PROJECT DESIGN DOCUMENT FORM
FOR CDM PROJECT ACTIVITIES (F-CDM-PDD)
Version 04.1

PROJECT DESIGN DOCUMENT (PDD)

Title of the project activity	***LaGeo, S.A. de C.V., Berlin Geothermal Project, Phase Two*** (for simplicity hereafter referred to simply as the "Project Activity")
Version number of the PDD	21
Completion date of the PDD	28/01/2014
Project participant(s)	LaGeo, S. A. de C. V.
Host Party(ies)	El Salvador
Sectoral scope and selected methodology(ies)	Sectoral Scope: 1. Energy industries (renewable - / non renewable sources). Category: Renewable electricity generation for a grid (energy generation, supply, transmission and distribution). Methodology: ACM0002, version 14.0.0 Consolidated methodology for grid-connected electricity generation from renewable sources
Estimated amount of annual average GHG emission reductions	150,171 tCO_2 e

SECTION A. Description of project activity

A.1. Purpose and general description of project activity

The primary objective of the Project Activity is to supply El Salvador's rising demand for energy due to economic growth and to improve the supply of electricity, while contributing to the environmental, social and economic sustainability by increasing renewable energy's share of total the Salvadoran electricity consumption. One fundamental goal of the project is the efficient use of resources, particularly indigenous resources, while minimizing impact on the environment.

The Project Activity will increase the power generation capacity at the existing Berlin Geothermal Power Plant through the drilling of additional geothermal wells and the installation of a new 44 MW condensation power unit that started commercial operations in February 2, 2007. The resource of the Berlin Geothermal Field is characterized by a depth between 1,000 and 1,500 m asl (above sea level) in the range of 280-300°C, 115 bar pressure, and good rock permeability. Hence, reservoir dimensions and characteristics are enough to sustain a 44 MW power plant for the entire life of the Project Activity, with an expected field depletion of about 1% per year.

Commercial exploration of the Berlin Geothermal field started in 1992 with 10 MW installed power and a generation technology based on backpressure turbines; then these turbines were substituted by two condensing units of 31.4899 MW[1] each one, which started operation in late 1999. This means that in the situation existing prior to the implementation of the Project Activity, the existing facility consists of a geothermal plant with a total installed capacity of 62.985 MW that would continue to supply electricity to the grid at historical levels, therefore the baseline scenario is the continuation of operation of the existing power plant.

<u>Contribution to Sustainable Development</u>

The use of an indigenous and cleaner source of electricity will also contribute to environmental sustainability by avoiding electricity generation from imported fossil fuel sources – and reducing the emissions of greenhouse gases (GHG) – which would be generated in the absence of the project. The estimate of total annual average GHG emission reductions for the second crediting period is 150,171 tCO_2e.

A better income distribution in the region where the Project Activity is carried out will come from less expenditure and more income in local municipalities. The additional regional income may be used for providing the population with better services, which would improve the coverage of basic needs. The project is in line with the national sustainable energy strategies and climate change mitigation principles (from MARN, 1999, "*sustainable exploration of geothermal and hydro resources*"). This is the one of the reasons why the project has received all needed government support and endorsement regarding the participation in the CDM since the phase of feasibility study.

Economical and/or strategic benefits include the decrease in dependence on fossil fuels, an exogenous and environmentally unsustainable source of energy. The Project Activity includes a biodiversity inventory research project to be done by the National University of El Salvador and a conservation and reforestation program in areas surrounding the plant.

The Berlin Geothermal Power Plant has a community engagement program aimed to create a balanced and constructive environment with neighbouring municipalities of Berlin. The fundamental elements of the program, used to maximize benefits to the community, are the generation of local employment opportunities, social investment activities, development of sustainable small businesses, and protection of the local environment. An indirect benefit is the construction and maintenance of road infrastructure that ensures communication and commercial activities in the surroundings of the project site.

[1] Calculated as per data of generator nameplate: capacity of 37.047 MVA and nominal power factor of 85%.

A.2. Location of project activity

A.2.1. Host Party(ies)

El Salvador.

A.2.2. Region/State/Province etc.

Departamento de Usulatán.

A.2.3. City/Town/Community etc.

Berlín and Alegría.

A.2.4. Physical/Geographical location

Berlín Geothermal Field is located 100 km to the east of San Salvador, in Central America (Figure 1). It lays on the North Slope of the Berlín-Tecapa volcanic system. The size of the field is roughly 4 km (W-E) and 6 km (N-S).

The geographical coordinates of the city of the facilities of the Project Activity are: latitude 13.524801, longitude -88.509223**.**

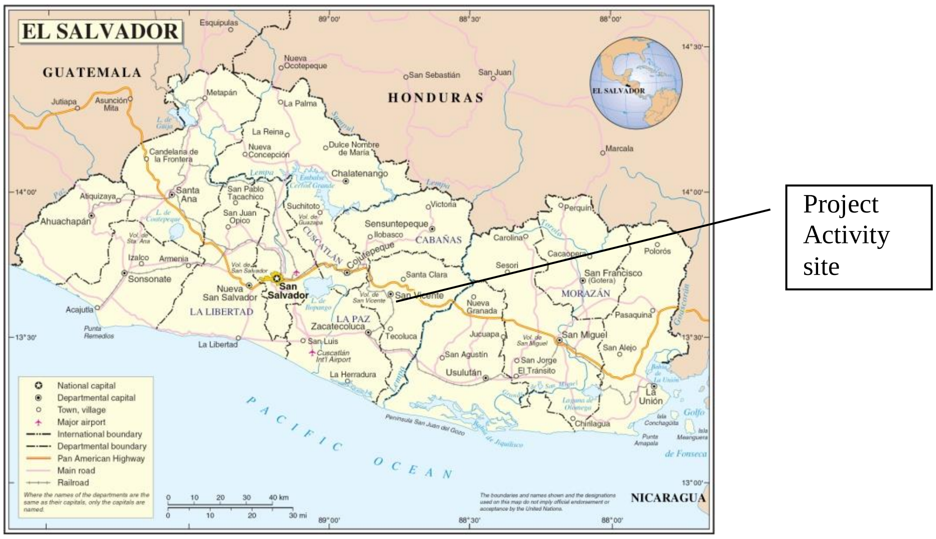

Figure 1. Location of the Project Activity site

A.3. Technologies and/or measures

The Project Activity is an extension of the Berlin Geothermal Power Plant through the drilling of additional geothermal wells. The Project exploits the resource of the Berlin Geothermal Field characterized by a depth between 1,000 and 1,500 m asl, temperature in the range of 280 to 300 °C, 115 bar pressure, and good rock permeability. Reservoir dimensions and characteristics are enough to sustain a 44 MW power plant for the entire life of the project, with an expected field depletion of about 1% per year.

Situation prior the implementation of the Project Activity:

The Berlin power plant has 2 condensing units (flash power plants) of 31.4925 MW each one and has capability for the installation of additional units. The existing power plant is fed by 8 wells producing a two-phase fluid (steam + liquid) at around 100 kg of steam per second, 10 bara[2] pressure and 180 ^{o}C temperature. Extracted fluid is a 3-1 ratio water-steam mixture. After being fed into the turbine to generate electricity the steam is partly evaporated (80%), and partly re-injected (20%), along with the separated fluid.

In the absence of the CDM Project Activity, the existing facility would continue to supply electricity to the grid at historical levels, until the time at which the generation facility would likely be replaced or retrofitted ($DATE_{BaselineRetrofit}$). From that point of time onwards, the baseline scenario is assumed to correspond to the Project Activity, and no emission reductions are assumed to occur.

Project Activity scenario:

For this Project Activity, the project participant opted for a "flash" or condensing power plant due to the reservoir characteristics (figure 2). The high temperature geothermal reservoir of Berlin Field produces a mixture of steam and water that is extracted through the production wells. The steam and water is separated in a cyclonic separator, then it is piped to the power station where drives the turbine to produce electric power. The steam is condensed after leaving the turbine, creating a partial vacuum and thereby maximizing the power generated by the turbine-generator. The steam is usually condensed either in a direct contact condenser. In a direct contact condenser the cooling water from the cooling tower is sprayed onto and mixed with the steam. The condensed steam then forms part of the cooling water circuit, and a substantial portion is subsequently evaporated and dispersed into the atmosphere through the cooling tower. Excess cooling water called blow down is disposed of in shallow injection wells.

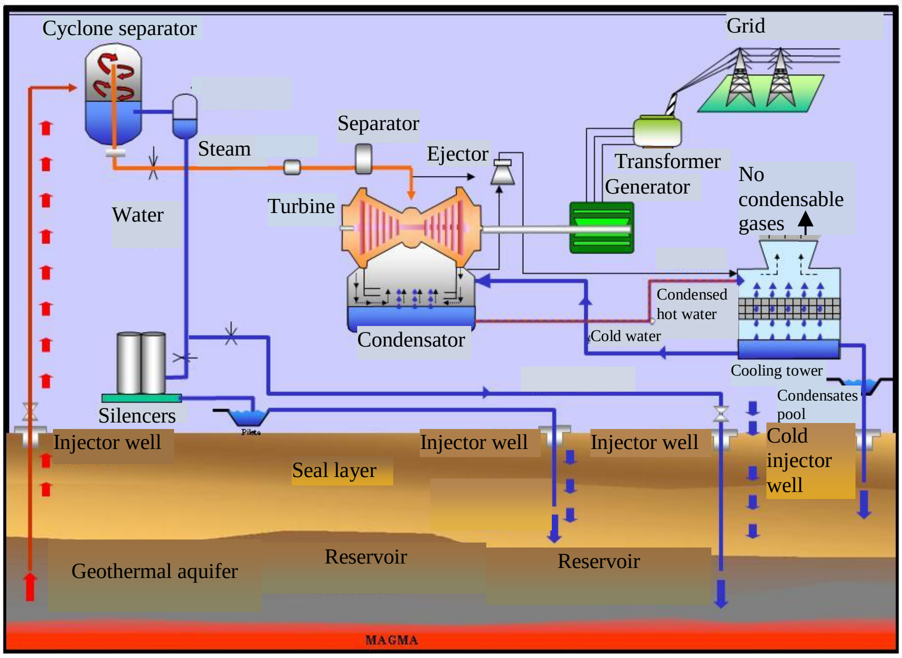

Figure 2. Schematic concept of the Project Activity

[2] In everyday use pressure is often measured with reference to atmospheric pressure: this is *gauge* pressure and denoted by barg, spoken "bar gauge" and sometimes using symbols such as 'barg' or 'bar(g)'. For example if someone says that their car tires are pressured up to 2.3 bar they actually mean bars gauge: the pressure in the tyre is really 3.3 bar, but only 2.3 bar above atmospheric. When absolute pressure is desired, then it is sometimes denoted 'bara' or 'bar(a)' for "bar absolute" (Source: Wikipedia, http://en.wikipedia.org/).

The Project Activity includes the installation of a third condensing unit with maximum gross output to the generator of 44 MW, and maximum net output to the grid of 42 MW (net accounting the ancillaries consumption).

The third condensation unit was purchased by means of a turnkey EPC contract[3] that includes basic and detailed engineering, procurement, supply, onsite delivery, construction, installation, testing, commissioning, and start-up of the turbine generator, as well as all ancillary equipment, mechanical and electrical, and common facilities.

The new generating unit demanded the drilling of up to six additional production wells and four re-injection wells. The wells were being drilled to depths ranging from 1,085 to 3,455 m and up to 12.25 inches in diameter[4].

The geothermal fluid transportation system includes a two phase flow pipeline connecting production wells to steam separators, the steam pipelines from separators to the plant area and the geothermal water pipelines from plant area (cooling tower) to the re-injection wells.

The electricity produced by the synchronous generator is transformed from 13.8 kV to 115 kV at Berlin electric substation before to be sent to the grid. The voltage and current transformers of the electricity metering system are located at the 115 kV bus of the step-up substation that is the delivery point. The instrument transformers send the voltage and current signals to the main and secondary electricity meters located in the control room of the power plant.

Due to the fact that not all the mass extracted from the reservoir is re-injected in the underground, the reservoir pressure and temperature will slightly decrease along with the exploitation of the geo-resource. The expected plant lifetime of the project activity is estimated on 30 years based on geothermal industry references[5]. Lifetime and recoverable reserves of a conventional geothermal field are governed by three resource factors: rock temperature, presence of a strong geothermal aquifer, and sufficient permeability to allow viable natural steam production. The energy stored in the hot rock bed is extracted by the geothermal aquifer, which acts as the natural heat exchange medium.

Geothermal power technologies employed by the Project Activity have been established in relatively few countries. Most geothermal development (more than 90% of worldwide installed capacity) is in the US, the Philippines, Mexico, Italy, Japan, Indonesia and New Zealand (IEA, 2003). More recent, Asia and Central and South America have shown particularly strong growth in relative terms since technologies used for the projects are becoming more financially secure and safer. Technology also gets environmentally safer as long as countries spend resources in technical issues such as: exploration techniques, resource assessment, field development, reservoir development techniques, and power generation technology (IEA, 2003). El Salvador and its private sector, such as the project participant, has been researching and developing geothermal technologies for many years through local studies and/or transferring knowledge from other countries. Geothermal wells, whether exploration or production, are

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[3] Turnkey: a form of delivery of a total process design, supply, construction, commissioning and start-up of a project to specific performance requirements. EPC contract: a contract for the engineering, procurement and construction of a facility - the implementation contractor provides all engineering, supply and construction works.

[4] The number of constructed wells varies with regard to the number of the estimated wells during the design stage. The original project required 10 wells to produce 44 MW according to the average production of the power plant-phase I. Finally, 6 production wells were constructed to achieve the goals of the project because the TR-18A well resulted higher productive than the initial estimation. On the other hand, the number of reinjection wells varied from 3 to 4, and the depth of the wells in relation to design, happened to be more considerable due to the fact that the impermeable substrates were found a long way below and therefore increased the complexity of the construction.

[5] Geothermal Energy Association, Geothermal Basics, section 8.6, http://geo-energy.org/geo_basics_plant_cost.aspx#gas_coal.

drilled using rotary drilling technologies adopted largely from the oil industry, and to a lesser extent from water and mineral exploration (World Bank, 2005). These have been modified to cater for the significantly higher temperatures and rock formation characteristics encountered. The drilling fluid used is water-based in order to avoid groundwater contamination. Wells are drilled in a series of stages, with each stage being of smaller diameter than the previous stage, and each being secured by steel casings, which are cemented in place prior to drilling the subsequent stage. The final production sections of the well are secured by a cemented, perforated liner. The design of a typical geothermal well, may be vertical (straight) or deviated (directional).

A.4. Parties and project participants

Detailed contact information on party (ies) and private/public entities involved in the Project Activity is listed in Annex 1.

Party involved (host) indicates a host Party	Private and/or public entity(ies) project participants (as applicable)	Indicate if the Party involved wishes to be considered as project participant (Yes/No)
El Salvador	LaGeo, S. A de C.V.	No

A.5. Public funding of project activity

No public funding was and will be used in the Project Activity.

SECTION B. Application of selected approved baseline and monitoring methodology

B.1. Reference of methodology

The Project Activity uses the approved methodology: Consolidated baseline methodology for grid-connected electricity generation from renewable sources (ACM0002, version 14.0.0).

As well as the following methodological tools referred by the ACM0002 (version 14.0.0):

- Tool to calculate the emission factor for an electricity system (version 04.0).

