Monitoring report form for CDM project activity
(Version 07.0)

Complete this form in accordance with the instructions attached at the end of this form.

MONITORING REPORT		
Title of the project activity	LaGeo, S.A. de C.V., Berlin Geothermal Project, Phase Two	
UNFCCC reference number of the project activity	0297	
Version number of the PDD applicable to this monitoring report	21	
Version number of this monitoring report	1	
Completion date of this monitoring report	01/06/2020	
Monitoring period number	Fifth of the second period	
Duration of this monitoring period	Duration from 01/01/2018 - 31/12/2018	
Monitoring report number for this monitoring period	Not applicable	
Project participants	LaGeo, S.A. de C.V.	
Host Party	El Salvador	
Applied methodologies and standardized baselines	1. Energy industries (renewable - / non-renewable sources)	
Sectoral scopes	Methodology: ACM0002, version 14 Consolidated methodology for grid-connected electricity generation from renewable sources	
Amount of GHG emission reductions or net anthropogenic GHG removals achieved by the project activity in this monitoring period	Amount achieved before 1 January 2013	Amount achieved from 1 January 2013
	0 tCO_2e	141,429 tCO_2e
Amount of GHG emission reductions or net anthropogenic GHG removals estimated ex ante for this monitoring period in the PDD	150,171 tCO_2e	

SECTION A. Description of project activity

A.1. General description of project activity

LaGeo, S.A. de C.V., Berlin Geothermal Project, Phase Two is a capacity addition 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 electricity produced is supplied to the national interconnected grid. This power unit is named Unit 3.

Further information about this project can be found in the PDD and documents associated, which are available on UNFCCC website:
http://cdm.unfccc.int/Projects/DB/DNV-CUK1141464500.33/view

Figure 1. Facilities of the project activity

Relevant dates for the project activity

- Registration as a large scale CDM project: May 25, 2006.
- Starting of the first crediting period: January 1st, 2007.
- Starting of generation tests and initial of electricity injections to the grid: January 4, 2007[1].
- Starting of commercial operations on February 2, 2007[2].
- End of the commissioning period and acceptance by LaGeo: April 17, 2007[3].

LaGeo, S.A. de C.V. is the owner of Berlin Geothermal Plant that has operated the facilities of the project activity in accordance to the Environment Law[4] and Electricity General Law[5] of the El Salvador since activity project registration.

LaGeo, S.A. de C.V. is committed to contribute to sustainable development and to pursue the harmonious relations between the company and surrounding communities to Berlín geothermal field, with the purpose to create development opportunities for increase the quality of life of its

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[1] According to data registered by the electricity meter and downloaded by Transactions Unit (UT).

[2] Letter issued by Transactions Unit (UT, Unidad de Transacciones).

[3] Acceptance by LaGeo

[4] Ministerio de Ambiente y Recursos Naturales, Ley del Ambiente, 1998.

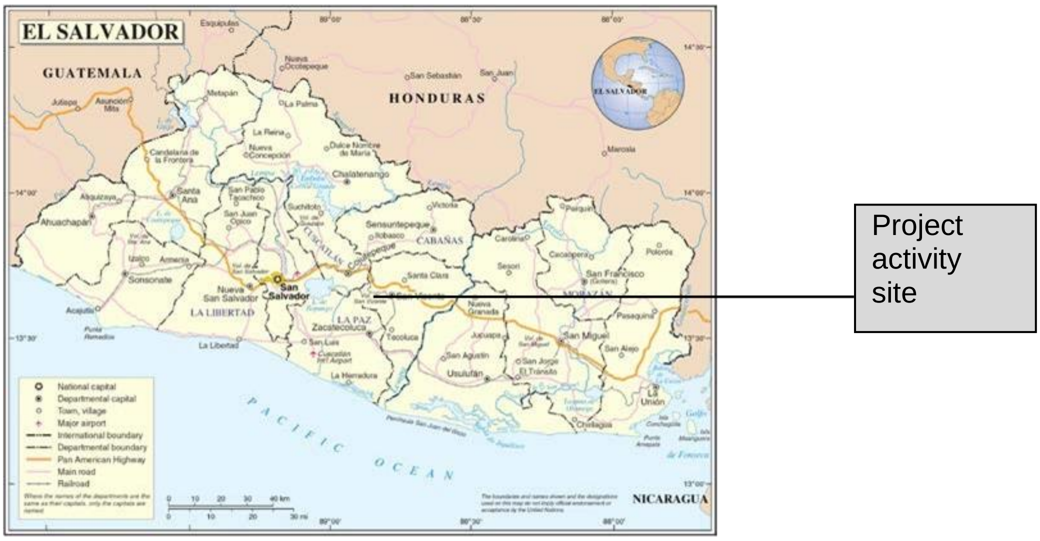
[5] 5 SIGET, Ley General de Electricidad, 1997, http://www.siget.gob.sv/images/documentos/electricidad/legislacion/ley_general_de_electricidad junio2009_0.pdf

neighbours. During the monitoring period, the Project Participant supported different community projects through its Corporate Responsibility Program, covering the environmental, social and economic dimensions of sustainable development and 24 communities of Alegría, Berlín and Mercedes Umaña municipalities resulted benefited.

