency factors	$EF_{EL,k,y}$ Emission factor of unit k	CO_2 emissions 2017
		(MWh)		(t CO_2/TJ)	TJ/MWh	%	t CO_2/MWh	t CO2
	AMM	AMM	AMM	Inventory Workbook (IPCC, 2006)	Conversion factor from the International System of	Meth tool 09, appendix	Calculated	Calculated
Geothermal		**253,048**						**0**
ORZUNIL	1999	108,730	Geothermal steam	0	-	0	0	0
ORTITLAN	2007	144,317	Geothermal steam	0	-	0	0	0
Hydroelectrics		**######### #**						**0**
CHIXOY	1983	1,551,746	Hydro resource	0	0	0	0	0
AGUACAPA	1982	253,385	Hydro resource	0	0	0	0	0
JURÚN MARINALA	1970	246,820	Hydro resource	0	0	0	0	0
LOS ESCLAVOS	1966	41,336	Hydro resource	0	0	0	0	0
SANTA MARÍA	1927	36,867	Hydro resource	0	0	0	0	0
EL SALTO	1938	1,278	Hydro resource	0	0	0	0	0
PORVENIR	1968	-	Hydro resource	0	0	0	0	0
CHICHAIC	1979	3,052	Hydro resource	0	0	0	0	0
RÍO BOBOS	1995	52,153	Hydro resource	0	0	0	0	0
SECACAO	1998	102,140	Hydro resource	0	0	0	0	0
PASABIEN	2000	49,237	Hydro resource	0	0	0	0	0
POZA VERDE	2000	35,977	Hydro resource	0	0	0	0	0
LAS VACAS	2002	99,231	Hydro resource	0	0	0	0	0
MATANZAS + SAN ISIDRO	2002	70,362	Hydro resource	0	0	0	0	0
RENACE	2002	302,311	Hydro resource	0	0	0	0	0
RENACE 2	2016	546,954	Hydro resource	0	0	0	0	0
RENACE 3	2016	304,977	Hydro resource	0	0	0	0	0
PALIN II	2005	13,475	Hydro resource	0	0	0	0	0
CANADA	2003	180,900	Hydro resource	0	0	0	0	0
MONTECRISTO	2006	49,400	Hydro resource	0	0	0	0	0
CANDELARIA	2006	26,451	Hydro resource	0	0	0	0	0
RECREO	2007	121,000	Hydro resource	0	0	0	0	0
RECREO 2	2016	95,868	Hydro resource	0	0	0	0	0
HIDRO XACBAL	2010	403,559	Hydro resource	0	0	0	0	0
HIDRO XACBAL DELTA	jul-17	117,495	Hydro resource	0	0	0	0	0
PANAN	2011	33,229	Hydro resource	0	0	0	0	0
SANTA TERESA	2011	65,398	Hydro resource	0	0	0	0	0
CHOLOMA	2011	31,403	Hydro resource	0	0	0	0	0
PALO VIEJO	2012	307,338	Hydro resource	0	0	0	0	0
VISIÓN DE AGUILA	2013	8,045	Hydro resource	0	0	0	0	0
HIDROAGUNA	2014	10,545	Hydro resource	0	0	0	0	0
EL MANANTIAL 1 + EL MANANTIAL 2 +	2015	59,799	Hydro resource	0	0	0	0	0
EL COBANO	2015	29,893	Hydro resource	0	0	0	0	0
OXEC	nov-15	64,587	Hydro resource	0	0	0	0	0
LA LIBERTAD	2015	33,707	Hydro resource	0	0	0	0	0
LAS FUENTES II	2016	34,684	Hydro resource	0	0	0	0	0
EL CAFETAL	2018	40,605	Hydro resource	0	0	0	0	0
RAAXHA	2016	21,479	Hydro resource	0	0	0	0	0
FINCA LORENA	2016	25,109	Hydro resource	0	0	0	0	0
Distribuited generation		**293,536**						**0**
HIDROELÉCTRICA LA PERLA	2011	11,238	Hydro resource	0	0	0	0	0
HIDROELÉCTRICA HIDROPOWER SDM	2011	13,303	Hydro resource	0	0	0	0	0
HIDROELÉCTRICA EL LIBERTADOR	2013	2,789	Hydro resource	0	0	0	0	0
HIDROELÉCTRICA IXTALITO + XOLHUIT	2014	15,292	Hydro resource	0	0	0	0	0
HIDROELÉCTRICA GUAYACAN	mar-17	5,661	Hydro resource	0	0	0	0	0
HIDROELÉCTRICA CORALITO	2014	9,310	Hydro resource	0	0	0	0	0
HIDROELÉCTRICA CERRO VIVO	2013	7,531	Hydro resource	0	0	0	0	0
HIDROELÉCTRICA SANTA TERESA	2012	8,802	Hydro resource	0	0	0	0	0
HIDROELÉCTRICA EL SALTO MARINAL	jun-15	19,532	Hydro resource	0	0	0	0	0
HIDROELÉCTRICA LOS PATOS	jun-17	21,178	Hydro resource	0	0	0	0	0
SANTA ELENA	2016-2017	3,734	Hydro resource	0	0	0	0	0
KAPLAN CHAPINA		3,974	Hydro resource	0	0	0	0	0
CUEVA MARÍA	2016	10,568	Hydro resource	0	0	0	0	0
CUEVA MARIA 2	2008	12,861	Hydro resource	0	0	0	0	0
LOS CERROS	2009	4,788	Hydro resource	0	0	0	0	0
COVADONGA	2009	8,714	Hydro resource	0	0	0	0	0
EL PRADO	2009	2,225	Hydro resource	0	0	0	0	0