And the following standard, guidance and guidelines drew upon by the version of the tools used:

- Clean Development Mechanism Project Standard, version 05.0
- Guidance on IPCC default values, EB 25, paragraph 59.
- Guidelines for the reporting and validation of plant load factors (version 01).
- Guidance related to monitoring requirements, EB 23, paragraph 24.

B.2. Applicability of methodology

The chosen methodology is applicable to grid-connected renewable power generation projects, under the condition of electricity capacity additions from geothermal sources, as is the case of the Project Activity.

Table 1. Analysis of ACM0002 (version 14.0.0) applicability

Applicability conditions according to ACM0002 (version 14.0.0) and referred tools	**Are the criteria met?**	**Justification**
The Project Activity is the installation, capacity addition, retrofit or replacement of a power plant/unit of one of the following types: hydro power plant/unit (either with a run-of-river reservoir or an accumulation reservoir), wind power plant/unit, geothermal power plant/unit, solar power plant/unit, wave power plant/unit or tidal power plant/unit;	Yes	The Project Activity is the capacity addition of a new power unit (the new power unit includes geothermal wells, steam conveyance system, generation units, electrical substation and the electricity metering system) beside to an existent power plant.
In the case of capacity additions, retrofits or replacements (except for capacity addition projects for which the electricity generation of the existing power plant(s) or unit(s) is not affected): the existing plant started commercial operation prior to the start of a minimum historical reference period of five years, used for the calculation of baseline emissions and defined in the baseline emission section, and no capacity addition or retrofit of the plant has been undertaken between the start of this minimum historical reference period and the implementation of the Project Activity;	Yes	The existent power plant started operations in 1992, which was retrofitted in 1999. These events occurred prior to the start of a minimum historical reference of five years and not capacity additions have been undertaken between the start of this minimum historical reference period and the implementation of the Project Activity.

In case of hydro power plants, one of the following conditions must apply: o The Project Activity is implemented in an existing single or multiple reservoirs, with no change in the volume of any of reservoirs; or o The Project Activity is implemented in an existing single or multiple reservoirs, where the volume of any of reservoirs is increased and the power density of each reservoir, as per the definitions given in the Project Emissions section, is greater than 4 W/m^2; or o The Project Activity results in new single or multiple reservoirs and the power density of each reservoir, as per the definitions given in the Project Emissions section, is greater than 4 W/m^2.	Not applicable	The Project Activity does not comprise a hydro power plant.
The methodology is not applicable to the following: o Project activities that involve switching from fossil fuels to renewable energy sources at the site of the Project Activity, since in this case the baseline may be the continued use of fossil fuels at the site; o Biomass fired power plants; o Hydro power plants that result in new reservoirs or in the increase in existing reservoirs where the power density of the power plant is less than 4 W/m^2.	Not applicable	o The Project Activity does not involve switching from fossil fuels to renewable energy sources at the site of the Project Activity. o The Project Activity is not a biomass fired power plants. o The Project Activity does not result in a new reservoir or in the increase in existing reservoirs.
In the case of retrofits, replacements, or capacity additions, this methodology is only applicable if the most plausible baseline scenario, as a result of the identification of baseline scenario, is “the continuation of the current situation, that is to use the power generation equipment that was already in use prior to the implementation of the project activity and undertaking business as usual maintenance”.	Yes	The baseline scenario of the project Activity is the continuation of use of the current equipment (units 1 and 2 of the Berlin Geothermal Plant) without any investment and undertaking business as usual maintenance.
In addition, the applicability conditions included in the tools referred in the ACM0002 (version 14.0.0) apply.	Yes	• Tool to calculate the emission factor

• Tool to calculate the emission factor for an electricity system (version 04.0) ○ This tool may be applied to estimate the OM, BM and/or CM when calculating baseline emissions for a Project Activity that substitutes grid electricity, i.e. where a Project Activity supplies electricity to a grid or a Project Activity that results in savings of electricity that would have been provided by the grid (e.g. demand-side energy efficiency projects). ○ Under this tool, the emission factor for the project electricity system can be calculated either for grid power plants only or, as an option, can include off-grid power plants. In the latter case, the conditions specified in "Appendix 2: Procedures related to off-grid power generation" should be met. Namely, the total capacity of off-grid power plants (in MW) should be at least 10 per cent of the total capacity of grid power plants in the electricity system; or the total electricity generation by off-grid power plants (in MWh) should be at least 10 per cent of the total electricity generation by grid power plants in the electricity system; and that factors which negatively affect the reliability and stability of the grid are primarily due to constraints in generation and not to other aspects such as transmission capacity. ○ In Case of CDM projects the tool is not applicable if the project electricity system is located partially or totally in an Annex-I country.		for an electricity system (version 04.0) ○ The Project Activity supplies electricity to a grid substituting grid electricity. ○ The emission factor for the project electricity system is calculated for grid power plants. ○ The project electricity system is not located in an Annex-I country.
The applicability conditions included in the Tool to calculate project or leakage CO_2 emissions from fossil fuel combustion (version 02), referred in the ACM0002 (version 14.0.0), does not apply. ○ It can be used in cases where CO_2 emissions from fossil fuel combustion are calculated based on the quantity of fuel combusted and its properties.	Not applicable	The Project Activity does not use fuels for electricity production.

B.3. Project boundary

The project boundaries are defined by the emissions targeted or directly affected by the project activities, construction and operation. It encompasses the physical, geographical site of the geothermal wells (extraction and re-injection) and power generation. The produced electricity will be fed into the grid and therefore the boundary includes the Salvadorian national grid.

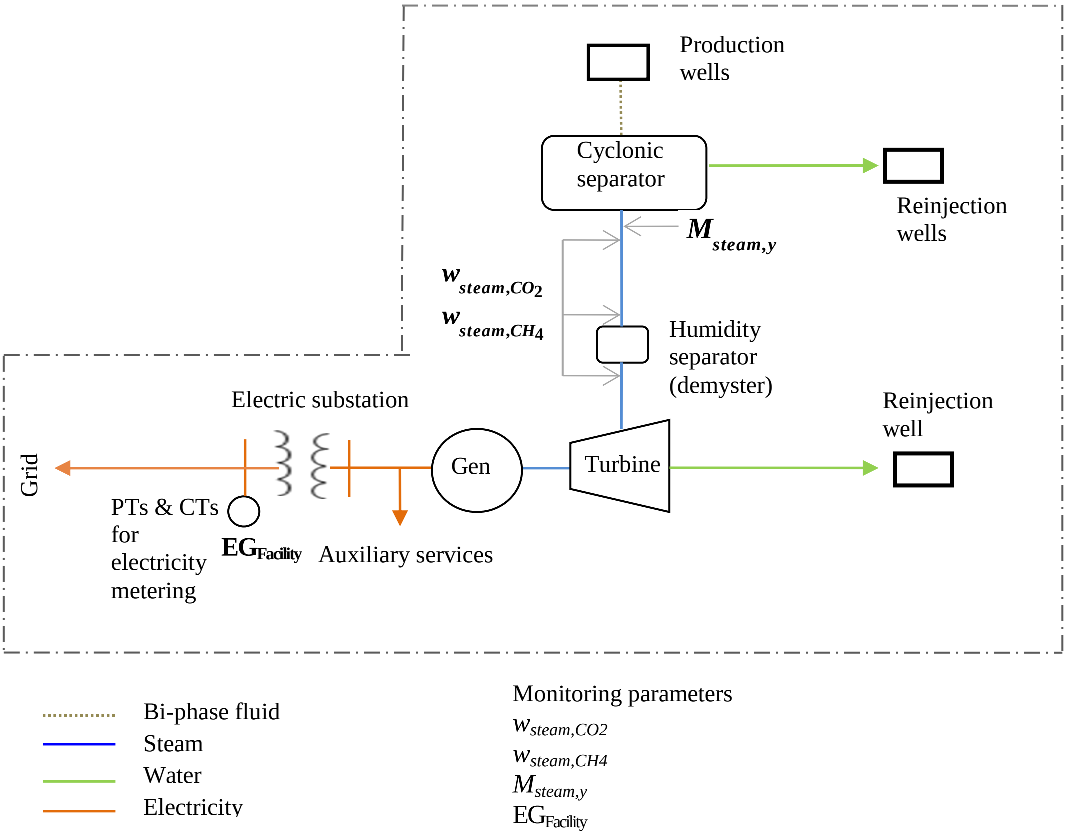

Figure 3. Boundaries of the Project Activity

Geothermal is a renewable clean energy source that directly generates no emissions. Nevertheless, there are fugitive emissions of carbon dioxide and methane due to release of non-condensable gases from produced steam. The Project Activity does not generate greenhouse gases from combustion of fossil fuels for electricity production.

Indirect on-site emissions are those from changes in the production of energy in other facilities. The presence of the geothermal plant will change the operating pattern of plants dispatching to the local grid. However, this is beyond the control of the project developer. Indirect off-site emissions, like shifts in demand of electricity or import/export will not be taken into account in the quantification of emissions, as these are very difficult to measure and are not within the control of the project developer.

Source		GHGs	Included?	Justification/Explanation
Baseline scenario	Source 1 CO_2 emissions from electricity generation in fossil fuel fired power plants that are displaced due to the Project Activity	CO_2	Yes	According to ACM0002 is a main emissions source. GHG in the baseline are due to fossil fuel fired plants connected to the grid.
		CH_4	No	According to ACM0002 is a minor emissions source.
		N_2O	No	According to ACM0002 is a minor emissions source.
Project scenario	Source 1 Fugitive emissions of CH_4 and CO_2 from non-condensable gases contained in the geothermal steam.	CO_2	Yes	According to ACM0002 is a main emissions source.
		CH_4	Yes	According to ACM0002 is a main emissions source
		N_2O	No	According to ACM0002 is a minor emissions source.
	Source 2 CO_2 emissions from combustion of fossil fuels for electricity generation in solar thermal power plants and geothermal power plants	CO_2	No	It is not included because the Project Activity does not use fossil fuel for electricity generation.
		CH_4	No	It is not included because the Project Activity does not use fossil fuel for electricity generation.
		N_2O	No	It is not included because the Project Activity does not use fossil fuel for electricity generation.

B.4. Establishment and description of baseline scenario

The baseline at the time of PDD registration was stated as:

"The Project Activity, a greenhouse gas (GHG) free power generation project, will result in GHG emissions reductions as the result of the displacement of electricity generation from fossil-fuel thermal plants that would have otherwise dispatched to the grid.

The baseline emission factor for the Project Activity is calculated as a combined margin of the operating and build margin emission factors. For the purpose of determining the build and the operating margin emission factors, the project electricity system is defined by the spatial extent of the power plants that can be dispatched without significant transmission constraints. Similarly, the connected electricity system is defined as an electricity system that is connected by transmission lines to the project electricity system and in which power plants can be dispatched without significant transmission constraints (Salvadoran interconnected grid)".

The version 0.3.0.0 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 continued validity of the baseline and to update the baseline at the renewal of a crediting period.

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

Step 1.1: Assessment 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 2010-2024 term[6] seeks to promote the energy renewable sources in order to diversify the energy matrix in El Salvador
- The Fiscal incentives Law is intended to promote the use of renewable resources for the electricity generation. It entered into force in December 28, 2007 for new investment projects, which occurred after the starting date of the first crediting period of the Project Activity.

Because geothermal projects are not mandatory and the investment in fuel based technologies is not limited, in the absence of the CDM project activity, the existing facility would continue to supply electricity to the grid at historical levels, until the time at which the generation facility would likely be replaced or retrofitted (*DATEBaselineRetrofit*). From that point of time onwards, the baseline scenario is assumed to correspond to the project activity, and no emission reductions are assumed to occur. This is a likely scenario in compliance with the relevant mandatory national and/or sectoral policies.

Step 1.2: Assessment of the impact of circumstances

Because the Project Activity consists of the capacity addition of an existing grid-connected renewable power plant, the baseline scenario has to be reassessed based on the ACM0002 methodology, version 14.0.0 as follow:

"In the absence of the CDM Project Activity, the existing facility would continue to supply electricity to the grid at historical levels, until the time at which the generation facility would likely be replaced or retrofitted ($DATE_{BaselineRetrofit}$). From that point of time onwards, the baseline scenario is assumed to correspond to the Project Activity, and no emission reductions are assumed to occur".

Step 1.3: Assessment of 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.

The updated baseline scenario of the Project Activity is the continuation of use of the current equipment (units 1 and 2 of Berlín Geothermal Plant) without any investment. Units 1 and 2 of Berlín Geothermal Plant, that started commercial operations in 1999, have and typical lifetime of approximately 30 year as is recognized in the geothermal industry[7]. Hence the technical life of the existent equipment exceeds the crediting period for which renewal is requested.

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

The emission factor of the grid is updated because has to be recalculated using the most recent information of the national grid and the most recent IPCCC default values.

In addition, the parameters based in historical data for baseline emissions calculation are calculated due to the baseline scenario is reassessed.

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

The baseline emissions for the second crediting period are recalculated taking in consideration the reassessment of the scenario baseline.

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[6] Consejo Nacional de Energía (Energy National Council), *Política Nacional de Energía* (Energy National Policy), page 24.

[7] Geothermal Energy Association, Geothermal Basics, section 8.6.

Step 2.2: Update the data and parameters

The data and parameters are updated taking in consideration the reassessment of the scenario baseline and the ACM0002 (version 14.0.0).

B.5. Demonstration of additionality

The project fulfils all the "additionality" prerequisites (see application of the "tool for the demonstration and assessment of additionality[8]", hereafter referred to simply as "additionality tool," in item B.3) demonstrating that it would not occur in the absence of the CDM.

The Project Activity will result in the reduction of greenhouse gases that would not occur if the project was not executed. The Project Activity faces numerous barriers and risks associated with the implementation, which is clearly elaborated below. These conditions demonstrate that the proposed Project Activity is not the baseline as usual scenario.

The "additionality tool" has been applied in conjunction with ACM0002 to describe how the anthropogenic emissions of GHG are reduced below those that would have occurred in the absence of the Project Activity. The additionality tool provides a general step-wise framework for demonstrating and assessing additionality. These steps, numbered from 0 to 5, include:

0. Preliminary screening
1. Identification of alternatives to the Project Activity
2. Investment analysis AND/OR
3. Barrier analysis
4. Common practice analysis
5. Impact of CDM registration

The application of the additionality tool to the Project Activity follows.

Step 0. Preliminary screening based on the project start date.

A previous development of the existing Berlin Geothermal Field, the "El Salvador Geothermal Energy Project," was submitted in 2001 by GESAL[9] to the Dutch Government CERUPT[10] tender. The project objective was to generate electricity (5 MW installed capacity) using hot fractured rock technology. The project was selected in a preliminary phase of the tender but it was finally not implemented. Later on the idea of using the geothermal potential of the Berlin Geothermal Field was further developed resulting in the Project Activity.

As it can be seen in the first version of the Project Activity schedule, the feasibility study for the Project Activity started in May 2000. Nevertheless the final revision of the feasibility study and decision to proceed or not with the Project would be carried out throughout the year of 2002.

The incentive of the CDM was seriously considered since the beginning of the Project Activity's feasibility study. During the year of 2002 an extensive exchange of information occurred between the project sponsors, PCF[11] and MARN[12] about the Project Activity. Documents produced in the period include draft Project Idea Notes and a Baseline Study of the project submitted to CERUPT. The following

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[8] *Tool for the demonstration and assessment of additionality*. UNFCCC, CDM Executive Board 16th Meeting Report, 22 October 2004, Annex 1.