The emission reductions due to the activity project during the monitoring period were 141,429 tCO_2e.

A.2. Location of project activity

- Host Party: El Salvador
- Department: Usulatán
- Municipality: Alegría
- Coordinates: latitude 13.525064 and longitude -88.508661



A.3. Parties and project participants

Parties involved	Project participants	Indicate if the Party involved wishes to be considered as project participant (Yes/No)
El Salvador	LaGeo, S.A. de C.V.	NO

A.4. References to applied methodologies and standardized baselines

For the second crediting period, 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 and methodologies:

- Type I: Renewable energy project
- Sectoral Scope: Energy industries (renewable - / non-renewable sources)
- Category Renewable electricity generation for a grid (energy generation, supply, transmission and distribution): Consolidated baseline methodology for grid-connected electricity generation from renewable sources (ACM0002, version 14.0.0)[6]

[6] https://cdm.unfccc.int/filestorage/A/0/4/A04BWNRKLUEP6O1QX75YVTH28JDICZ/EB%2075_repan13_ACM0002_ver%2014.0.pdf?t=Qmd8cGg1amlzfDBUDNQe6bbaB84gjm8ruE9C

- Tool reference : Tool to calculate the emission factor for an electricity system (version 04.0)[7].
- Assessment of the validity of the original/current baseline and update of the baseline at the renewal of the crediting period. Version 03.0.1 (https://cdm.unfccc.int/methodologies/PAmethodologies/tools/am-tool-11-v3.0.1.pdf)

A.5. Crediting period type and duration

Renewable crediting period, seven (7) years, with the option of renewing the contract for two other 7-year crediting periods (total 21 years).

This monitoring report refers to the fith monitoring period of the second crediting period. The duration of the crediting period corresponding to this monitoring period has the start and end dates in 01/01/2014 to 31/12/2020.

SECTION B. Implementation of project activity

B.1. Description of implemented project activity

The project activity uses condensing units and includes the following facilities: TR-18, TR-17 and TR-19 platform wells, the steam and water conveyor systems, the power generation equipment, the electricity measurement system and auxiliary services. The following simplified diagram illustrates the main components of the power unit located within the physical boundaries of the activity project during the monitoring period[8].

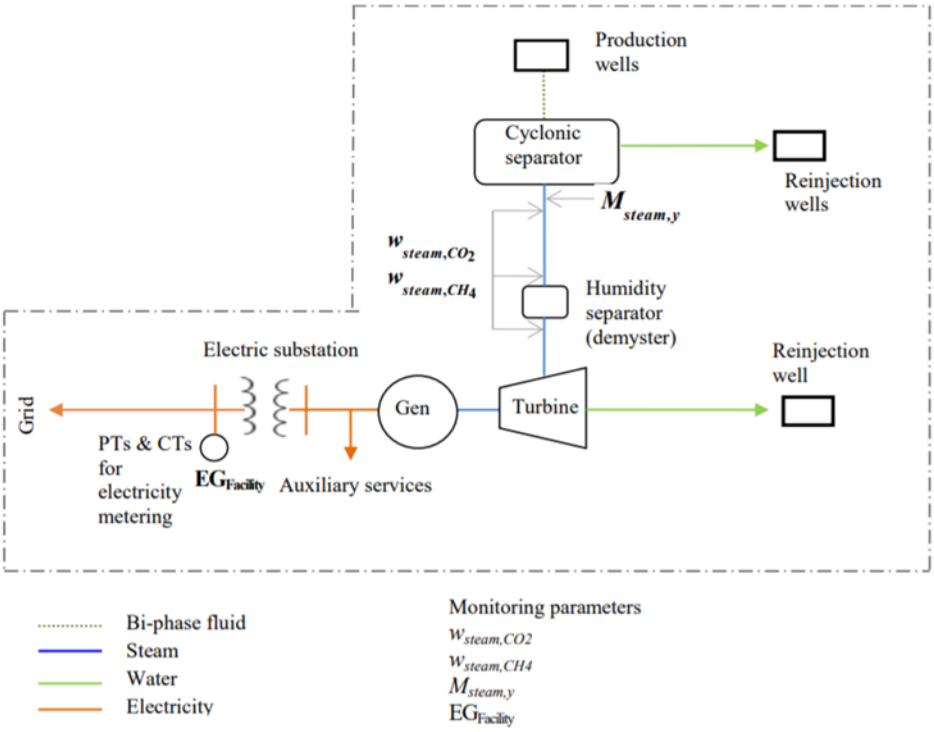


Figure 3. Boundaries of the project activity at the moment of the monitoring period