LAS MARGARITAS 1 + LAS MARGARITA	2010	4,554	Hydro resource	0	0	0	0	0
SAC-JA	2010	10,091	Hydro resource	0	0	0	0	0
SAN JOAQUIN	2010	5,002	Hydro resource	0	0	0	0	0
LUARCA	2010-2012	0	Hydro resource	0	0	0	0	0
LAS VICTORIAS	2011	2,243	Hydro resource	0	0	0	0	0
EL ZAMBO	2012	4,866	Hydro resource	0	0	0	0	0
MONTE MARÍA	2012	2,301	Hydro resource	0	0	0	0	0
LA PAZ	2013	5,850	Hydro resource	0	0	0	0	0
TUTO DOS	2013	5,411	Hydro resource	0	0	0	0	0
EL PANAL	2014	3,833	Hydro resource	0	0	0	0	0
PACAYAS	2014	16,186	Hydro resource	0	0	0	0	0
SAMUC	2014	5,101	Hydro resource	0	0	0	0	0
SAMUC 2	2015	4,966	Hydro resource	0	0	0	0	0
CONCEPCIÓN	may-15	1,160	Hydro resource	0	0	0	0	0
SAN JOSE	jul-15	1,075	Hydro resource	0	0	0	0	0
PEÑA FLOR	mar-17	1,301	Hydro resource	0	0	0	0	0
SANTA ANITA	Dec 2015	1,878	Hydro resource	0	0	0	0	0
MAXANAL	feb-16	6,310	Hydro resource	0	0	0	0	0
LAS UVITAS	2015	7,183	Hydro resource	0	0	0	0	0
CONACASTE	2015	17,482	Hydro resource	0	0	0	0	0
EL BROTE	2016	7,622	Hydro resource	0	0	0	0	0
MOPÁ	2016	4,222	Hydro resource	0	0	0	0	0
EL COROZO	2016	3,503	Hydro resource	0	0	0	0	0
MIRAFLORES	ene-17	3,375	Hydro resource	0	0	0	0	0
LA CEIBA 1	feb-17	2,049	Hydro resource	0	0	0	0	0
CARMEN AMALIA	feb-17	2,247	Hydro resource	0	0	0	0	0
NUEVA HIDROCON	mar-17	3	Hydro resource	0	0	0	0	0
EL TRIÁNGULO	may-17	2,117	Hydro resource	0	0	0	0	0
LA VIÑA	may-17	104	Hydro resource	0	0	0	0	0
CUTZÁN	jun-17	0	Hydro resource	0	0	0	0	0
Cogenerators (biomass)		**######### #**						0
CONCEPCION	1994	58,577	Biomass	0.0	0	0.0%	0	0
PANTALEON B1	1991	217,946	Biomass	0.0	0	0.0%	0	0
PANTALEON B3	2016	46,397	Biomass	0.0	0	0.0%	0	0
SANTA ANA	1995	77,799	Biomass	0.0	0	0.0%	0	0
SANTA ANA B2	2015	205,863	Biomass	0.0	0	0.0%	0	0
MAGDALENA	1994	658,505	Biomass	0.0	0	0.0%	0	0
LA UNION B1	1995	165,201	Biomass	0.0	0	0.0%	0	0
MADRE TIERRA	1996	83,713	Biomass	0.0	0	0.0%	0	0
GENERADORA SANTA LUCÍA	2014	28,546	Biomass	0.0	0	0.0%	0	0
TULULA B1	2001	10,609	Biomass	0.0	0	0.0%	0	0
TULULA B4	2013	33,589	Biomass	0.0	0	0.0%	0	0
TRINIDAD B3	2011-2012	19,935	Biomass	0.0	0	0.0%	0	0
TRINIDAD B4	2015	130,660	Biomass	0.0	0	0.0%	0	0
TRINIDAD B5	2016	142,171	Biomass	0.0	0	0.0%	0	0
EL PILAR B3	2012-2013	29,255	Biomass	0.0	0	0.0%	0	0
PALO GORDO B2	2014	144,914	Biomass	0.0	0	0.0%	0	0
GENERADORA DEL ATLÁNTICO (GDR)	2014	147	Biomass	0.0	0	0.0%	0	0
BIOMASA SANTA ANA (GDR)	dic-17	-	Biomass	0.0	0	0.0%	0	0
Wind Power Plants		**218,055**						0
SAN ANTONIO EL SITIO	2015	147,299	Wind	0.0	0	0.0%	0	0
VIENTO BLANCO	2015	70,756	Wind	0.0	0	0.0%	0	0
Solar Power Plants		**198,203**						0
HORUS I	2015	109,589	Solar radiation	0.0	0	0.0%	0	0
HORUS II	2015	68,668	Solar radiation	0.0	0	0.0%	0	0
FOTOVOLTAICA SIBO (GDR)	2014	12,253	Solar radiation	0.0	0	0.0%	0	0
GRANJA SOLAR AVELLANA (GDR)	mar-17	1,690	Solar radiation	0.0	0	0.0%	0	0
GRANJA SOLAR EL JOBO (GDR)	mar-17	1,260	Solar radiation	0.0	0	0.0%	0	0
GRANJA SOLAR PEDRO DE ALVARADO	mar-17	1,624	Solar radiation	0.0	0	0.0%	0	0
GRANJA SOLAR TAXISCO (GDR)	mar-17	2,153	Solar radiation	0.0	0	0.0%	0	0
GRANJA SOLAR BUENA VISTA (GDR)	ago-17	966	Solar radiation	0.0	0	0.0%	0	0
Biogas		**17,558**						0
BIOGÁS DEL VERTEDERO EL TRÉBOL	2015	6,260	Biogas	0.0	0	0.0%	0	0
BIOGÁS DEL VERTEDERO EL TRÉBOL	may-17	7,121	Biogas	0.0	0	0.0%	0	0
GABIOSA (GDR)	2015	4,177	Biogas	0.0	0	0.0%	0	0
Imports		773,037		0				0
	Σ	**9,279,055**					Σ	**0**