[9] From the Spanish ***GE****otérmica* ***SAL***vadoreña, today's LaGeo.

[10] Certified Emission Reduction Procurement Tender closed on January 31, 2002 and organized by the Dutch governmental agency Senter.

[11] World Bank's Prototype Carbon Fund, for simplicity referred hereafter simply as PCF.

[12] El Salvador's Ministry of Environment and Natural Resources (MARN from the Spanish *Ministerio del Medio Ambiente y Recursos Naturales*) the Designated National Authority for the CDM.

two correspondences demonstrate that the incentive of the CDM was considered before the decision to proceed with the project:

- In August 15, 2001, Mr. Mauricio Ayala, from MARN, initiated the contact with Mr. Ruben Loy (from GESAL, today's LaGeo) regarding the submission of potential renewable energy projects from GESAL in El Salvador under the Clean Development Mechanism. One of the project ideas was the development of the Berlin Geothermal Field, then with an estimated 56 MW capacity addition. At that time, a portfolio of potential CDM projects were under development by the Central American Commission on Environment and Development to be presented at the Nordic Council of Ministers Meeting, to be held from August 20 to 25 in Finland.
- In January 24, 2002, Mr. Eduardo Dopazo (PCF associate) sent an e-mail message to his colleagues (Mr. Ken Newcombe, Mr. Jari Vayrynen, Ms. Odil Tunali Payton and Mr. Charles Cormier), to Mr. Mauricio Ayala, and to Mr. Ruben Loy, reporting the meeting with Mr. Loy during a visiting mission to El Salvador. In the report three likely eligible geothermal project developments under the CDM are mentioned. The Project Activity was one of them.

Copies of the various documents and e-mail messages exchanged, including the two above mentioned, are available upon request.

The project participants consider that the above information alone provides sufficient evidence that the CDM was seriously considered in the decision to proceed with the Project Activity.

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

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

The identified realistic alternative to the project activity are:

- Continuation of the present scenario (use of grid electricity to supply El Salvadoran energy requirements, actually, the alternative is the baseline scenario) or,
- The implementation of the project without incentives from the CDM.

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

2. The alternatives are in compliance with all applicable legal and regulatory requirements.

3. Non-applicable (the alternatives are in compliance with all applicable legal and regulatory requirements).

4. The Project Activity and the alternative scenarios are in compliance with the legal and regulatory requirements.

Step 2. Investment Analysis

Not applicable.

Step 3. Barrier Analysis.

To substantiate the barrier analysis, a brief overview of the El Salvadoran electricity market in the recent past is presented first.

<u>Regulatory Framework</u>

The electricity sector in El Salvador is regulated by the 1996 *General Law of Electricity Power*[13] and the creation of the *Electricity and Telecommunications Agency*[14] (SIGET, from the Spanish *Superintendencia General de Electricidad y Telecomunicaciones*). SIGET is responsible for ensuring compliance with all

[13] *Ley General de Electricidad, Decreto Legislativo N^o 843 del 10 de Octubre de 1996.*

[14] *Ley General de Creación de la SIGET, Decreto Legislativo N^o 808 del 12 de Septiembre de 1996.*

applicable laws and regulations. It is an autonomous organization headed by a presidential-appointed "*General Superintendent"* (serving a seven-year term), and two directors, of which one is appointed by the Supreme Court and the other by the private sector. The restructuring of the electric industry in El Salvador has as key objective the creation of an open and competitive electric market. The Electricity Law regulates generation, transmission, distribution, and trading of electricity. Competition is fostered through fully competitive markets in generation and trading. Under the Electricity Law, the state owned CEL[15] was obliged to restructure its generation and transmission assets. In particular, by November 1999 maintenance of the transmission lines and operational control of the network had to be conducted by separate entities and a structural change of ownership of the generating assets had to be accomplished. In October of 1998 CEL established *Empresa Transmisora de El Salvador, S.A. de C.V.* (ETESAL), responsible for maintenance of the national grid, operating independently since the end of 1999. The law does not restrict vertical or horizontal ownership within the electric industry except that no company involved in the generation, distribution or trading of electricity may own shares in ETESAL.

In 2001, the *Dirección de Energía Eléctrica*, (Department of Electric Energy) was created. The department is part of the Ministry of Economy. The Department's function is to look after the efficient operation of the activities of generation, transmission, distribution and commercialization of electric power, by means of setting National Policies.

<u>Power Pricing</u>

The Electricity Law provides for a Wholesale Electric Market (WEM) administered by the *Unidad de Transacciones* (UT, Transactions Unit). The WEM consists of a bilateral Contract Market based on predetermined contracts between operators for the supply of electricity and the *Mercado Regulador del Sistema* (MRS, Spot Market Regulation System) operated by UT.

The function of the MRS is to resolve congestion and to maintain system balance based on bids from market participants specifying prices at which they will buy or sell additional energy. UT is responsible for operating the transmission system and maintaining system security, and has primary responsibility for operating the WEM and coordinating the dispatch of energy from generating plants. UT cannot buy or sell energy for its own account.

The UT was established as a corporate entity in April 1998 and is in operation since September 1998. According to the electricity law, shareholders are drawn from transmission companies, generators, distributors and large users who are connected directly to the transmission network with a total nominal capacity demand in excess of 5MW. Payments are calculated at the MRS-price according to variances between each participant's supply or consumption of energy and the scheduled dispatch. The calculated MRS-price is set as follows:

- Distributors or Large Users whose consumption differs from scheduled consumption are paid or charged for the difference at the MRS price of energy;
- Generators that produce more than scheduled are reimbursed for the difference at the MRS price;
- Generators that produce less than scheduled are charged for the difference at the price of the energy purchased to replace the energy that was not supplied; and
- Where a plant generates less than scheduled as a result of a transmission failure, the transmission company is charged by the Transactions Unit for the difference between the cost of the replacement energy and the value of the energy supplied to the MRS by the plant concerned.

The UT calculates the balance of each participant and manages settlements.

Prices during the dry season tend to be higher (fossil-fuelled generation dominated) than in the wet season (hydro generation dominated). In contrast to other Latin American countries, the wholesale electricity

[15] Hydroelectric Company of the Lempa River (CEL from the Spanish *Hidroeléctrica del Río Lempa*), which controlled generation, transmission and distribution of electrical energy in El Salvador before privatization.

market does not provide for any explicit or regulated capacity payment nor does it establish a merit order for dispatch. Contracts are dispatched irrespective of the underlying electricity costs. Investment returns for new entrants (and existing generators) are a function of pricing trends in the MRS market as established by the bidding system and bilateral contract negotiation. All market participants defray the operating costs of the Transaction Unit in proportion to the energy supplied or received.

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

There is a set of identified barriers to the development of renewable sources of energy in El Salvador. The ones specifically applicable to geothermal projects under competitive markets (with wholesale markets of electricity), as it is the El Salvadoran case, are presented below.

1. Technical barriers, *"inter alia"*:

   i. Insufficient information on the resources of renewable energies. The lack of reliable data is a problem. The project sponsor has to make considerable investments to evaluate the possible resource, for example, in geothermal studies and exploratory well perforation, of course, without guarantee of success. The barrier increases the uncertainty on the availability and quality of the resource, increases its financial risk and, therefore, has a considerable impact in the evaluation of the project and in the guarantees demanded by the financial institutions.

   ii. Geothermal plants are not recognized as elements of regulation of voltage and reducing of losses. Although geothermal projects, as well as hydroelectric ones, usually are located at one of the ends of the interconnected electricity grid contributing to regulate transmission voltage and reducing transmission losses, these benefits are simply not considered, especially in the cases of countries, such as El Salvador, with liberalized and competitive markets, I other words, essentially price based merit.

2. Investment barriers, "*inter alia*":

   iii. As the economics of geothermal energy extraction are highly variable and wide ranging…high upfront risks to initial investigation to prove reserves. Diesel powered generation plant capital costs, for example, are typically less than 50% of the cost of geothermal plant (World Bank, 2005).

   iv. Free market and tariffs depend only on marginal price of power. Electricity price volatility in El Salvador is high. Price is determined by the marginal generation, which during the summer is mostly occupied by thermal fossil fuel plants (highest price season supplied by private generators); and during winter by hydropower generation (lowest price season supplied by state-owned generation). Geothermal generation is practically never at the margin. Due to this, prices of the spot market can hardly sustain/guarantee new investments. In addition, due to the lack of long-term contract offers, medium-capacity projects have no alternative other than the spot market as reference. This situation makes renewable projects cash flow very uncertain and limits the projects' financing possibilities. In addition, although expected to function as free market, there have been signals that may anticipate government intervention towards changing market rules and tariff mechanism, situation that increases investment risk

   v. Higher transaction costs for renewable energy projects. Geothermal energy projects face relatively greater costs of development than the conventional thermal projects using fossil fuels. The reasons are explained mainly because though many of the projects of renewable energies are small, they must fulfill the same set of proceedings of larger conventional projects. Despite the good will of the government, environmental impact

assessment of conventional thermal generation projects is simpler than of a geothermal project. In order to obtain licenses of installation and operation from the Ministry of Environment, LaGeo had to carry out complex technical evaluations given the nature of infrastructure works and the project's impacts (opening of roads, construction of drilling sites, handling of wastes, etc.). Therefore, the project must go through difficult, more expensive and longer bureaucratic process than those required for conventional thermal power generation. The procedures to obtain environmental and operation licenses are highly more cumbersome than, for example, for fossil-fuelled power generation. One of the major reasons is that the thermal projects do not need to bid on the concession of the area

3. Regulatory barriers, "*inter alia*":

vi. Relative regulatory uncertainty makes projects depending on long-term returns less attractive. Example of uncertainty is an approved law (*Decreto N^o 1216*, *Reformas a la Ley General de Electricidad*) issued in April 10, 2003 to implement caps on prices that it is until today not regulated. As a geothermal generator is a price taker this law does not affect LaGeo at all.

vii. Lack of long-term contracts (PPA or power purchase agreements). The El Salvadoran market is regulated to guarantee (and to bid) the demand only for the following 24 months (there is no regulation for longer term contracts). Business as usual is to sign one-year agreements. As explained above, renewable energy projects, like the Project Activity, are more capital intensive, i.e. they have to capitalize the means used to tap their energy resources in advance and, therefore, have higher financing requirements. This model requires from the project sponsor the management of a credit portfolio, something that needs a different sort of expertise from that of running a renewable energy business.

viii. There is no specific incentive for renewable or indigenous sources of energy. All existing incentives for power generation are equally applicable to any source of energy (including imported and polluting ones like fuel oil and coal). All other countries in Central America have some kind of incentives to support the development of renewable energy sources.

ix. There are no policies or plans that look at diversifying available mix of sources of energy for power generation.

4. Institutional barriers, "*inter alia*":

x. Power authorities do not recognize specific renewable energy project benefits. Many of the benefits derived from developing renewable energy projects are not directly reflected on the price of generated electricity. Energy sector planners and decision-makers do not factor in various indirect benefits such as development of poor regions, environmental conservation, cleaner power, energy decentralization, or generation of local productive chains. Authorities are normally not aware of these positive aspects but mostly concerned with the higher cost that renewable energy has vis-à-vis conventional energy sources. Therefore, these benefits (positive externalities) are not internalized in the price of the electricity, and are not properly weighted in public policies.

5. Other barriers, "*inter alia*":

xi. Unfounded social bias against geothermal plants. In spite of their inherent environmental value, communities are reluctant to accept the implementation of geothermal facilities due to the unjustified fear of groundwater contamination. Although

extracted from an aquifer, groundwater never comes in contact with pollutant components, and thus, there is no actual risk of contamination. Groundwater is either returned to the aquifer or is discharged at ground surface. From an environmental perspective it is desirable to re-inject the groundwater so that reductions in the water table do not occur. Local communities usually express concerns regarding superficial water (contamination and warming), gas releases, and local climate change.

xii. Lack of actual market competition. In reality there are only four major companies involved in electricity generation in El Salvador: These are: El Paso (thermal fossil-fuelled generation), Duke (fossil-fuelled), CEL (hydro), LaGeo (geothermal). Distribution, on the other hand, is controlled by AES (a large US power company). Regulation and operation are determined by UT that has considerable authority for the system that coordinates, which is vulnerable to influences exerted by the main generators (main shareholders). Decisions at UT are defined according to the generation share of participation, which was defined according to the installed capacity at the time of UT's establishment. No change in the participation was forecasted (not even due to grow or changes in the installed capacity). Government is considering changing the participation share to one vote per company. This will provide a more level plain field in terms opportunities for non-fossil fuels energy sources.

Sub-step 3 b. Show that the identified barriers would not prevent the implementation of at least one of the alternatives.

As described above, the main alternative to the Project Activity is continuing the current situation without the expansion. The project sponsor could invest its resources in various different investments, mainly in the financial market, with much lower uncertainty and risks. So the barriers above would not affect the investment in any of the alternatives.

Step 4. Common practice analysis

Sub-step 4a. Analyze other activities similar to the proposed project:

The installed capacity in El Salvador in 2004 was 1,087 MW (45.9% of which are thermal power plants using fossil fuels, 39.5% hydropower projects and the remaining 14.5% are geothermal. Regarding electricity generation in 2004[16], 39.2% of net electricity was supplied by fossil fuel fired power plants, 29.4% by hydroelectric, 20.7% by geothermal power generation, with the remaining 10.7% supplied by imports, mostly fossil fuelled power generation from Honduras and Guatemala. From January 1999 to September 2004 energy demand in El Salvador grew an average of 2.51% per year.

All hydropower plants are owned and operated by state-owned CEL. In the last 18 years only 33.9 MW of installed capacity from hydro sources were added to the systems through repowering of existing power plants.

There are two geothermal fields in El Salvador under operation, Ahuachapán (operation start of the last unit in 1980) and Berlín (operation start of the last unit in 1999). Both plants were state-financed and have a combined installed capacity of 165 MW.

The first step in privatizing the electricity generation sector (previously mostly owned and operated by state owned *Comisión Ejecutiva Hidroeléctrica del Río Lempa*, CEL) took place in 1995 with the sale of 145 MW of fuel oil fired generating capacity. In 1999 the remaining fossil fuelled capacity (approximately 400 MW) was sold to Duke Energy International. These plants have been retrofitted and extended between 1998 and 2004.

[16] Up to and including September, totalizing 3,425 GWh.

Since 2003 there is also a biomass power plant (CASSA, 20 MW installed capacity) with an availability to export excess electricity to the grid. The plant operates only during the sugarcane season. Since start-up the plant delivered a very small amount of energy to the grid - 10.3 GWh in 2003 (less than 0.3% of a total of 4,460 GWh load) and 22.4 GWh in 2004 up to September (less than 0.7% of a total of 3,226 GWh load).

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

The most recent installed capacity addition using geothermal resources occurred in 1999.

Since 2000 fossil fuel fired power generation has dominated the El Salvadorian electricity market in terms of installed capacity growth[17] and in terms of market share. The growth owed to opportunities arising from the privatization of the generation sector, and favorable market conditions such as lower capital costs, easy start-up, shorter lead times for thermal projects using fossil fuels and internal combustion engines in comparison with those of hydro- and geothermal power generation.