[7] https://cdm.unfccc.int/methodologies/PAmethodologies/tools/am-tool-07-v4.0.pdf

[8] The PDD establishes the boundaries of the project activity as: “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”.

The platforms TR-18 and TR-17 comprises three production wells each one, from which geothermal fluid is extracted. Platform TR-19 comprises four injection wells. The description of the constructed wells is as follow:

Table 1. Characteristics of the constructed production wells for unit 3

	Type	Final diameter (inches)	Measured Depth (m)	Characteristics		
				WHP Bar g	Steam kg/s	Production (MWe)
TR-17	Vertical	8.5"	2,600	10.14	12.5	6.2
TR-17A	Directional	8.5"	2,690	10.10	12.5	6.1
TR-17B	Directional	12.25"	1,845	11.35	18.5	8.0
TR-18	Vertical	8.5"	2,660	13.70	14.2	6.2
TR-18A	Directional	12.25"	1,085	11.90	57.8	25.1
TR-18B	Directional	9.625"	1,191.5	9.26	13.18	5.7

Table 2. Characteristics of the constructed reinjection wells for unit 3

		Final diameter (inches)	Measured Depth (m)	Average reinjection rate (Tonnes/hour)
TR-19	Vertical	12.25"	1,176.5	180
TR-19A	Directional	8.5"	2,369	50
TR-19B	Directional	8.5"	3,125	325
TR-19C	Directional	8.5"	3,455	100

The geothermal fluid from the wells flows to the separators, where is separated in steam and liquid phases. Then, the surface pipelines deliver the steam to the powerhouse and high temperature liquid flow is delivered to the geothermal reservoir through the reinjection wells at TR-19 platform.

The powerhouse is equipped with a turbine and a synchronous generator as is illustrated in figure 4. The steam drives the turbine to produce electricity that is delivered to the grid through a line transmission. In order to avoid geothermal resource depletion, the steam used in the powerhouse passes to a condenser to return it to liquid phase before is injected back into earth through a reinjection well.