Power units *k* in 2018

Name of the power plant/unit (clasified by technology)	Starting year	$EG_{k,2018}$ Energy produced 2018 (MWh)	i Fuel Type	$EF_{CO2,k,i,y}$ Average emission factor of fuel type i ($t\ CO_2/TJ$)	Conversion factor TJ/MWh	η_k Default efficiency factors %	$EF_{EL,k,y}$ Emission factor of unit k ($t\ CO_2/MWh$)	CO_2 emissions 2018 t CO2
	AMM	AMM	AMM	Inventory Workbook (IPCC, 2006)	Conversion factor from the International System of	Meth tool 09, appendix	Calculated	Calculated
Geothermal		**249,754**						**0.0**
ORZUNIL	1999	110,097	Geothermal steam	0	-	0	0	0
ORTITLAN	2007	139,657	Geothermal steam	0	-	0	0	0
Hydroelectrics		**######### #**						**0**
CHIXOY	1983	1,296,611	Hydro resource	0	0	0	0	0
AGUACAPA	1982	262,503	Hydro resource	0	0	0	0	0
JURÚN MARINALA	1970	254,435	Hydro resource	0	0	0	0	0
LOS ESCLAVOS	1966	40,120	Hydro resource	0	0	0	0	0
SANTA MARÍA	1927	35,526	Hydro resource	0	0	0	0	0
EL SALTO	1938	-	Hydro resource	0	0	0	0	0
PORVENIR	1968	-	Hydro resource	0	0	0	0	0
CHICHAIC	1979	2,903	Hydro resource	0	0	0	0	0
RÍO BOBOS	1995	40,571	Hydro resource	0	0	0	0	0
SECACAO	1998	102,412	Hydro resource	0	0	0	0	0
PASABIEN	2000	11,704	Hydro resource	0	0	0	0	0
POZA VERDE	2000	39,879	Hydro resource	0	0	0	0	0
LAS VACAS	2002	81,628	Hydro resource	0	0	0	0	0
MATANZAS + SAN ISIDRO	2002	61,193	Hydro resource	0	0	0	0	0
RENACE	2002	225,492	Hydro resource	0	0	0	0	0
RENACE 2	Ap 2016	429,550	Hydro resource	0	0	0	0	0
RENACE 3	nov-16	249,894	Hydro resource	0	0	0	0	0
PALIN II	2005	13,439	Hydro resource	0	0	0	0	0
CANADA	2003	163,797	Hydro resource	0	0	0	0	0
MONTECRISTO	2006	44,468	Hydro resource	0	0	0	0	0
CANDELARIA	2006	26,530	Hydro resource	0	0	0	0	0
RECREO	2007	105,926	Hydro resource	0	0	0	0	0
RECREO 2	2016	87,312	Hydro resource	0	0	0	0	0
HIDRO XACBAL	2010	356,807	Hydro resource	0	0	0	0	0
HIDRO XACBAL DELTA	jul-17	213,782	Hydro resource	0	0	0	0	0
PANAN	2011	25,004	Hydro resource	0	0	0	0	0
SANTA TERESA	2011	58,556	Hydro resource	0	0	0	0	0
CHOLOMA	2011	28,579	Hydro resource	0	0	0	0	0
PALO VIEJO	2012	298,114	Hydro resource	0	0	0	0	0
VISIÓN DE AGUILA	2013	5,485	Hydro resource	0	0	0	0	0
HIDROAGUNA	2014	10,527	Hydro resource	0	0	0	0	0
EL MANANTIAL 1	2015	8,033	Hydro resource	0	0	0	0	0
EL MANANTIAL 2	2015	37,697	Hydro resource	0	0	0	0	0
EL MANANTIAL 3	oct-17	1,392	Hydro resource	0	0	0	0	0
EL COBANO	2015	30,287	Hydro resource	0	0	0	0	0
OXEC	nov-15	56,993	Hydro resource	0	0	0	0	0
OXEC 2	2018	75,703	Hydro resource	0	0	0	0	0