Also, in August 2004 the addition of 85 MW using fossil fuels was announced (Trujillo, 2004). The capacity addition will be implemented in two different locations, Lourdes with 11.9 MW in the first quarter of 2005 and, Acajutla with 73.6 MW and start at the end of 2005.

Step 5 – Impact of CDM Registration

The evolution of the installed capacity in the recent past clearly indicated that the investment in internal combustion engines using fossil fuels is a more interesting option for the private sector. Reciprocating engines, also called internal combustion engines, are a widespread and well-known technology. Reciprocating engines range in size from a few kW to several MW. Advantages of reciprocating engines include low capital costs, easy start-up, proven reliability, good load-following characteristics, and good heat recovery. With compact modular engines the plants can be quickly expanded or even moved. Applications in power generation include prime power generation, peak-shaving, back-up power, premium power, remote power, and standby power.

As mentioned in step 0, the first attempt towards a more intensive use of the Berlin geothermal field was developed in 2001 to be submitted to the CERUPT tender. It was already recognized then that the risks involved in an investment in geothermal power generation required extraordinary incentives. Possible financial benefits obtained from a long-term "*emission reductions purchase agreement*" (ERPA) attracted the attention of investors to the planned expansion of 5 MW. In the beginning of 2002 the project was selected under the CERUPT program. While developing the expansion the project investors realized that the benefits from an ERPA could effectively help to overcome most of the barriers to implementing the new geothermal Project Activity. Yet, although during COP-7 in 2001 it was agreed on a prompt start for the CDM, with projects starting from 1 January 2000 being eligible for earning CDM credits (UNFCCC, 2001), the entry-into-force of the Kyoto Protocol was doubtful. At the time the emission reductions "market" was precarious, and the activity was finally not developed. Nevertheless the experience rendered further consideration of incentives derived from the CDM. However, it was only after the approach of the Latin-American Carbon Program[18] in 2002 offering to lower the risk through the CDM investment component that the project participants decided to seriously consider a larger entrepreneurship.

The Project Activity is the first geothermal project to be implemented by private initiative in El Salvador. The benefit from the sale of CERs will provide a crucial economic benefit that allowed project

[17] 86.6% using fuel oil (*CESSA*, 30 MW in 2000, retrofitted to 33.3 in 2004; *Acajutla*, 144 MW, in 2001, retrofitted to 151 in 2004; and *Nejapa Power*, 151.2 MW in 1998); 4.6% using diesel oil (*Soyapango*, 17.9 MW in 2003); and 8.8% using hydro resources (*5 de Septiembre*, 15 MW repotentiation in 2001-2002; and *Cerron Grande*, 18.9 MW repotentiation in 2003). There was also an addition of a sugar mill power plant using biomass (*CASSA*, 20 MW in 2003) operating intermittently during the sugarcane season.

[18] PLAC from the Spanish *Programa Latino-Americano de Carbono*, created by *Corporación Andina de Fomento* (CAF) in 1999 with the objective of fostering participation and entry, of Latin American and Caribbean countries in the evolving GHG emission reduction markets.

proponents to further evaluate the geothermal field potential. The approval and registration of the CDM activity means that a solid and worldwide scrutinized project is able to secure a long term financial flow through an ERPA. With a signed ERPA the project owners will be capable of sustaining the new investment by overcoming higher transaction costs (higher upfront investments and consequently taxes) and the absence of long-term power purchase agreements.

But the benefits cannot and will not be restricted to economic return but will also help to assure sustainable development, for example, helping a renewable energy project to overcome barriers such the failure to recognize the environmental benefits and social rejection. In the operation of the Project Activity the extracted groundwater will be re-injected so that reductions in the water table do not occur.

The Project Activity also foresees a considerable investment in socio-economic benefits directed to the local communities, such as capacity building courses, creation of jobs, construction and maintenance of infra-structure, etc.

From the above the most likely conclusion is that the Project Activity (the Project Activity scenario) would not be implemented without the incentive from the CDM and ultimately the registration of the project. Also the most likely baseline scenario is the continuation of the present scenario, i.e., the use of grid electricity to supply El Salvadoran energy requirements.

B.6. Emission reductions

B.6.1. Explanation of methodological choices

a. Calculation of the emission factor

According to the selected approved methodology (ACM0002, version 14.0.0, hereafter referred to as ACM0002, V14), the emission factor (EF_y) is calculated as a combined margin (*CM*), consisting of the combination of operating margin (OM) and build margin (BM) factors, which is calculated following the procedures established in the approved "Tool to calculate the emission factor for an electricity system", version 4.0. (Hereafter referred to as the Tool).

<u>Step 1. Identification of the relevant electricity systems</u>

El Salvador´s DNA has not published a delineation of the project electricity system; hence the national grid is identified as the project electricity system.

The identified project electricity system is correct according to the Tool that defines it as the spatial extent of the power plants that are physically connected through transmission and distribution lines to the Project Activity and that can be dispatched without significant transmission constraints. Next graph shows a schematic diagram of national grid of El Salvador that includes the transmission system and the grid-power plants. Because the transmission system is extended along of the country, the geographical extent of the project electricity system is the entire territory of El Salvador.

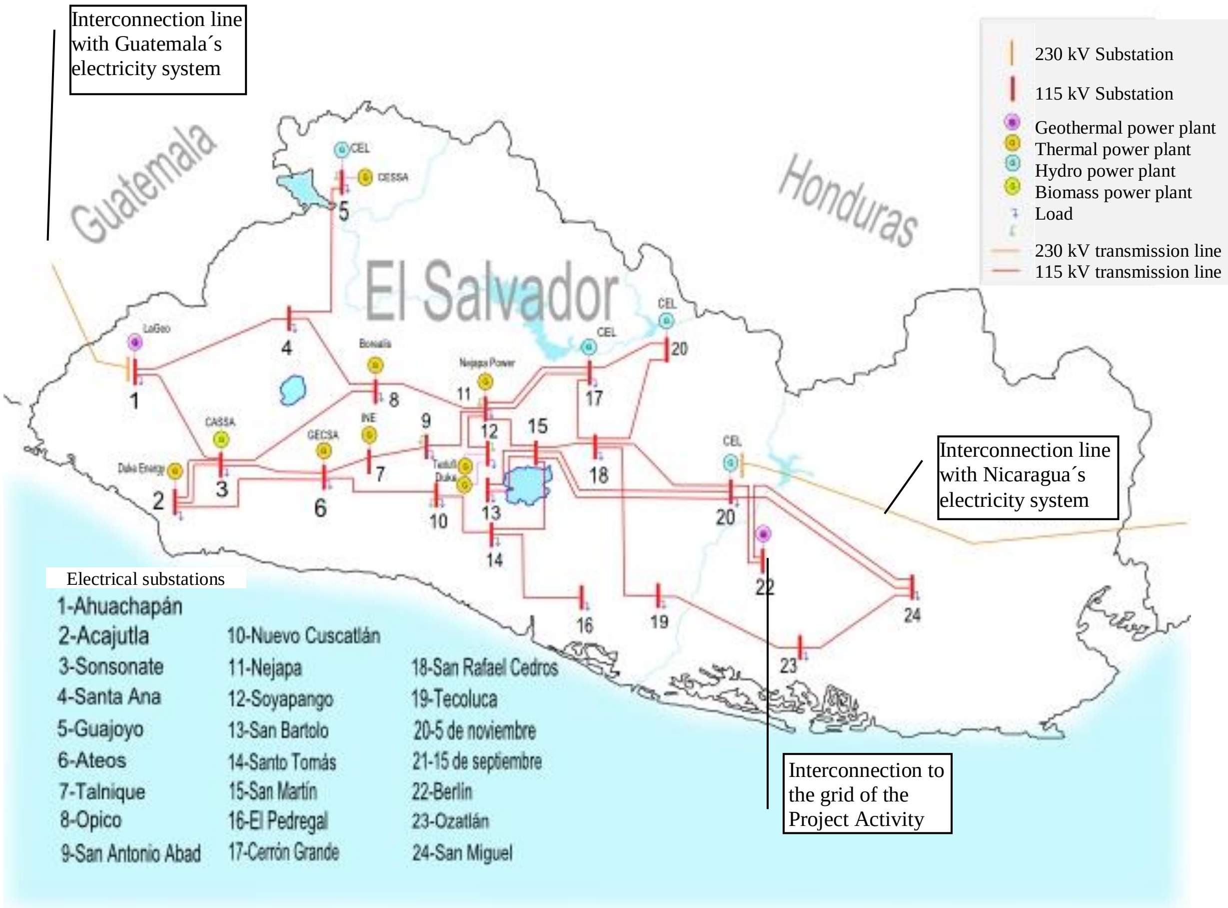


Figure 4. Generation and transmission system of El Salvador.
Source: *Unidad de Transacciones* (Transactions Unit), One line diagram, http://www.ut.com.sv/web/guest/15

It is concluded that the grid-power plants connected to the project electricity system do not face transmission constraints during normal operation conditions. All grid-power plants that participate in the electricity market and present market offers are economically dispatched by the Transactions Unit (*Unidad de Transacciones*, UT)[19] as per the Regulations of the Transmission System and Electricity Market. The evidences regarding to the reliability level of the transmission system show that the number of transmission outages could be considered normal and not a limitation in the transmission system operation. According to SIGET, the number of unplanned outages in the transmission system in 2011 was of 71[20].
On the other hand, the Tool defines the connected electricity system as the electricity system that is connected by transmission lines to the project electricity system. In the case of El Salvador, the project electricity system is interconnected to the national grids of the countries of Central America through the Interconnection System for Central America and Mexico (*Sistema de Interconexión Eléctrica para Centroamérica*, SIEPAC), therefore, the connected electricity system is formed by the electrical grids of Guatemala, Honduras, Nicaragua, Costa Rica and Panama. Power plants within the grids of the connected electricity system can be dispatched without significant transmission constraints because the systems of each country are coordinated independently, while energy exports and imports are coordinated by the Central America Market Operator (Ente Operador Regional, EOR)[21].

There are not legal restrictions for international electricity exchanges because there is a framework agreement between the countries of Central America that set out a regional electricity market operated by the EOR[22].

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 method selected is the Simple adjusted OM method because 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 and the average electricity generation for the five most recent years is 3,376,200 MWh (61% of the total historical generation).

Table 2. Composition of total grid generation (MWh)[23]

	2008	2009	2010	2011	2012
Fuel based	2,011,700	2,362,500	1,970,300	2,134,400	2,367,100
Hydro	2,034,200	1,500,400	2,079,200	2,006,400	1,338,600
Biomass	105,200	161,000	179,900	157,900	204,700
Geothermal	1,421,000	1,420,800	1421200	1,430,000	1,420,500
Total	5,574,108	5,446,709	5,650,600	5,728,700	5,330,900
Renewables	3,560,400	3,082,200	3,680,300	3,594,300	2,963,800
% Renewables	64%	57%	65%	63%	56%

[19] The Transactions Unit (Unidad de Transacciones, UT) is in charge of the transmission grid operation, the dispatch of the power plants connected to the grid and the transactions in the whosale electricity market of El Salvador. Transactions Unit´s web page, www.ut.com.sv : UT´s mission.
[20] SIGET, Boletín de Estadísticas Electricas 2011 (Statistics Report 2011), page 110, table 47.
[21] Transactions Unit´s web page, http://www.ut.com.sv/web/guest/14 : Sector information, hierarchical structure.
[22] Ente Operador Regional (EOR), http://www.enteoperador.org/index.html# : MER regulations.
[23] Unidad de Transacciones, UT (Transactions Unit) Statistical reports from 2008 to 2012, table 2.

It is selected the *ex-ante* option for data vintages. Because only grid-power plants are selected, 3-year generation-weighted average is used for the calculation of the OM emission factor, based on the most recent data available at the time of submission of the PDD to the DOE for validation.

The power plants registered as CDM project activities are included in the sample group that is used to calculate the operating margin.

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

The simple adjusted OM method is calculated on the basis of the CO_2 emission factor and net electricity generation of each power unit connected to the grid; therefore option A of the simple OM calculation is selected.

Assumptions:

- Net electricity imports are considered low-cost/must-run units *k*.
- 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 of Central America.
- For the *ex-ante* calculation of the OM emission factor, 2010, 2011 and 2012 data is used, based on the most recent statistics available at the time of requesting the renewal of the crediting period.
- The set of power plants *k*, low-cost plants, are the hydroelectric, geothermal and cogenerating power plants connected to the grid.
- The set of power plants *m* comprises the remaining units.

The Operating Margin emission factor is calculated using equation 8 of the tool as the generation-weighted average emissions per electricity units serving the system.

$$EF_{grid,OM-adj,y} = (1-\lambda_y) \times \frac{\sum_m EG_{m,y} \bullet EF_{EL,m,y}}{\sum_m EG_{m,y}} \oplus \lambda_y \times \frac{\sum_k EG_{k,y} \bullet EF_{EL,k,y}}{\sum_k EG_{k,y}}$$ Eq. 8 from the Tool

Where:

$EF_{grid,OM-adj,y}$	=	Simple adjusted operating margin CO_2 emission factor in year y (t CO_2/MWh).
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 3 of the Tool.
$EF_{EL,k,y}$	=	CO_2 emission factor of power unit *k* in year *y* and given in tCO_2/MWh. It is determined using Equation 3 of the Tool.
$EG_{m,y}$	=	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 Statistical Reports published on UT´s website.
$EG_{k,y}$	=	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 Statistical Reports published on UT´s website.

m	=	All grid power units serving the grid in year y except low-cost/must-run power units. See appendix 4.
k	=	All low-cost/must run grid power units serving the grid in year y. See appendix 4.
y	=	2010, 2011 and 2012

The emission factor for the subset of power plants *m* and *k*, connected to transmission system (the grid), is calculated as per option A2 of the simple OM method, stated in the Tool (paragraph 44), because it is not known the amount of fuels consumed, only the amount of electricity production and fuel types. The average CO_2 emission factor of fuel type *i* is used for each generating unit and the default efficiencies, as the following equation describes:

$$EF_{EL\,m,,y} = \frac{EF_{co2,m,i,y} \times 3.6}{\eta_{m,y}} \quad \text{Eq. 3 from the Tool}$$

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 = 2010, 2011 and 2012

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 *Unidad de Transacciones*, UT (Transactions Unit).

Table 3. Effective CO_2 emission factors for fuel types used in El Salvador

	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 El Salvador, therefore the default values from Annex I of the Version 04.0. of the Tool to calculate the emission factor for an electricity system are used, which are indicated in next table. The efficiency factor is selected according the operations starting year and technology of each generating unit from SIGET, *Boletín de Estadísticas Eléctricas 2011* (Electricity Statistics Report - 2011), Table 7.