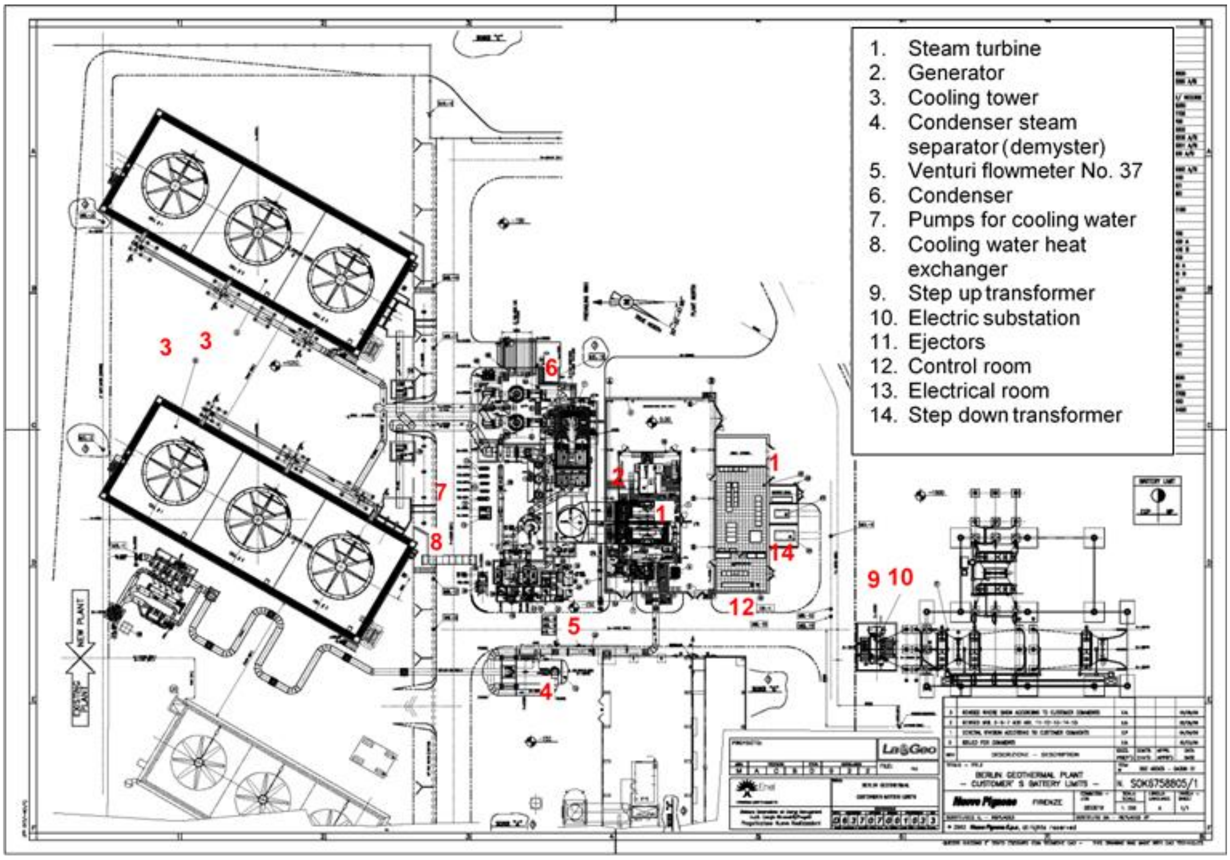


Figure 4. Components of the generating unit

The project activity began operation tests on January 4, 2007 and commercial operations on February 2, 2007.

During the monitoring period there have been no significant events at the facility

B.2. Post-registration changes

B.2.1. Temporary deviations from the registered monitoring plan, applied methodologies, standardized baselines or other methodological regulatory documents

Not applicable

B.2.2. Corrections

Not applicable.

B.2.3. Changes to the start date of the crediting period

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

The second crediting period started on January 1st, 2014 and finishes on December 31, 2020.

B.2.4. Inclusion of monitoring plan

Not applicable

B.2.5. Permanent changes to the registered monitoring plan, or permanent deviation of monitoring from the applied methodologies, standardized baselines, or other methodological regulatory documents

The monitoring plan was revised twice during the first crediting period. The first revision was to consider the parameter Mt,y (quantity of steam generated during well testing) as negligible. The revision was approved on June 10, 2009. The second revision of the monitoring plan was done in 2011 in order to be more realistic and according to the ACM0002, which was approved on May 3, 2011.

B.2.6. Changes to project design

There have not been permanent changes in relation to the project design of the registered project activity

B.2.7. Changes specific to afforestation or reforestation project activity

Not applicable

SECTION C. Description of monitoring system

The implemented monitoring system consists of eight main processes illustrated in the following chart and each process comprises several procedures that are indicated in the tables of parameters described in section D

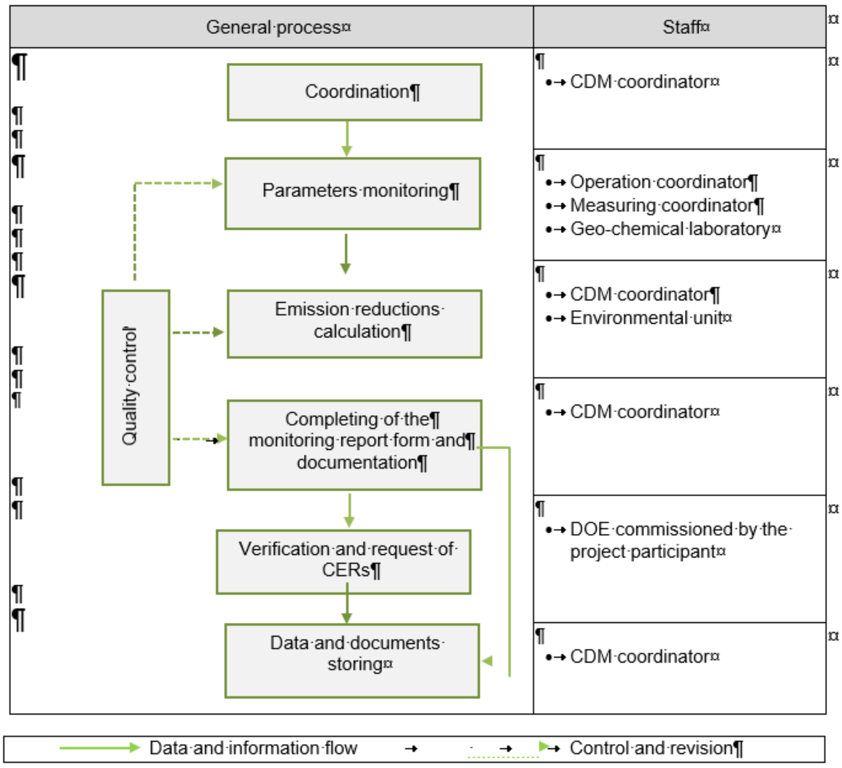


Figure 5. Process of the monitoring system

Quality control and quality assurance involves different procedures and good practices:

- Use of electric energy meters with accuracy and technical specifications according to Unit Transactions´s standards.