LA LIBERTAD	2016	24,988	Hydro resource	0	0	0	0	0
LAS FUENTES II	2016	28,048	Hydro resource	0	0	0	0	0
EL CAFETAL	2016	40,339	Hydro resource	0	0	0	0	0
RAAXHA	2016	21,677	Hydro resource	0	0	0	0	0
FINCA LORENA	2016	21,484	Hydro resource	0	0	0	0	0
Distribuited generation		**271,599**						**0**
HIDROELÉCTRICA LA PERLA	2011	11,139	Hydro resource	0	0	0	0	0
HIDROELÉCTRICA HIDROPOWER SDMM	2011	11,312	Hydro resource	0	0	0	0	0
HIDROELÉCTRICA EL LIBERTADOR	2013	4,583	Hydro resource	0	0	0	0	0
HIDROELÉCTRICA IXTALITO	2014	5,730	Hydro resource	0	0	0	0	0
HIDROELÉCTRICA XOLHUITZ	mar-17	6,400	Hydro resource	0	0	0	0	0
HIDROELÉCTRICA GUAYACAN	2014	5,943	Hydro resource	0	0	0	0	0
HIDROELÉCTRICA CORALITO	2013	9,012	Hydro resource	0	0	0	0	0
HIDROELÉCTRICA CERRO VIVO	2012	6,472	Hydro resource	0	0	0	0	0
HIDROELÉCTRICA SANTA TERESA	oct-11	8,472	Hydro resource	0	0	0	0	0
HIDROELÉCTRICA EL SALTO MARINALÁ	jun-17	23,107	Hydro resource	0	0	0	0	0
HIDROELÉCTRICA LOS PATOS	2016-2017	18,936	Hydro resource	0	0	0	0	0
HIDROELÉCTRICA MAXANAL	2016	5,304	Hydro resource	0	0	0	0	0
HIDROELÉCTRICA LAS UVITAS	2016	7,097	Hydro resource	0	0	0	0	0
SANTA ELENA	2008	3,892	Hydro resource	0	0	0	0	0
KAPLAN CHAPINA	2009	5,238	Hydro resource	0	0	0	0	0
CUEVA MARÍA	2009	8,663	Hydro resource	0	0	0	0	0
CUEVA MARIA 2	2009	11,606	Hydro resource	0	0	0	0	0
LOS CERROS	2010	2,404	Hydro resource	0	0	0	0	0
COVADONGA	2010	6,634	Hydro resource	0	0	0	0	0
EL PRADO	2010	2,171	Hydro resource	0	0	0	0	0
LAS MARGARITAS 1 + LAS MARGARITAS 2	2010-2012	3,385	Hydro resource	0	0	0	0	0
SAC-JA	2011	6,544	Hydro resource	0	0	0	0	0
SAN JOAQUIN	2012	5,398	Hydro resource	0	0	0	0	0
LUARCA	2012	788	Hydro resource	0	0	0	0	0
LAS VICTORIAS	2013	2,430	Hydro resource	0	0	0	0	0
EL ZAMBO	2013	3,598	Hydro resource	0	0	0	0	0
MONTE MARÍA	2014	2,075	Hydro resource	0	0	0	0	0
LA PAZ	2014	5,037	Hydro resource	0	0	0	0	0
TUTO DOS	2014	5,291	Hydro resource	0	0	0	0	0
EL PANAL	2015	979	Hydro resource	0	0	0	0	0
PACAYAS	2015	15,564	Hydro resource	0	0	0	0	0
SAMUC	2015	5,013	Hydro resource	0	0	0	0	0
SAMUC 2	mar-17	6,084	Hydro resource	0	0	0	0	0
CONCEPCIÓN	2015	1,072	Hydro resource	0	0	0	0	0
SAN JOSE	2015	1,729	Hydro resource	0	0	0	0	0
PEÑA FLOR	2015	992	Hydro resource	0	0	0	0	0
SANTA ANITA	Dec 2015	1,711	Hydro resource	0	0	0	0	0
CONACASTE	2016	15,455	Hydro resource	0	0	0	0	0
EL BROTE	2016	4,515	Hydro resource	0	0	0	0	0
MOPÁ	2016	3,385	Hydro resource	0	0	0	0	0
EL COROZO	ene-17	2,893	Hydro resource	0	0	0	0	0