Table 4. Default efficiency factors for power plants

Generation technology	Old units (before and in 2000)	New units (after 2000)
Coal	-	-
Subcritical	37%	39%
Supercritical	-	45%
Ultra-supercritical	-	50%
IGCC	-	50%
FBS	35.5%	-
CFBS	36.5%	40%
PFBS	-	41.5%
Oil	-	-
Steam turbine	37.5%	39%
Open cycle	30%	39.5%
Combined cycle	46%	46%
Natural gas	-	-
Steam turbine	37.5%	37.5%
Open cycle	30%	39.5%
Combined cycle	46%	60%

The denominators of the terms of the Operating Margin equation are:

$\sum_m EG_{m,y}$ = 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 calculated as follow:

$$\lambda(\%) = \frac{\text{Number of low cost/must-run sources are on the margin in year y}}{8760 \text{ hours per year}}$$ Eq. 9 from the Tool

Step (i) A load duration curve is plotted with the chronological generation data (load data + transmission losses) (in MW) for each hour of the year *y*. The curve is plotted in descending order, hours in axis *x* and MW in axis *y*. The information is obtained directly from UT;

Step (ii) The total annual generation (in MWh) from low-cost/must-run grid-connected power plants is calculated;

Step (iii) The load duration curve is filled. A horizontal line across the load duration curve is plotted, such that the area under horizontal line and the curve right from the intersection point (MW times hours) equals the total generation (in MWh) from low-cost/must-run power plants/units;

Step (iv) The "Number of hours for which low-cost/must-run sources are on the margin in year y are determined. First, the intersection of the horizontal line plotted in Step (iii) and the load duration curve plotted in Step (i) is located. 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. If the lines do not intersect, then one may conclude that low-cost/must-run sources do not appear on the margin and λ y is equal to zero.

Step 5. Calculation of Build Margin emission factor

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.

Option 1 is selected respect to data vintages for the second and third crediting period. The build margin emission factor is calculated *ex-ante*, including those units built up to the latest year for which information is available. For the *ex-ante* calculation of the BM emission factor, 2012 data is used, based on the most recent statistics available at the time of PDD submission.

Capacity additions from retrofits are not included.

The set of power plants selected for the build margin are selected according to the following premises:

i. The set of five power units, excluding CDM project activities, which started to supply electricity to the grid most recently, is identified. See tables of appendix 4.
   The power units registered as CDM project activities are excluded from the cohort of power plants[24], these power plants are:
   Berlin Binary Cycle power plant
   El Angel Cogeneration Project
   Central Izalco Cogeneration Project

ii. The total annual generation of the project electricity system (AEGtotal), excluding CDM project activities, is calculated.

iii. The build margin is calculated with the sample group of power plants/units used 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.

iv. The set of power plants that comprise 20% of the generation system is selected because have a larger electricity generation than the group of the five power plants that started to supply electricity to the grid most recently.

v. From the chosen group, power plants older than ten years are excluded and CDM projects are included.

The build margin is calculated using the following equation:

$$EF_{grid,BM,y} = \frac{\sum_m EG_{m,y} \times EF_{EL,m,y}}{\sum_m EG_{m,y}} \qquad \text{Eq. 13 from the Tool}$$

Where:

[24] UNFCCC, http://cdm.unfccc.int/Projects/projsearch.html

$EF_{grid,BM,y}$ = 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* (tCO2/MWh). It is determined using equation 3 according to option A2 of the Tool.

$EG_{m,y}$ = Net quantity of electricity generated and delivered to the grid by power unit *m*, during the year 2012, given in MWh.

m = Power units included in the build margin

y = 2012

Step 6. Calculation of the combined margin emission factor

The emission factor of the electrical system is based on the weighted average CM method, as following equation:

$$EF_{grid, CM, y} \text{ (t } CO_2\text{/MWh)} = EF_{grid, OM, y} \bullet w_{OM} + EF_{grid, BM, y} \bullet w_{BM}$$ Eq. 14 from the Tool

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 (%)

For the second and third crediting period, the default values are chosen for the weighting factors, w_{OM} = 0.25 and w_{BM} = 0.75.

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.

b. Estimation of project emissions

As per version 14.0.0 of the ACM0002, project participants shall account the emissions described in the following equation.

$$PE_y = PE_{FF,y} + PE_{GP,y}$$ Eq. 1 from the ACM0002, V.14

Where:

PE_y = Project emissions in year *y* (tCO_2e/yr)

$PE_{FF,y}$ = Project emissions from fossil fuel consumption in year *y* (tCO_2/yr)

$PE_{GP,y}$ = Project emissions from the operation of geothermal power plants due to the release of non-condensable gases in year *y* (tCO_2e/yr)

The procedure to calculate the components of the equation 1 of the methodology is:

a) Carbon dioxide emissions resulting from combustion of fossil fuels related to the operation of the geothermal power plant

There is no forecasted combustion of fossil fuels related to the operation of the project for electricity production because the power unit is not equipped with an emergency diesel plant. Essential electrical loads are supplied by batteries in case of an emergency, then:

$$PE_{FF,y} = 0$$

b) Fugitive emissions of carbon dioxide and methane due to release of non-condensable gases from produce steam

$$PE_{GP,y} = (w_{steam,CO2}, y + w_{steam,CH4}, y \cdot GWP_{CH4}) \cdot M_{steam,y}$$ Eq. 2 from the ACM0002, V14

Where:

- $PE_{G,y}$ are the project emissions due to release of carbon dioxide and methane from the produced steam during the year *y* (in *tCO_2e*)
- $w_{steam,CO2,y}, w_{steam,CH4,y}$ are the average mass fractions of carbon dioxide and methane in the produced (in tCO_2/t steam and tCH_4/t steam, respectively)
- GWP_{CH4} is the global warming potential of methane (default value = 25) valid for the second commitment period (tCO_2e/tCH_4)
- $M_{S,y}$ is the quantity of steam produced during year *y* (in *t steam/year*)

c. Estimation of leakages

According to the version 14.0.0 of the ACM0002, no leakage emissions are considered.

d. Calculation of baseline emissions

In accordance to the version 14.0.0 of the ACM0002, the baseline emissions are calculated as follows:

$$BE_y = EG_{PJ,y} \cdot EF_{grid,CM,y}$$ Eq. 6 from the ACM0002, V.14

Where:

BE_y	=	Baseline emissions in year *y* (tCO_2/yr)
$EG_{PJ,y}$	=	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/yr)
$EF_{grid,CM,y}$	=	Combined margin CO_2 emission factor for grid connected power generation in year *y* calculated using the version 4.0 of the “Tool to calculate the emission factor for an electricity system” (tCO_2/MWh)

Because the Project Activity consists of a new geothermal power unit installed next to an existing geothermal energy based power plant (units 1 and 2 of Berlin Geothermal Plant), $EG_{PJ,y}$ is calculated using the option 1 of the ACM0002 methodology as follows:

$$EG_{PJ,y} = EG_{facility,y} - (EG_{historical} + \sigma_{historical})\text{; until } DATE_{BaselineRetrofit}$$ Eq. 8 from the ACM0002, V14

and

$$EG_{PJ,y} = 0\text{; on/after } DATE_{BaselineRetrofit}$$

Where:

$EG_{PJ,y}$	=	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)
$EG_{facility,y}$	=	Quantity of net electricity generation supplied by the project plant to the grid in year *y* (MWh)
$EG_{historical}$	=	Annual average historical net electricity generation delivered to the grid by the existing renewable energy plant that was operated at the project site prior to the implementation of the Project Activity (MWh)
$\sigma_{historical}$	=	Standard deviation of the annual average historical net electricity generation delivered to the grid by the existing renewable energy plant that was operated at the project site prior to the implementation of the Project Activity (MWh)
$DATE_{BaselineRetrofit}$	=	Point in time when the existing equipment would need to be replaced in the absence of the Project Activity (date)

For $EG_{historical}$ determination, the option of five last calendar years prior to the implementation of the Project Activity is selected as the analysis period.

e. Calculation of emission reductions

Emission reductions are calculated according to the version 14.0.0 of the ACM0002 methodology as follow:

$$ER_y = BE_y - PE_y$$

Eq.11 from the ACM0002, V14

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)

B.6.2. Data and parameters fixed ex ante

Data / Parameter	**EF**
Unit	tCO_2/MWh
Description	Emission factor of the grid
Source of data	Spreadsheet “EF calculation-Berlin Geothermal Project Phase II-V2”
Value(s) applied	0.569
Choice of data or Measurement methods and procedures	Calculated as per the “Tool to calculate the emission factor for an electricity system”, version 4.0.
Purpose of data	This factor is used for baseline emissions calculation.
Additional comment	

Data / Parameter	GWP_{CH4}
Unit	tCO_2e/tCH_4
Description	Global warming potential of methane valid for the second commitment period.
Source of data	Table 2.14 of the errata to the contribution of Working Group I to the Fourth Assessment Report of the Intergovernmental Panel on Climate Change as per Decision 4/CMP.7.
Value(s) applied	25 tCO_2e/tCH_4
Choice of data or Measurement methods and procedures	N/A
Purpose of data	Project emissions calculation
Additional comment	-

Data / Parameter	$EG_{historical}$
Unit	MWh
Description	Annual average historical net electricity generation delivered to the grid by the existing renewable energy plant that was operated at the project site prior to the implementation of the project activity.
Source of data	Electricity meters at project activity site prior the implementation of the project activity. Data provided by the Transacctions Unit (UT).
Value(s) applied	440,843
Choice of data or Measurement methods and procedures	The project participant chooses the five last calendar years prior to the implementation of the project activity as the time span of historical data to determine $EG_{historical}$.
Purpose of data	Baseline emissions calculation
Additional comment	-

Data / Parameter	$\sigma_{historical}$
Unit	MWh
Description	Standard deviation of the annual average historical net electricity generation delivered to the grid by the existing renewable energy plant that was operated at the project site prior to the implementation of the Project Activity
Source of data	Calculated from data used to establish $EG_{historical}$. Information provided by the Transactions Unit (UT).
Value(s) applied	12,904
Choice of data or Measurement methods and procedures	Parameter calculated as the standard deviation of the annual generation data used to calculate $EG_{historical}$.
Purpose of data	Baseline emissions calculation
Additional comment	-

Data / Parameter	$DATE_{BaselineRetrofit}$
Unit	Date
Description	Point in time when the existing equipment would need to be replaced in the absence of the project activity
Source of data	Project activity site
Value(s) applied	2029
Choice of data or Measurement methods and procedures	As per provisions in the methodology above
Purpose of data	Calculation of $EG_{PJ,y}$ (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/yr))
Additional comment	-

B.6.3. Ex ante calculation of emission reductions

Ex-ante calculation of project emissions

Project emissions are calculated as per equation 1 of the ACM0002, Version 14.0.0 and indicated below:

$$PE_y = PE_{FF,y} + PE_{GP,y} \ .$$

The first term is related to the project emissions due to fuels consumption. Because the Project Activity does not uses fossil fuels, PEFF,y is equal zero and $PE_y = PE_{GP,y}$.

The second term of the equation is related to the project emissions due to the release of non-condensable gases from produced steam. These project emissions are estimated *ex-ante* using equation 2 from the ACM0002, Version 14.0.0 as is described in next equation, whose terms are detailed in the table below.

$$PE_{GP,y} = (w_{steam,CO2}, y + w_{steam,CH4}, y \cdot GWP_{CH4}) \cdot M_{steam,y}$$

The estimates used for the *ex-ante* calculation are indicated in the next table and are contained in the tables in section B7.1. These estimates are based on production data from 2012[25].

Table 5. Data to calculate project emissions

$PE_{G,y}$	Project emissions due to release of carbon dioxide and methane from the produced steam during the year *y*	tCO_2e	
$w_{steam,CO2,y}$	Average mass fractions of carbon dioxide	tCO_2/t steam	1.01E-02
$w_{steam,CH4,y}$	Average mass fractions of methane	tCH_4/t steam	4.95E-07
GWP_{CH4}	Global warming potential of methane		25
$M_{S,y}$	Quantity of steam produced during year *y*	*t steam/year*	2,858,252

Substituting values of table 5 in Equation 2 from the ACM0002, Version 14.0.0, results:

$PE_{G,y}$ = (1.01E-02 t CO_2/ t steam + 4.95E-07 t CH_4/ t steam x 25) x 2,858,252 t steam/year

$PE_{G,y}$ = 28,904 t CO_2e per year

[25] LaGeo, S.A. de C.V., Berlin Geothermal Project, Phase Two, Monitoring Report 2012.

Substituting $PE_{G,y}$ in equation 1, the project emissions estimated for each year of the second crediting period results:

PE_y = 0 + 28,904 t CO_2e = 28,904 t CO_2e.

Ex-ante calculation of baseline emissions

Baseline emissions are calculated using the equation 6 from the ACM0002 methodology:
$BE_y = EG_{PJ,y} \cdot EF_{grid,CM,y}$

Where $EG_{PJ,y}$ is calculated according to equation 8 from the ACM0002, Version 14.0.0:
$EG_{PJ,y} = EG_{facility,y} - (EG_{historical} + \sigma_{historical})$

For the *ex-ante* calculation, the first term of the equation 8, $EG_{facility,y}$ (the total electricity generation of the existing plant and the added unit), is assumed as the sum of the annual average historical net electricity generation data and the value forecasted for the Project Activity as per the feasibility studies, then:

$EG_{facility,y}$ = 440,843 MWh + (44 MW x 8760 hours x 0.85) = 768,467 MWh

Where:
The total electricity generation of the existing plant = 440,843 MWh
The generation of the added unit = 327,624, which is calculated of the capacity of the new power unit (44 MW), the 8760 hours in a year and 0.85 that is the plant factor as the registered PDD.

For the second term of the equation, the time span for historical data is chosen from 2002 to 2006 because the implementation date of the Project Activity is 02/02/2007[26]. Hence, the annual average historical net electricity generation, $EG_{historical}$, is calculated using data from next table.

Table 6. Annual average historical net electricity generation data of existing power units

Year	Historical data
2002	440,743.376
2003	461,930.520
2004	433,891.929
2005	427,719.411
2006	439,928.442

$EG_{historical}$ is calculated as the average of the historical data and results equal to 440,843 MWh.

And the third term of equation 8, $\sigma_{historical}$ (standard deviation historical), is calculated from data of the table above and is 12,902.

Then substituting values in the equation 8 to calculate $EG_{PJ,y}$ gives:

$EG_{PJ,y}$ = $EG_{facility,y} - (EG_{historical} + \sigma_{historical})$
= 768,467 MWh - (440,843 MWh + 12,904)
= 314,720 MWh

Finally, baseline emissions results:

[26] Letter issued by Transactions Unit (UT, *Unidad de Transacciones*), 06/05/2013.

$BE_y = EG_{PJ,y} * EF_{grid,CM,y}$
= 285,854 MWh * 0.569
= 179,076 tCO_2/MWh

Where, the combined emission factor of the grid is fixed *ex-ante* according to equation 14 from the Tool as follow:

EF_y (tCO_2/MWh) = 0.25 • 0.711 + 0.75 • 0.522 = 0.569 tCO_2/MWh

For W_{OM} (Weighting of operating margin emissions factor) is used the default value 0.25%.
W_{BM} (Weighting of build margin emissions factor) is used the default value 0.75%.

Please see Appendix 4 for more details of EF_y calculation.

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

The implementation of Project Activity connected to the El Salvadoran grid will yearly avoid GHG emissions of around 150,171 tCO_2 and a total reduction of about 1,051,199 tCO_2 over the second crediting period.

Next table shows the summary of *ex-ante* estimates of emission reductions 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)
2014	179,075	28,904	0	150,171
2015	179,075	28,904	0	150,171
2016	179,075	28,904	0	150,171
2017	179,075	28,904	0	150,171
2018	179,075	28,904	0	150,171
2019	179,075	28,904	0	150,171
2020	179,075	28,904	0	150,171
Total	1,253,525	202,326	-	1,051,199
Total number of crediting years	7			
Annual average over the crediting period	179,075	28,904	-	150,171

B.7. Monitoring plan

The name and reference of the approved baseline monitoring methodology applied to the monitoring plan of the Project Activity is: **ACM0002** "Consolidated baseline methodology for grid-connected electricity generation from renewable sources" (version 14.0.0).

The Monitoring Plan foresees the storage of sufficient data to allow the calculation of GHG emissions generated and avoided by the Project Activity in a straightforward manner.

B.7.1. Data and parameters to be monitored

Data and parameters to be monitored are described in the following tables. Data will be collected and archived for two years following the end of the crediting period.

Data / Parameter	w_{steam,CO_2}
Unit	tCO_2/t steam
Description	Average mass fraction of CO_2 in the produced steam in year y.
Source of data	Project Activity site
Value(s) applied	1.01E-02
Measurement methods and procedures	Non-condensable gases sampling should be carried out in production wells and at the steam field-power plant interface using ASTM Standard Practice E1675 for Sampling 2-Phase Geothermal Fluid for Purposes of Chemical Analysis and the ASTM Standard Practice E947 for Sampling Single-Phase Geothermal Liquid or Steam for Purposes of Chemical Analysis. The CO_2 and CH_4 sampling and analysis procedure consists of collecting non-condensable gases samples from the main steam line with glass flasks, filled with sodium hydroxide solution and additional chemicals to prevent oxidation. Hydrogen sulphide (H_2S) and carbon dioxide (CO_2) dissolve in the solvent while the residual compounds remain in their gaseous phase. The gas portion is then analyzed using gas chromatography to determine the content of the residuals including CH_4. All alkanes concentrations are reported in terms of methane. The average mass fraction of steam of CO_2 will be analyzed by a titration method.
Monitoring frequency	At least every three months and more frequently, if necessary.
QA/QC procedures	Internal procedures will be followed to systematize activities and minimize error. The laboratory equipment will be calibrated at least once a year. The Geo-chemical Laboratory of LaGeo is accredited by ISO/IEC 17025.
Purpose of data	Activity emissions calculation.
Additional comment	Data is archived in electronic and paper

Data / Parameter	$W_{steam,CH4}$
Unit	tCH_4/t steam
Description	Average mass fraction of CH_4 in the produced steam
Source of data	Project Activity site
Value(s) applied	4.95E-07
Measurement methods and procedures	Non-condensable gases sampling should be carried out in production wells and at the steam field-power plant interface using ASTM Standard Practice E1675 for Sampling 2-Phase Geothermal Fluid for Purposes of Chemical Analysis and the ASTM Standard Practice E947 for Sampling Single-Phase Geothermal Liquid or Steam for Purposes of Chemical Analysis. The CO_2 and CH_4 sampling and analysis procedure consists of collecting non-condensable gases samples from the main steam line with glass flasks, filled with sodium hydroxide solution and additional chemicals to prevent oxidation. Hydrogen sulphide (H_2S) and carbon dioxide (CO_2) dissolve in the solvent while the residual compounds remain in their gaseous phase. The gas portion is then analyzed using gas chromatography to determine the content of the residuals including CH_4. All alkanes concentrations are reported in terms of methane.
Monitoring frequency	Quarterly At least every three months and more frequently, if necessary.
QA/QC procedures	Internal procedures will be followed to systematize activities and minimize error. The laboratory equipment will be calibrated at least once a year. The Geo-chemical Laboratory of LaGeo is accredited by ISO/IEC 17025.
Purpose of data	Activity emissions calculation.
Additional comment	Data is archived in electronic and paper.

Data / Parameter	$M_{steam,y}$
Unit	t steam/yr
Description	Quantity of steam produced in year *y*
Source of data	Project Activity site
Value(s) applied	2,858,252
Measurement methods and procedures	Annubar flow meters will be used for the determination of steam quantities discharged from geothermal wells, which should be conducted on a continuous basis. Measurement of temperature and pressure upstream of the flow meter is required to define the steam properties. The calculation of steam quantities should be conducted on a continuous basis and should be based on international standards. The measurement results should be summarized transparently in regular production reports
Monitoring frequency	Daily
QA/QC procedures	Internal procedures will be followed to systematize activities and minimize error. Annubar flow meters will be calibrated twice a year.
Purpose of data	Activity emissions calculation.
Additional comment	Data will be archived in electronic and paper

Data / Parameter	$EG_{facility,y}$
Unit	MWh
Description	Quantity of net electricity generation supplied by the project plant to the grid in year *y*
Source of data	Electricity meters at project site.
Value(s) applied	768,467
Measurement methods and procedures	The net electricity generation supplied to the grid is monitored by the Project Participant as well as by the Transactions Unit (Unidad de Transacciones, UT). Because UT is the grid operator, the data monitored by UT constitutes the official data used for commercial purposes and emissions reductions calculation. 1. Measurement: Measurements are undertaken using two bidirectional electricity meters per power unit with an accuracy class of at least 0.2. One meter is used as the main and the other as the secondary. Both meters measure the electricity delivery to the grid at the delivery point. The net electricity supplied to a grid is the difference between the measured quantities of the grid electricity export and the import. 2. Data Reading: Data reading will be carried out periodically by the project participant an UT, downloading data directly from the electricity meters or remotely. 3. Data Registration: Data download from the electricity meters is saved monthly by the project participant in an electronic format. 4. Data Storage: All data collected as part of monitoring should be archived electronically and be kept at least for 2 years after the end of the last crediting period.
Monitoring frequency	Continuous measurement and at least monthly recording.
QA/QC procedures	1. Verification of the meters accuracy: Equipments used to measure the electricity delivered to the grid are audited at least each two years by private companies accredited by the national dispatch center (UT). Audits are realized in the presence of members from the power producer and the audit-company commissioned by UT. Meter accuracy of the electricity meters have to meet the UT´s Annex of the Operation Norms of the Transmission System and Wholesale Market. In case of the meter accuracy is out of range or one of the meters is damaged, the meter is calibrated or substituted.

QA/QC procedures (continuation)	2. Cross checking: The project participant checks that the electricity generation data read by personnel of the power plant coincides with data stated in the monthly invoices. 3. Emergency procedures for the monitoring system: The electricity registered by the main meter constitutes the official metering. If this meter fails, the data of the back-up meter is used. The main and the back-up meter have been authorized by the Transactions Unit (Unidad de Transacciones, UT) of the electricity market. According to Wholesales Electricity Market and Transmission System Operation Regulation, if UT cannot to access the meters remotely, then downloads the metering data on site. When both meters fail, UT use the data registered by its SCADA system or the historical data or the data registered by LaGeo, in the mentioned order.
Purpose of data	These data will be used to calculate the baseline emissions.
Additional comment	Because electricity metering is by power unit at Berlin Power Plant, $EG_{facility,y}$ is calculated as the sum of the electricity measured by the electricity meters of units 1, 2 and 3 of Berlin Geothermal power plant.

B.7.2. Sampling plan

Not applicable.

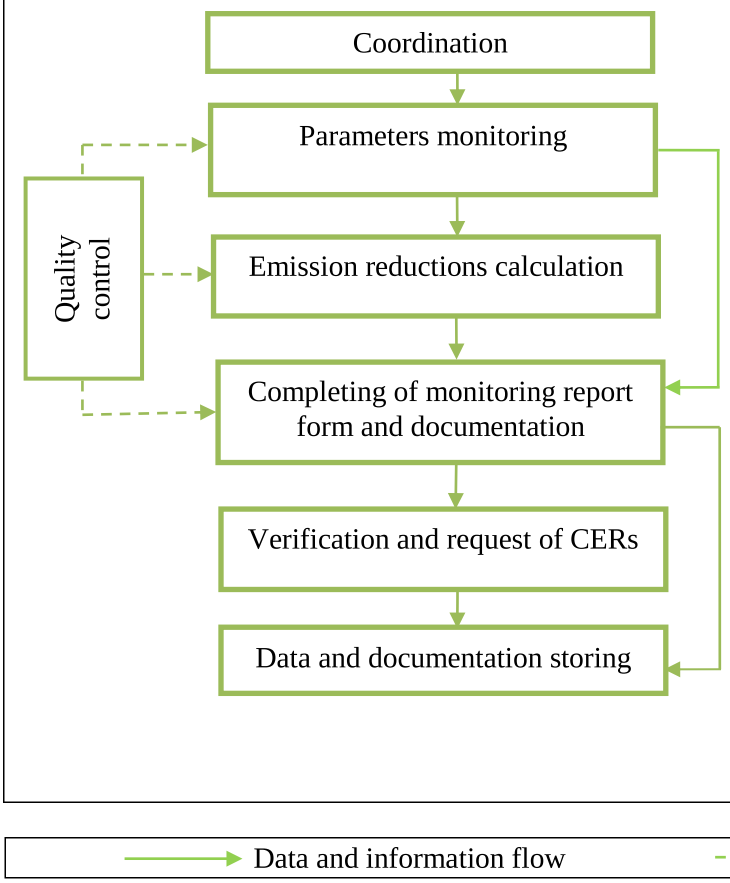
B.7.3. Other elements of monitoring plan

The operational and management structures necessary to monitor emission reductions and emissions of the Project Activity are described in the following chart.

The person in charge of the internal quality control is assigned by the CDM coordinator.

Table 7. Operational and management structure of the monitoring plan

Monitoring system



General process	Responsible
Coordination	• CDM coordinator
Parameters monitoring	• Operations coordinator • Measuring coordinator • Geo-chemical laboratory
Emission reductions calculation	• CDM coordinator • Environmental unit
Completing of monitoring report form and documentation	• CDM coordinator
Verification and request of CERs	• DOE commissioned by the project participant
Data and documentation storing	• CDM coordinator

SECTION C. Duration and crediting period

C.1. Duration of project activity

C.1.1. Start date of project activity
02/02/2007[27]

C.1.2. Expected operational lifetime of project activity
30y-0m.

C.2. Crediting period of project activity

C.2.1. Type of crediting period
Renewable (second crediting period)

C.2.2. Start date of crediting period

01/01/2014 (second crediting period)

C.2.3. Length of crediting period

7y-0m

[27] Letter issued by Transactions Unit (UT, *Unidad de Transacciones*), 06/05/2013.

SECTION D. Environmental impacts

D.1. Analysis of environmental impacts

The first environmental impact study regarding the exploration of the potential of the Berlin geothermal field to generate power was carried out in 1994 by Geotérmica Salvadoreña S.A de C.V (GESAL, today's LaGeo). The study was one of the requirements to obtain the environmental license for a geothermal condensation power plant. The objectives of the environmental impact study were:

- Identifying environmental (land, air and water) and socioeconomic impacts caused by all different activities related to the development of the project;
- Planning the mitigation of identified significant environmental and socioeconomic impacts; and
- Developing a control plan to assure that emissions are in compliance with applicable regulations and laws.

In May 1998, the El Salvadorian government approved a new environmental law. In the law, article #107 demanded that projects, which were already in place, should submit an environmental diagnosis in two years period. The environmental diagnosis for the Berlin Geothermal Power Plant was finished in the first semester of 2000 and subsequently submitted to MARN.

In February 2001, MARN act in response to the environmental diagnosis requesting from the project proponents clarifications on the following issues:

- Earmarked budget for environmental impacts mitigation;
- System for the canalization and re-injection of condensate;
- Inclusion of the activities listed in management plans, including monitoring program, in the compliance environmental program;
- Updating financial data on environmental plan.

In June 2001 MARN issued the resolution MARN-086-2001 providing the final environmental permit for the operation the Berlin Geothermal Power Plant. The permit foresees the generation of electricity by means of accessing a deep reservoir through a superficial structure that channels geothermal fluids from the reservoir to the surface by 24 wells in an area of 4 km^2. The decision was based on the evaluation and acceptance of the environmental diagnosis and the corresponding environmental adaptation and management plans. The proponent of the project also provided MARN a financial commitment to the environmental impact mitigation measures. All the documentation and licenses issued for the first phase of the Berlin Geothermal Power Plant were used as basis for the proposed Project Activity.

The proposed Project Activity is the expansion of the power generation capacity at the existing Berlin Geothermal Power Plant by 44 MW through the drilling of additional geothermal wells and the installation of a new condensation power unit. Specifically for the proposed Project Activity the following documents were issued by the El Salvadoran environmental agency:

- In October 21, 2002, MARN issued two documents MARN-DGA-NPA-337/2002, and 338/2002 freeing LaGeo from the environmental license for drilling of the re-injection wells and in March 10, 2003, MARN issued the document MARN-DGA-NPA-063/2003 freeing LaGeo from the environmental license for drilling of the production wells, both related to the Project Activity. The decision of releasing the project from these phases of the environmental permit was based on the low potential environmental impacts that these additional activities would generate, as confirmed by the analysis of the environmental diagnosis reports and site visits.
- Following, MARN received from LaGeo in March 11, 2003, an environmental management plan containing precautionary measures for environmental, social, safety and occupational health issues, for the construction phase of the project.

- Together with the plan, in March 11, 2003, MARN also received the authorization and acceptance of the project by the municipal government, represented by the major of Los Cañales, and the list of attendants to the public hearing, affirming the acceptance of the project by the local community.
- In July 2004, the project participants published in a national newspapers[28] three times a call for 10-day period stakeholders' comments after the third publication. The public notice informed that LaGeo S.A. had submitted an environmental impact study for carrying out the Project Activity. There was also an explanation on how any citizen or company could express his/her/its opinion about the project.
- In December 2, 2004, MARN issued Resolution-5133-796-2004, which granted LaGeo the needed license to operate. The license was issued since the ministry had received from the Project Activity the following documents: environmental impact study, management plan, two commentaries ("without any technical relevancy" according to MARN) during the stakeholder comment period, and a financial warranty as a guarantee for the environmental mitigation measures. MARN also stated that the Project Activity attended all environmental laws.
- Finally, in February 16th, 2005, MARN issued Resolution MARN-6259-123-2005, releasing LaGeo from preparation of additional environmental impact assessments for the activity based on the analysis of the environmental report made by LaGeo.

All mentioned resolutions, documents, studies and reports are available upon request.

D.2. Environmental impact assessment

In order to assess the potential environmental impacts of the project, LaGeo carried out all the studies and verifications required by the environmental agency. The objective was to mitigate potential adverse impacts on the natural and social environment surrounding the plant. The following series of studies were performed by LaGeo and thoroughly analyzed and approved by the authorities:

- Environmental impact information – December, 1994
- Environmental diagnosis – May, 2000
- Environmental characterization study – February, 2001
- Environmental impact study for the drilling of wells – June 2003, December 2003
- Environmental characterization of San Simon river – May 2003
- Environmental study for thermal fluid pipelines – May 2004
- Environmental analysis for complementary drilling – April 2004
- Environmental analysis of geothermal fluid transportation pipelines connection – August 2004
- Environmental analysis of power plant expansion – December 2004

According to the documents mentioned in the previous section and listed below, Project Activity environmental impacts were considered significant neither by the project participants nor by the host Party.

- MARN-086-2001
- MARN-DGA-NPA-337/2002
- MARN-DGA-NPA-338/2002

[28] El Diario de Hoy, San Salvador, El Salvador, July 7, 2004, page 56; July 8, 2004, page 52; July 7, 2004, page 66.

- MARN-DGA-NPA-063/2003
- MARN 5133-796-2004
- MARN-6259-123-2005

All mentioned resolutions, documents, studies and reports are available upon request.