MIRAFLORES	feb-17	2,671	Hydro resource	0	0	0	0	0
LA CEIBA 1	feb-17	2,093	Hydro resource	0	0	0	0	0
CARMEN AMALIA	mar-17	1,961	Hydro resource	0	0	0	0	0
NUEVA HIDROCON	may-17	2,235	Hydro resource	0	0	0	0	0
EL TRIÁNGULO	may-17	2,347	Hydro resource	0	0	0	0	0
LA VIÑA	jun-17	329	Hydro resource	0	0	0	0	0
CUTZÁN	jul-17	-	Hydro resource	0	0	0	0	0
CHOLIVA	2018	1,151	Hydro resource	0	0	0	0	0
HIDROXOCOBIL	2018	573	Hydro resource	0	0	0	0	0
GDR HIDROSAN	2018	182	Hydro resource	0	0	0	0	0
Cogenerators (biomass)		**######### #**		0	0	0	0	0
CONCEPCION	1994	50,819	Biomass	0	0	0	0	0
PANTALEON B1	1991	56,515	Biomass	0	0	0	0	0
PANTALEON B3	2016	200,738	Biomass	0	0	0	0	0
SANTA ANA	1995	74,943	Biomass	0	0	0	0	0
SANTA ANA B2	2015	219,298	Biomass	0	0	0	0	0
MAGDALENA	1994	641,970	Biomass	0.0	0	0.0%	0	0
LA UNION B1	1995	185,782	Biomass	0.0	0	0.0%	0	0
MADRE TIERRA	1996	102,238	Biomass	0.0	0	0.0%	0	0
GENERADORA SANTA LUCÍA	2014	29,173	Biomass	0.0	0	0.0%	0	0
TULULA B1	2001	10,819	Biomass	0.0	0	0.0%	0	0
TULULA B4	2013	32,553	Biomass	0.0	0	0.0%	0	0
TRINIDAD B3	2011-2012	22,671	Biomass	0.0	0	0.0%	0	0
TRINIDAD B4	2015	135,476	Biomass	0.0	0	0.0%	0	0
TRINIDAD B5	2016	192,307	Biomass	0.0	0	0.0%	0	0
EL PILAR B3	2012-2013	34,350	Biomass	0.0	0	0.0%	0	0
PALO GORDO B2	2014	167,639	Biomass	0.0	0	0.0%	0	0
GENERADORA DEL ATLÁNTICO (GDR)	2014	403	Biomass	0.0	0	0.0%	0	0
BIOMASA SANTA ANA (GDR)	dic-17	419	Biomass	0.0	0	0.0%	0	0
Wind Power Plants		**319,501**						0
SAN ANTONIO EL SITIO	2015	154,064	Wind	0.0	0	0.0%	0	0
VIENTO BLANCO	2015	81,154	Wind	0.0	0	0.0%	0	0
LAS CUMBRES	2018	84,282	Wind	0.0	0	0.0%	0	0
Solar Power Plants		**208,313**						0
HORUS I	2015	112,742	Solar radiation	0.0	0	0.0%	0	0
HORUS II	2015	69,940	Solar radiation	0.0	0	0.0%	0	0
FOTOVOLTAICA SIBO (GDR)	2014	13,588	Solar radiation	0.0	0	0.0%	0	0
GRANJA SOLAR AVELLANA (GDR)	mar-17	2,238	Solar radiation	0.0	0	0.0%	0	0
GRANJA SOLAR EL JOBO (GDR)	mar-17	1,695	Solar radiation	0.0	0	0.0%	0	0
GRANJA SOLAR PEDRO DE ALVARADO (GD	mar-17	2,134	Solar radiation	0.0	0	0.0%	0	0
GRANJA SOLAR TAXISCO (GDR)	mar-17	2,961	Solar radiation	0.0	0	0.0%	0	0
GRANJA SOLAR BUENA VISTA (GDR)	ago-17	3,016	Solar radiation	0.0	0	0.0%	0	0
Biogas		**26,327**						0
BIOGÁS DEL VERTEDERO EL TRÉBOL (GDR	2015	5,942	Biogas	0.0	0	0.0%	0	0
BIOGÁS DEL VERTEDERO EL TRÉBOL 2 (GD	may-17	17,952	Biogas	0.0	0	0.0%	0	0
GABIOSA (GDR)	2015	2,433	Biogas	0.0	0	0.0%	0	0
Imports		415,844		0	0	0	0	0
	Σ	8,568,837					Σ	0

d. Calculation of lambda

Lambda is equal to the number of hours per year for which low cost and must-run plants are on the margin divided by the total hours per year.

- Lambda is calculated graphically as the intersection of the load duration curve and the horizontal line, and the area below represents the annual generation of low cost and must-run plants.
- Low cost and must-run plants are hydroelectric, geothermal power plants and imports. Additionally, the obligated dispatched components of cogenerators power units and coal based power plants.
- Data of the load duration curve are provided by Wholesale Electricity Administrator.

As per version 7.0 of the Tool to calculate the emission factor for an electricity system, Lambda ($\lambda_{2016\text{-}2018}$) is calculated as follows:

Step (1) Load duration curve is plotted. Chronological load data (in MW) for each hour of the year *y* are plotted in descending order.

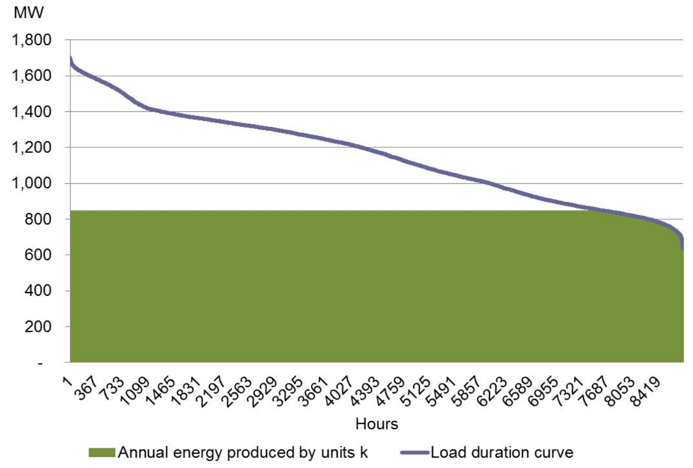
Step (2) The total annual generation (in MWh) from low-cost/must-run power units and imports is calculated.

Step (3) A horizontal line across the load duration curve is plotted such that the area under the curve (MW times hours) equals the total generation (in MWh) from low- cost/must-run power plants/units (i.e. $\sum_k EG_{k,y}$).

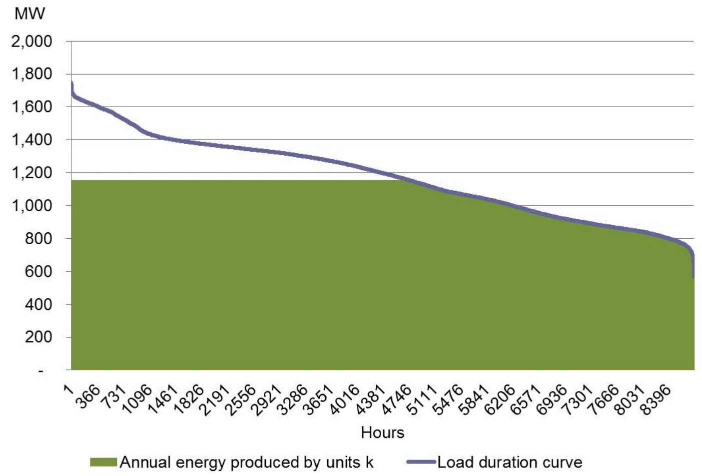
Step (4) The "Number of hours for which low-cost/must-run sources are on the margin in year *y*" are calculated, locating the intersection of the horizontal line plotted in Step (3) and the load duration curve plotted in Step (1). The number of hours (out of the total of 8760 hours) to the right of the intersection is the number of hours for which low-cost/must-run sources are on the margin.

Step (5) Lambda is calculated as follow:
λ is equal to the number of hours low-cost/must-run sources are on the margin divided by the hours per year.

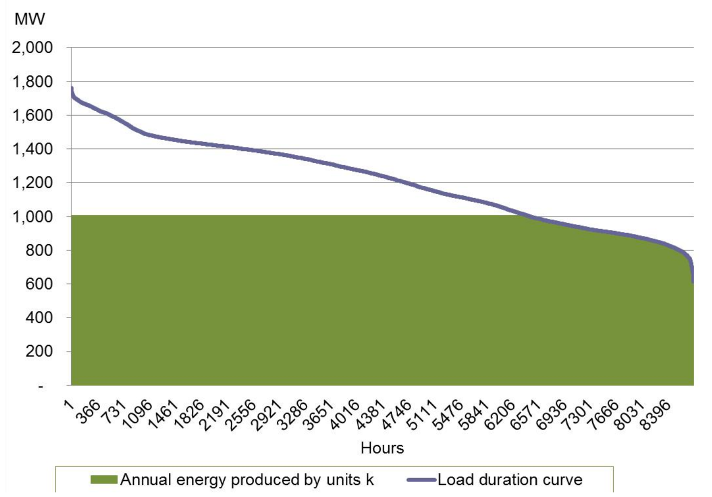
Graphics for Lambda calculation 2016



Graphics for Lambda calculation 2017



Graphics for lambda calculation 2018



e. Group of power plants for build margin

- Identification of the set of five power units, excluding CDM project activities, which started to supply electricity to the grid most recently.