SECTION E. Local stakeholder consultation

E.1. Solicitation of comments from local stakeholders

Local stakeholders' comments have been invited in the process of environmental licensing. Three public hearings were performed[29] in an open and transparent manner, facilitating comments to be received from local stakeholders and allowing for a reasonable time for comments to be submitted. As result of the hearings the Mayor of the City of Berlin sent on February 10, 2003, a letter to the Ministry of Environment expressing the agreement of the administration and its communities to the execution of the project. The mayor also stated believes of the communities on the beneficial role of the project to the region and the country.

Afterwards the project participants published in a national newspaper three times a call for 10-day period stakeholders' comments after the third publication[30]. The call in the paper informed that LaGeo S.A. had submitted an environmental impact study for carrying out the Project Activity. There was also an explanation on how any person or company could express his/her/its opinion about the project.

In order to obtain operation licenses, sponsors also developed education and communication programs for local communities regarding environmental aspects and projects impacts and benefits.

Work and engagement with stakeholders is managed through the Community Engagement Program (PACO from the Spanish "*Programa de Atención Comunitaria*") aimed at creating a harmonious, balanced and constructive environment with neighboring municipalities of Berlín, Mercedes Umaña and Alegría. The fundamental elements of PACO that maximize benefits to the community are the generation of local employment opportunities, social investment activities, development of sustainable small businesses and protection of the local environment.

E.2. Summary of comments received

The concerns expressed made by the stakeholders in the local public hearings are summarized below:

- Noise attenuation in the construction site
- Control of water drainage
- Protection and stabilization of slopes
- Improvement of roads and access to the site and surroundings
- Reforestation at the places damaged
- Adequate management of wastes and residues
- Actions directed to the protection of the wild life
- Generate local job positions during construction phase

Two comments were received after the three-day publication of call for comments in a national newspaper. The two comments were not taken into account since MARN did not consider them relevant.

[29] Hearings performed: First on August 23, 2002 (19 participants); second on October 25, 2002 (34 participants); third on November 12, 2002 (117 participants). Lists of participants as of sessions available upon request.

[30] El Diário de Hoy, San Salvador, El Salvador, July 7, 2004, page 56; El Diário de Hoy, July 8, 2004, page 52; El Diário de Hoy, July 7, 2004, page 66.

E.3. Report on consideration of comments received

LaGeo never received any complain from stakeholders (NGO, MARN or any public entity) regarding the Project Activity. All relevant[31] comments received, in the context of public hearings carried out within the environmental licensing and operation permitting process, were incorporated into the implementation of the project. Some of these concrete actions, aimed at managing public concerns and improving the wellbeing of the neighboring community, include:

Underground Water Management Publication: LaGeo published and communicated (via talks and seminars) an educational document providing detailed information on site underground conditions and best management practices. The document explains how are aquifers protected during the drilling and reservoir production process. The publication educates and allows the public to understand how is the company safeguarding the water supplies.

Water Monitoring: LaGeo conducts a permanent groundwater monitoring plan that surveys areas near operations through periodic sampling and analyses (this survey includes wells, aquifers, and point sources of water supply).

Public Affairs Office: in order to be available to the community and respond to any concern or issue, a Public Affairs office operates at the site. This office receives stakeholders and provides up-to-date information on environmental and social aspects related to the Project Activity. Some of the tools available to the stakeholder are: direct telephone hot line, newsletters, and public service announcements.

Environmental Education Program: a program has been implemented to enhance peoples understanding of geothermal resources and its importance in providing clean sustainable energy while protecting the environment. The program includes activities such as: school cleaning and maintenance practices; reforestation; etc.

[31] According to MARN.

SECTION F. Approval and authorization

MINISTERIO DE MEDIO AMBIENTE Y
RECURSOS NATURALES

MARN-DGGA-271/2005

San Salvador, October 31, 2005

Reference: Letter of approval of the project "LaGeo S.A. de C.V., Berlin Geothermal Project, Phase Two"

Mr. José Antonio Rodríguez
General Manager
LaGeo S.A. de C.V.

Dear Mister Rodríguez:

We wish to refer to the project "LaGeo S.A. de C.V., Berlin Geothermal Project, Phase Two" (the Project), submitted for our approval. As authorized representative of the Designated National Authority (DNA) for the Clean Development Mechanism (CDM) of the Republic of El Salvador, we hereby confirm:

i) The Republic of El Salvador ratified the Kyoto Protocol on September 17, 1998.
ii) The Republic of El Salvador and the project participants, voluntary participate in the CDM.
iii) The Republic of El Salvador recognizes the Project Participant's rights to all Certified Emission Reductions (CERs) generated by the Project, and accepts the transfer of all CERs during the crediting period of the Project.
iv) The Project assists the Republic of El Salvador in achieving sustainable development.

This letter of approval is valid, only if the Project Design Document (PDD) had been validated by a Designated Operational Entity (DOE).

Sincerely,

Hugo Barrera
Minister

Kilómetro 5 ½ Carretera a Santa Tecla, Calle y Colonia Las Mercedes, Edificio MARN (Instalaciones ISTA), San Salvador, El Salvador. Tel: (503) 2267-9343, Fax: (503) 2267-9339
http://www.marn.gob.sv

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Appendix 1: Contact information of project participants

Organization name	LaGeo, S. A. de C. V.
Street/P.O. Box	15 Avenida Sur, Colonia Utila
Building	LaGeo
City	Santa Tecla
State/Region	La Libertad
Postcode	N/A
Country	El Salvador
Telephone	+ (503) 2211-6700
Fax	+ (503) 2211-6746
E-mail	info@lageo.com.sv
Website	http://www.lageo.com.sv/
Contact person	
Title	CDM Coordinator
Salutation	Ingeniero
Last name	Loy
Middle name	
First name	Rubén Antonio
Department	
Mobile	+503 7843-9588
Direct fax	N/A
Direct tel.	+503 2211-6757
Personal e-mail	rloy@lageo.com.sv

Appendix 2: Affirmation regarding public funding

No public funding was and will be used in the present project.

Appendix 3: Applicability of selected methodology

See sections B.1 and B.2

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

Calculation of the Operating Margin 2010

Group of plants m

Power unit	Technology type	Operation starting date	$EGm_{,2010}$ Energy produced 2010	i Fuel Type	$EF_{CO2,m,i,y}$ Average emission factor	Conversion factor	η_m Default efficiency	$EF_{EL,m,y}$ Emission factor of unit	CO_2 emissions (tCO_2)
UT	SIGET	SIGET	UT		Inventory Workbook (IPCC, 2006)	Conversion factor from the International System of Units	Meth tool, appendix 1	Calculated	Calculated
Fuel based power plants* (see below)									
Acajutla	Diesel engines and internal combustion motors	1995-2007	533,100	Diesel	72.60	3.6	39.5%	0.662	352,736.75
Soyapango	Internal combustion motors	1972	24,400	Bunker	75.50	3.6	30%	0.906	22,106.40
Nejapa Power	Internal combustion motors	1995	406,600	Bunker/diesel	72.60	3.6	30%	0.871	354,229.92
Clesa 1/	Distributed generation	N/A	100	N/A	-	-	-	-	-
Cessa	Internal combustion motors	2001	55,400	Bunker	75.50	3.6	39.5%	0.688	38,120.81
Textufil	Internal combustion motors	2006	200,800	Bunker	75.50	3.6	39.5%	0.688	138,170.73
Ine	Internal combustion motors	2006	600,200	Bunker	75.50	3.6	39.5%	0.688	412,998.38
Borealis	Internal combustion motors	2007	54,800	Bunker	75.50	3.6	39.5%	0.688	37,707.95
Gecsa	Internal combustion motors	2007	56,800	Bunker	75.50	3.6	39.5%	0.688	39,084.15
Inm. Apopa	Internal combustion motors	2012	38,100	Bunker	75.50	3.6	39.5%	0.688	26,216.66
Total			**1,970,300**						**1,421,371.75**

Group of plants k

Power unit	Technology type	Operation starting date	$EGk_{,2010}$ Energy produced 2010 (MWh)	i Fuel Type	$EF_{CO2,m,i,y}$ Average emission factor of fuel type i (tCO_2/TJ)	Conversion factor (TJ/MWh)	η_m Default efficiency factors (%)	$EF_{EL,m,y}$ Emission factor of unit m (tCO_2/MWh)	CO_2 emissions (tCO_2)
UT			UT		Inventory Workbook (IPCC, 2006)	Conversion factor from the International System of Units	Meth tool, appendix 1	Calculated	Calculated
Hydro (see below)**									
Guajoyo	Hydroelectric plant	1963-1964	84,800	Water	-	-	-	-	-
Cerrón Grande	Hydroelectric plant	1977-1979	723,700	Water	-	-	-	-	-
5 de Noviembre	Hydroelectric plant	1954-1956	529,300	Water	-	-	-	-	-
15 de Septiembre	Hydroelectric plant	1983	741,400	Water	-	-	-	-	-
Geothermal									
Ahuachapán	Geothermal plant	1975	643,500	Geothermal steam		-	-	-	-
Berlín	Geothermal plant	1992	777,700	Geothermal steam	-	-	-	-	-
Cogenerators									
Cassa	Internal combustion motors	2003	109,100	Biomass	-	-	-	-	-
Ing. El Angel	Internal combustion motors	2008	43,000	Biomass	-	-	-	-	-
Ing. La Cabaña	Internal combustion motors	2008	27,800	Biomass	-	-	-	-	-
Imports									
Imports			174,200		-	-	-	-	-
Total			**3,854,500**						**0**

$EF_{grid,OM-adj,\ 2010}$	**0.705**	**tCO2/MWh**

Calculation of the Operating Margin 2011

Group of plants m

			$EGm_{,2011}$	i	EF $_{CO2,m,i,y}$		η_m	EF $_{EL,m,y}$	
Power unit	**Technology type**	**Operation starting date**	**Energy produced 2011 (MWh)**	**Fuel Type**	**Average emission factor of fuel type i (tCO_2/TJ)**	**Conversion factor (TJ/MWh)**	**Default efficiency factors (%)**	**Emission factor of unit m (tCO_2/MWh)**	**CO_2 emissions (tCO_2)**
UT	**SIGET**	**SIGET**	**UT**		**Inventory Workbook (IPCC, 2006)**	**Conversion factor from the International System of Units**	**Meth tool, appendix 1**	**Calculated**	**Calculated**
Fuel based power plants * (see below)									
Acajutla	Diesel engines and internal combustion motors	1995-2007	723,400	Diesel	72.60	3.6	39.5%	0.662	478,652.72
Soyapango	Internal combustion motors	1972	30,100	Bunker	75.50	3.6	30%	0.906	27,270.60
Nejapa Power	Internal combustion motors	1995	435,200	Bunker/diesel	72.60	3.6	30%	0.871	379,146.24
AES Clesa 1/	Distributed generation	N/A	200	N/A	-	-	-	-	-
Cessa	Internal combustion motors	2001	37,900	Bunker	75.50	3.6	39.5%	0.688	26,079.04
Textufil	Internal combustion motors	2006	192,000	Bunker	75.50	3.6	39.5%	0.688	132,115.44
Ine	Internal combustion motors	2006	592,200	Bunker	75.50	3.6	39.5%	0.688	407,493.57
Borealis	Internal combustion motors	2007	39,100	Bunker	75.50	3.6	39.5%	0.688	26,904.76
Gecsa	Internal combustion motors	2007	45,200	Bunker	75.50	3.6	39.5%	0.688	31,102.18
Inm. Apopa	Internal combustion motors	2012	27,100	Bunker	75.50	3.6	39.5%	0.688	18,647.54
Cassa-Com	Internal combustion motors	2003	11,700						
DELSUR 1/	Distributed generation	N/A	300	N/A	0.00	0	0.0%	-	-
Edesal 1/	Distributed generation	N/A	-	N/A	-	-	-	-	-
Total			**2,134,400**						**1,527,412.09**

Group of plants k

			$EGk_{,2011}$	i	EF $_{CO2,m,i,y}$		η_m	EF $_{EL,m,y}$	
Power unit	**Technology type**	**Operation starting date**	**Energy produced 2011 (MWh)**	**Fuel Type**	**Average emission factor of fuel type i (tCO_2/TJ)**	**Conversion factor (TJ/MWh)**	**Default efficiency factors (%)**	**Emission factor of unit m (tCO_2/MWh)**	**CO_2 emissions (tCO_2)**
UT			**UT**		**Inventory Workbook (IPCC, 2006)**	**Conversion factor from the International System of Units**	**Meth tool, appendix 1**	**Calculated**	**Calculated**
Hydro* (see below)									
Guajoyo	Hydroelectric plant	1963-1964	102,000	Water	-	-	-	-	-
Cerrón Grande	Hydroelectric plant	1977-1979	643,600	Water	-	-	-	-	-
5 de Noviembre	Hydroelectric plant	1954-1956	551,800	Water	-	-	-	-	-
15 de Septiembre	Hydroelectric plant	1983	709,000	Water	-	-	-	-	-
Geothermal									
Ahuachapán	Geothermal plant	1975	645,800	Geothermal steam	-	-	-	-	-
Berlín	Geothermal plant	1992	784,200	Geothermal steam	-	-	-	-	-
Cogenerators									
Cassa	Internal combustion motors	2003	99,700	Biomass	-	-	-	-	-
Ing. El Angel	Internal combustion motors	2008	40,200	Biomass	-	-	-	-	-
Ing. La Cabaña	Internal combustion motors	2008	18,000	Biomass	-	-	-	-	-
Imports									
Imports			215,800		-	-	-	-	-
Total			**3,710,400**						**-**

$EF_{grid,OM-adj, 20121}$	**0.706**	**tCO2/MWh**

Calculation of the Operating Margin 2012

Group of plants m

Power unit	Technology type	Operation starting date	$EGm_{,2012}$ Energy produced 2012 (MWh)	i Fuel Type	$EF_{CO2,m,i,y}$ Average emission factor of fuel type i (tCO_2/TJ)	Conversion factor (TJ/MWh)	η_m Default efficiency factors (%)	$EF_{EL,m,y}$ Emission factor of unit m (tCO_2/MWh)	CO_2 emissions (tCO_2)
UT	SIGET	SIGET	UT		Inventory Workbook (IPCC, 2006)	Conversion factor from the International System of Units	Meth tool, appendix 1	Calculated	Calculated
Fuel based power plants* (see below)									
Acajutla	Diesel engines and internal combustion motors	1995-2007	841,000	Diesel	72.60	3.6	39.5%	0.662	556,465.22
Soyapango	Internal combustion motors	1972	35,000	Bunker	75.50	3.6	30%	0.906	31,710.00
Nejapa Power	Internal combustion motors	1995	560,900	Bunker/diesel	72.60	3.6	30%	0.871	488,656.08
AES Clesa 1/	Distributed generation	N/A	100	N/A	-	-	-	-	-
Holcim	Internal combustion motors	2001	12,300	Bunker	75.50	3.6	39.5%	0.688	8,463.65
Textufil	Internal combustion motors	2006	224,400	Bunker	75.50	3.6	39.5%	0.688	154,409.92
Ine	Internal combustion motors	2006	661,700	Bunker	75.50	3.6	39.5%	0.688	455,316.61
Borealis	Internal combustion motors	2007	8,300	Bunker	75.50	3.6	39.5%	0.688	5,711.24
Gecsa	Internal combustion motors	2007	9,200	Bunker	75.50	3.6	39.5%	0.688	6,330.53
Inm. Apopa	Internal combustion motors	2012	14,200	Bunker	75.50	3.6	39.5%	0.688	9,771.04
Edesal 1/	Distributed generation	N/A	-	N/A	-	-	-	-	-
Total			**2,367,100**						**1,716,834.28**