Build Margin	Starting year	Energy produced 2018	Accumulative energy producction	Fuel Type	Average emission factor of fuel type i	Conversion factor	Default efficiency factors	Emission factor of unit m	CO2 emissions 2016
		$EG_{m,2018}$		i	$EF_{CO2,m,i,y}$		η_m	$EF_{EL,m,2018}$	
		(MWh)	(MWh)		(t CO_2/TJ)	TJ/MWh	%	t CO_2/MWh	t CO2
	AMM	AMM		AMM	Inventory Workbook (IPCC, 2006)	Conversion factor from the International System of Units	Meth tool 09, appendix	Calculated	Calculated
Option 1. Five most recent plants									
CHOLIVA	2,018	1,151	1,151	Hydro resource	-	-	-	-	-
GDR HIDROSAN	2,018	182	1,333	Hydro resource	-	-	-	-	-
OXEC 2	2,018	75,703	77,036	Hydro resource	-	-	-	-	-
LAS CUMBRES	2,018	84,282	161,318	Wind	-	-	-	-	-
BIOMASA SANTA ANA (GDR)	Dec-17	419	161,738	Biomass	-	-	-	-	-
TOTAL		**160,404.60**							**0.0**

- Calculation of the total annual generation of the project electricity system, excluding CDM project activities

AEG_{total}	11,577,455
20% AEG_{total}	2,315,491

- CDM project activities excluded:

Project activity	Annual generation 2018
LAS VACAS	81,628
EL CANADÁ	163,797
MATANZAS + SAN ISIDRO	61,193
MONTECRISTO	44,468
CANDELARIA	26,530
HIDROXACBAL	356,807
CHOLOMA	28,579
PALO VIEJO	298,114
EOLICA SAN ANTONIO EL SITIO	154,064
ORTITLÁN	139,657
VERTEDERO EL TREBOL	5,942
Total	1,360,780

- Identification of the set of the power units, excluding CDM project activities, that started to supply electricity to the grid most recently

Option 2. Additions represents 20% of the system generation										
CHOLIVA	2,018	1,151	1,151	Hydro resource	-	-	-	-	-
GDR HIDROSAN	2,018	182	1,333	Hydro resource	-	-	-	-	-
OXEC 2	2,018	75,703	77,036	Hydro resource	-	-	-	-	-
LAS CUMBRES	2,018	84,282	161,318	Wind	-	-	-	-	-
BIOMASA SANTA ANA (GDR)	Dec-17	419	161,738	Biomass	-	-	-	-	-
EL MANANTIAL 3	Oct-17	1,392	163,129	Hydro resource	-	-	-	-	-
HIDRO XACBAL DELTA	July-17	213,782	376,911	Hydro resource	-	-	-	-	-
HIDROELÉCTRICA XOLHUITZ	Mar-17	6,400	383,311	Hydro resource	-	-	-	-	-
HIDROELÉCTRICA EL SALTO MARINALÁ	Jun-17	23,107	406,419	Hydro resource	-	-	-	-	-
SAMUC 2	Mar-17	6,084	412,502	Hydro resource	-	-	-	-	-
EL COROZO	Jan-17	2,893	415,396	Hydro resource	-	-	-	-	-
MIRAFLORES	Feb-17	2,671	418,067	Hydro resource	-	-	-	-	-
LA CEIBA 1	Feb-17	2,093	420,160	Hydro resource	-	-	-	-	-
CARMEN AMALIA	Mar-17	1,961	422,120	Hydro resource	-	-	-	-	-
NUEVA HIDROCON	May-17	2,235	424,355	Hydro resource	-	-	-	-	-
EL TRIÁNGULO	May-17	2,347	426,702	Hydro resource	-	-	-	-	-
LA VIÑA	Jun-17	329	427,031	Hydro resource	-	-	-	-	-
CUTZÁN	Jul-17	-	427,031	Hydro resource	-	-	-	-	-
GRANJA SOLAR AVELLANA (GDR)	Mar-17	2,238	429,270	Solar	-	-	-	-	-
GRANJA SOLAR EL JOBO (GDR)	Mar-17	1,695	430,965	Solar	-	-	-	-	-
GRANJA SOLAR PEDRO DE ALVARADO (GDI	Mar-17	2,134	433,099	Solar	-	-	-	-	-
GRANJA SOLAR TAXISCO (GDR)	Mar-17	2,961	436,059	Solar	-	-	-	-	-
GRANJA SOLAR BUENA VISTA (GDR)	Aug-17	3,016	439,075	Solar	-	-	-	-	-
RENACE 3	Nov-16	249,894	688,970	Hydro resource	-	-	-	-	-
MOPA	Nov.2016	3,385	692,355	Hydro resource	-	-	-	-	-
LOS PATOS	Nov.2016	18,936	711,291	Hydro resource	-	-	-	-	-
RECREO 2	Oct.2016	87,312	798,602	Hydro resource	-	-	-	-	-
TRINIDAD B5	Jul-05	57,999	856,602	Bituminous coal	89.5	3.6	0.8	0.39	22,380
EL BROTE	Aug 2016	4,515	861,117	Hydro resource	-	-	-	-	-
PANTALEON B3	Jul-05	62,205	923,322	Bituminous coal	89.5	3.6	0.8	0.39	24,003
SAN ISIDRO	2,016	157,784	1,081,106	Bituminous coal	89.5	3.6	39%	0.83	130,354
RENACE 2	Ap 2016	429,550	1,510,656	Hydro resource	-	-	-	-	-
LAS FUENTES II	May.2016	28,048	1,538,704	Hydro resource	-	-	-	-	-
EL CAFETAL	May.2016	40,339	1,579,043	Hydro resource	-	-	-	-	-
RAAXHA	May.2016	21,677	1,600,720	Hydro resource	-	-	-	-	-
FINCA LORENA	Aug.2016	21,484	1,622,204	Hydro resource	-	-	-	-	-
GDR MAXANAL	Feb.2016	5,304	1,627,508	Hydro resource	-	-	-	-	-
HIDROELECTRICA LA LIBERTAD CINCO M	Feb.2016	24,988	1,652,496	Hydro resource	-	-	-	-	-
LAS UVITAS	Ap 2016	7,097	1,659,593	Hydro resource	-	-	-	-	-
EL CONACASTE	May.2016	15,455	1,675,048	Hydro resource	-	-	-	-	-
EOLICA VIENTO BLANCO	Dec 2015	81,154	1,756,202	Wind	-	-	-	-	-
SANTA ANITA	Dec 2015	1,711	1,757,913	Hydro resource	-	-	-	-	-
OXEC	Nov-15	56,993	1,814,906	Hydro resource	-	-	-	-	-
JAGUAR ENERGY 2	2,015	976,796	2,791,702	Bituminous coal	89.5	3.6	39%	1	806,984
TOTAL		**2,791,702**							**983,721**

f. Calculation of the combined margin of the grid for the ex-ante estimation of the emission reductions

A	**Estimated operating margin emission rate**	tCO_2/MWh	0.536
B	**Estimated build margin emission rate**	tCO_2/MWh	0.352
C = A x 025 + B x 0.75	**Estimated baseline emission rate**	tCO_2/MWh	**0.398**

Appendix 5. Further background information on monitoring plan

See section B.7.

Appendix 6. Summary report of comments received from local stakeholders

See Section E.

Appendix 7. Summary of post-registration changes

The starting date of the first crediting period indicated was changed and approved by the Executive Board from 01/03/2013 to 01/01/2013.

- - - - -

Document information

Version	Date	Description
11.0	31 May 2019	Revision to: • Ensure consistency with version 02.0 of the “CDM project standard for project activities” (CDM-EB93-A04-STAN); • Make editorial improvements.
10.1	28 June 2017	Revision to make editorial improvement.
10.0	7 June 2017	Revision to: • Improve consistency with the “CDM project standard for project activities” and with the PoA-DD and CPA-DD forms; • Make editorial improvement.
09.0	24 May 2017	Revision to: • Ensure consistency with the “CDM project standard for project activities” (CDM-EB93-A04-STAN) (version 01.0); • Incorporate the “Project design document form for small-scale CDM project activities” (CDM-SSC-PDD-FORM); • Make editorial improvement.
08.0	22 July 2016	EB 90, Annex 1 Revision to include provisions related to automatically additional project activities.
07.0	15 April 2016	Revision to ensure consistency with the “Standard: Applicability of sectoral scopes” (CDM-EB88-A04-STAN) (version 01.0).
06.0	9 March 2015	Revision to: • Include provisions related to statement on erroneous inclusion of a CPA; • Include provisions related to delayed submission of a monitoring plan; • Provisions related to local stakeholder consultation; • Provisions related to the Host Party; • Make editorial improvement.
05.0	25 June 2014	Revision to: • Include the Attachment: Instructions for filling out the project design document form for CDM project activities (these instructions supersede the "Guidelines for completing the project design document form" (Version 01.0)); • Include provisions related to standardized baselines; • Add contact information on a responsible person(s)/ entity(ies) for the application of the methodology (ies) to the project activity in B.7.4 and Appendix 1; • Change the reference number from F-CDM-PDD to CDM-PDD-FORM; • Make editorial improvement.

Version	Date	Description
04.1	11 April 2012	Editorial revision to change version 02 line in history box from Annex 06 to Annex 06b.
04.0	13 March 2012	Revision required to ensure consistency with the "Guidelines for completing the project design document form for CDM project activities" (EB 66, Annex 8).
03.0	26 July 2006	EB 25, Annex 15
02.0	14 June 2004	EB 14, Annex 06b
01.0	03 August 2002	EB 05, Paragraph 12 Initial adoption.

Decision Class: Regulatory
Document Type: Form
Business Function: Registration
Keywords: project activities, project design document