Group of plants k

Power unit	Technology type	Operation starting date	$EGk_{,2012}$ Energy produced 2012 (MWh)	i Fuel Type	$EF_{CO2,m,i,y}$ Average emission factor of fuel type i (tCO_2/TJ)	Conversion factor (TJ/MWh)	η_m Default efficiency factors (%)	$EF_{EL,m,y}$ Emission factor of unit m (tCO_2/MWh)	CO_2 emissions (tCO_2)
UT			UT		Inventory Workbook (IPCC, 2006)	Conversion factor from the International System of Units	Meth tool, appendix 1	Calculated	Calculated
Hydro* (see below)									
Guajoyo	Hydroelectric plant	1963-1964	75,500	Water	-	-	-	-	-
Cerrón Grande	Hydroelectric plant	1977-1979	49,400	Water	-	-	-	-	-
5 de Noviembre	Hydroelectric plant	1954-1956	553,800	Water	-	-	-	-	-
15 de Septiembre	Hydroelectric plant	1983	659,900	Water	-	-	-	-	-
Geothermal									
Ahuachapán	Geothermal plant	1975	639,500	Geothermal steam		-	-	-	-
Berlín	Geothermal plant	1992	781,000	Geothermal steam	-	-	-	-	-
Cogenerators									
Cassa	Internal combustion motors	2003	132,100	Biomass	-	-	-	-	-
Ing. El Angel	Internal combustion motors	2008	55,000	Biomass	-	-	-	-	-
Ing. La Cabaña	Internal combustion motors	2008	17,600	Biomass	-	-	-	-	-
Imports									
Imports			163,400		-	-	-	-	-
Total			**3,127,200**						**0**

$EF_{grid,OM-adj,\ 2012}$	0.725	tCO_2/MWh

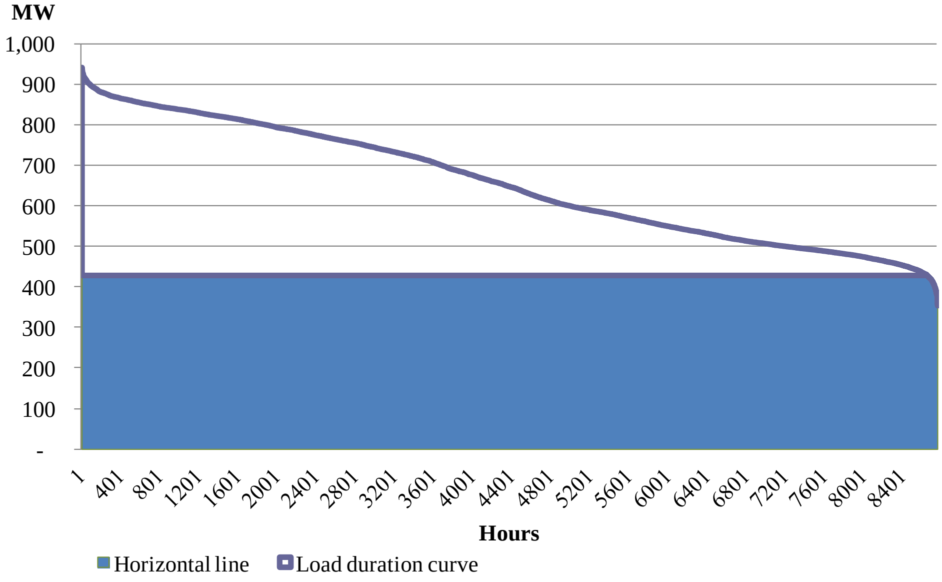
Calculation of Operating Margin according to the simple adjusted method

	2010	2011	2012	Total
EFgrid,OMsimple, y	0.705	0.706	0.725	
EGy	5,824,800	5,844,800	5,494,300	17,163,900
Weight	0.339	0.341	0.320	
$EF_{OMsimple, y}$ weigthened	0.239	0.240	0.232	

$EF_{grid,OM,2009-2011}$	0.711	(t CO_2/MWh)

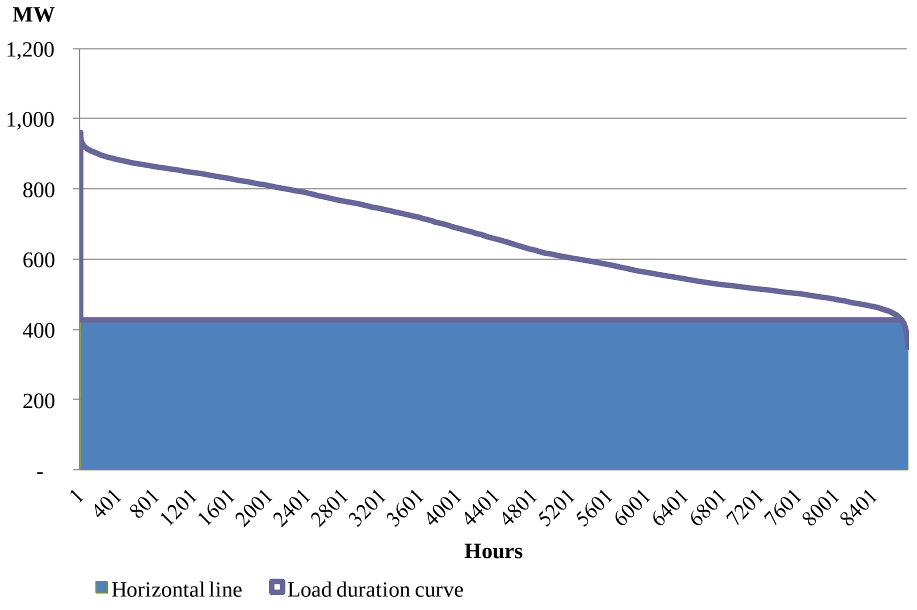
Lambda 2010

LAMBDA CALCULATION		2010
Annual energy produced by group of plants k	MWh	3,854,500
Intersection point with the horizontal line	MW	441
No. hours that plants k are on the margin	hours	200
λ	%	0.0228
1 - λ	%	0.9772



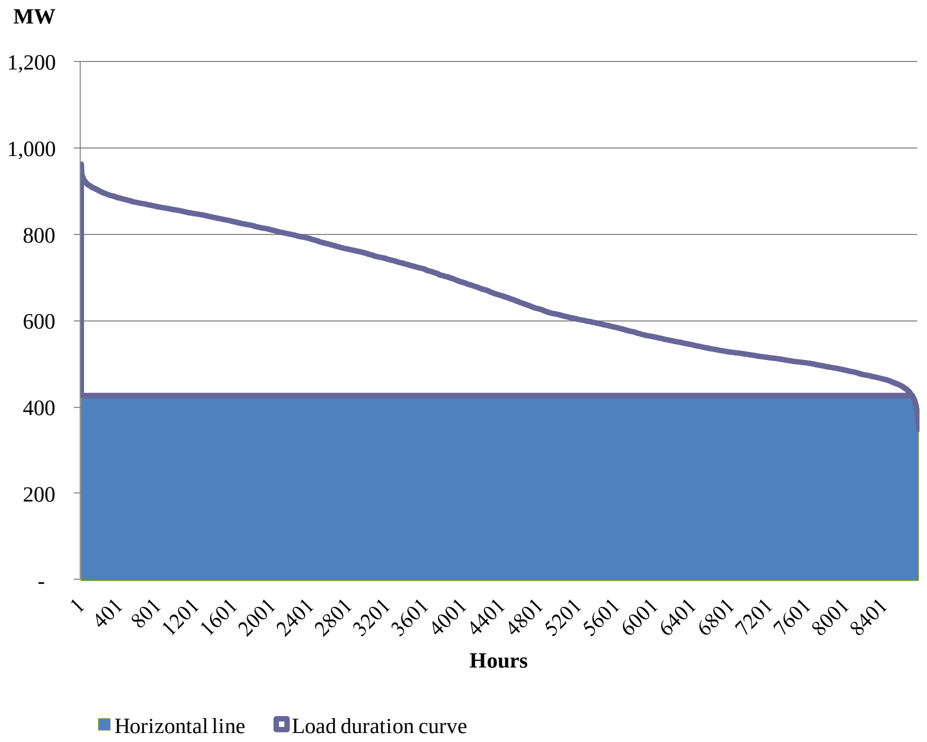
Lambda 2011

LAMBDA CALCULATION		2011
Annual energy produced by group of plants k	MWh	3,854,500
Intersection point with the horizontal line	MW	440
No. hours that plants k are on the margin	hours	114
λ	%	0.0130
1 - λ	%	0.9870



Lambda 2012

LAMBDA CALCULATION		2012
Annual energy produced by group of plants k	MWh	3,127,200
Intersection point with the horizontal line	MW	366
No. hours that plants k are on the margin	hours	2
Number of days in the year		366
λ	%	0.0002
1 - λ	%	0.9998



Calculation of the operating margin

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

			$EGm_{,2011}$		i	$EF_{CO2,m,i,y}$		η_m	$EF_{EL,m,y}$	
Power unit	Technology type	Operation starting date	Energy produced 2011 (MWh)	Accumulative energy producction (MWh)	Fuel Type	Average emission factor of fuel type i (t CO2/TJ)	Conversion factor (TJ/MWh)	Default efficiency factors (%)	Emission factor of unit m t (CO2/MWh)	CO_2 emissions 2010 (t CO2)
ENEE	ENEE	ENEE	ENEE	Calculated	ENEE	Inventory Workbook (IPCC, 2006)	Conversion factor from the International System of Units	Meth tool, appendix 1	Calculated	Calculated
Inm. Apopa	Internal combustion motors	2012	14200	14200	Bunker	75.50	3.6	39.5%	0.688	9,771.04
Ing. La Cabaña	Internal combustion motors	2008	17600	31800	Biomass	-	-	-	-	-
Borealis	Internal combustion motors	2007	8300	40100	Bunker	75.50	2.6	39.5%	0.497	4,124.78
Gecsa	Internal combustion motors	2007	9200	49300	Bunker	75.50	3.6	39.5%	0.688	6,330.53
Textufil	Internal combustion motors	2006	224400	273700	Bunker	75.50	4.6	39.5%	0.879	197,301.57
Total			49,300							10,455.32

b) Calculation of the 20% of total annual generation of the project electricity system, excluding CDM project activities (20% AEGtotal)

20% AEG_{total} = 1,051,352 MWh

c) Selection of the set of units that comprises 20% of total annual generation

			$EGm_{,2012}$		i	$EF_{CO2,m,i,y}$		η_m	$EF_{EL,m,y}$	
Power unit	Technology type	Operation starting date	Energy produced 2012 (MWh)	Accumulative energy producction (MWh)	Fuel Type	Average emission factor of fuel type i (tCO_2/TJ)	Conversion factor (TJ/MWh)	Default efficiency factors (%)	Emission factor of unit m (tCO_2/MWh)	CO_2 emissions (tCO_2)
ENEE	ENEE	ENEE	ENEE	Calculated	ENEE	Inventory Workbook (IPCC, 2006)	Conversion factor from the International System of Units	Meth tool, appendix 1	Calculated	Calculated
Inm. Apopa	Internal combustion motors	2012	14,200	14,200	Bunker	75.50	3.6	39.5%	0.688	9,771.04
Ing. La Cabaña	Internal combustion motors	2008	17,600	31,800	Biomass	-	-	-	-	-
Borealis	Internal combustion motors	2007	8,300	40,100	Coal	89.50	3.6	39%	0.826	6,857.08
Gecsa	Internal combustion motors	2007	9,200	49,300	Bunker	75.50	1.6	39.5%	0.306	2,813.57
Textufil	Internal combustion motors	2006	224,400	273,700	Bunker	75.50	2.6	39.5%	0.497	111,518.28
Ine	Internal combustion motors	2006	661,700	935,400	Bunker	75.50	3.6	39.5%	0.688	455,316.61
Holcim	Internal combustion motors	2001	12,300	947,700	Bunker	75.50	4.6	39.5%	0.879	10,814.66
Nejapa Power	Internal combustion motors	1995	560900	1,508,600	Bunker/die	72.6	3.6	30%	0.8712	488656.08
Total			**1,508,600**							**597,091.23**

d) Plants older than 10 years are excluded and CDM projects included.

			$EGm_{,2012}$		i	$EF_{CO2,m,i,y}$		η_m	$EF_{EL,m,y}$	
Power unit	Technology type	Operation starting date	Energy produced 2012 (MWh)	Accumulative energy producction (MWh)	Fuel Type	Average emission factor of fuel type i (tCO_2/TJ)	Conversion factor (TJ/MWh)	Default efficiency factors (%)	Emission factor of unit m (tCO_2/MWh)	CO_2 emissions (tCO_2)
ENEE	ENEE	ENEE	ENEE	Calculated	ENEE	Inventory Workbook (IPCC, 2006)	Conversion factor from the International System of Units	Meth tool, appendix 1	Calculated	Calculated
Inm. Apopa	Internal combustion motors	2012	14,200	14,200	Bunker	75.5	3.6	39.5%	0.688	9,771.04
Ing. La Cabaña	Internal combustion motors	2008	17,600	31,800	Biomass	-	-	-	-	-
Ing. El Angel	Internal combustion motors	2008	55,000	86,800	Biomass	-	-	-	-	-
Borealis	Internal combustion motors	2007	8,300	95,100	Coal	89.5	3.6	39%	0.826	6,857.08
Gecsa	Internal combustion motors	2007	9,200	104,300	Bunker	75.5	1.6	39.5%	0.306	2,813.57
Textufil	Internal combustion motors	2006	224,400	328,700	Bunker	75.5	2.6	39.5%	0.497	111,518.28
Ine	Internal combustion motors	2006	661,700	990,400	Bunker	75.5	3.6	39.5%	0.688	455,316.61
Cassa	Internal combustion motors	2003	132,100	1,122,500	Biomass	-	-	-	-	-
Total			**1,122,500**							**586,276.57**

e) The set of units that represent 20% of total annual generation is selected because comprises the larger annual generation. Additionally the set does not have a power unit older than 10 years.

$EF_{grid, BM, 2012}$	0.522 tCO_2/MWh

Calculation of the combined margin

Emission Factor	*Ex-post* option
	tCO_2/MWh
Operating Margin	0.711
Build Margin	0.522
W_{OM}	0.250
W_{BM}	0.750
Combined Margin	**0.569**

Appendix 5: Further background information on monitoring plan

This section is intentionally left empty (see section D for monitoring plan).

Appendix 6: Summary of post registration changes

Permanent changes from registered monitoring plan or applied methodology

1. The monitoring plan has been revised to consider the parameter $M_{t,y}$ (quantity of steam generated during well testing) as negligible. The revision was approved on June 10, 2009.

2. The monitoring plan was revised in 2011 in order to be more realistic and according to ACM0002. The revision was approved on May 3, 2011.

Changes to start date of crediting period

1. The starting date on the registered PDD changed from June 1st, 2006 to January 1st, 2007.

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History of the document

Version	Date	Nature of revision
04.1	11 April 2012	Editorial revision to change version 02 line in history box from Annex 06 to Annex 06b.
04.0	EB 66 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	EB 25, Annex 15 26 July 2006	
02	EB 14, Annex 06b 14 June 2004	
01	EB 05, Paragraph 12 03 August 2002	Initial adoption.
Decision Class: Regulatory **Document Type:** Form **Business Function:** Registration		