- There is a back-up electricity metering equipment and duplicated sampling points to avoid loss of information.
- Development of clear and defined procedures for data downloading and recording.
- Development of clear and defined procedures for emissions reductions calculations.
- There are emergency procedures for each monitoring parameter.

Following figure shows the location of site where is measured the quantity geothermal steam produced ($M_{steam,y}$) and the steam sampling sites to determinate the average mass fraction of CO_2 and CH_4 in the produced steam in year y. The figure also shows the configuration of wells connections.

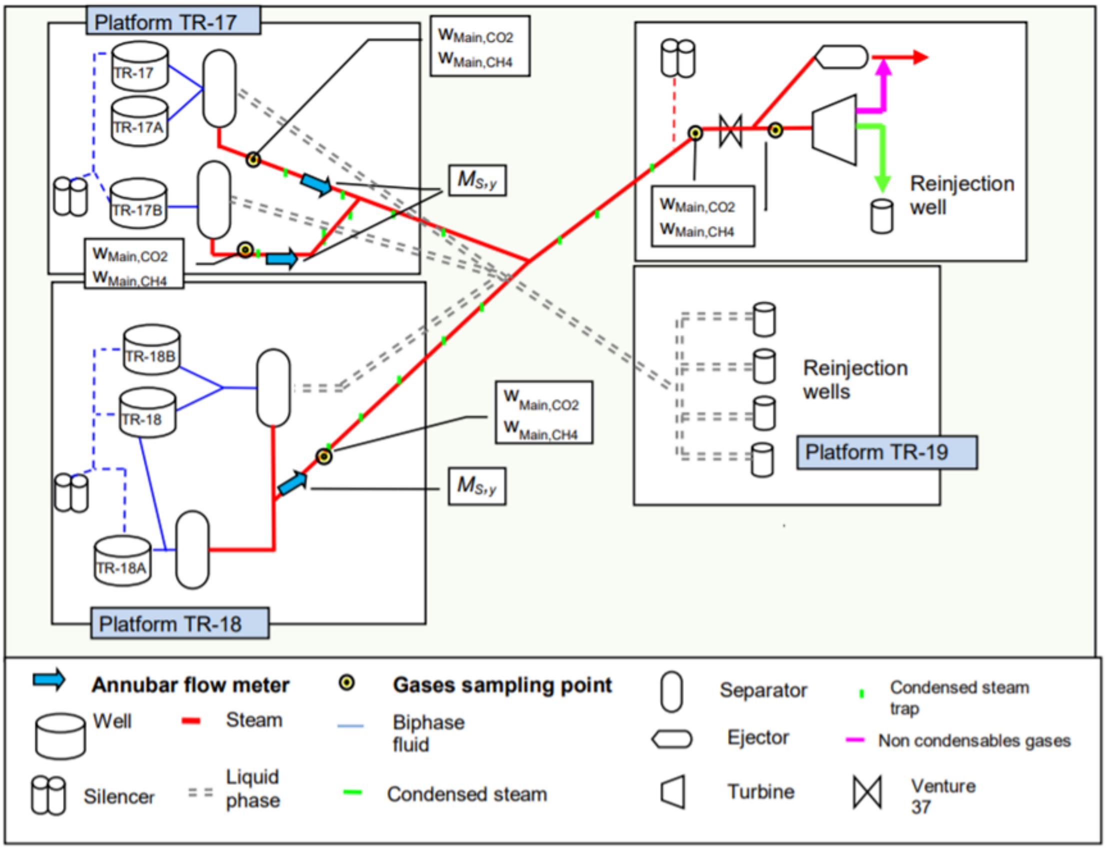


Figure 6. Location of flowmeters and the steam sampling points

SECTION D. Data and parameters

D.1. Data and parameters fixed ex ante

As per the updated PDD at the renewal of the crediting period, and considering that the project activity is capacity addition, the parameters and data fixed ex ante are:

- EF (emission factor of the grid)
- GWP_{CH4} (global warming potential of methane valid for the second commitment period)
- $EG_{historical}$ (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)
- $\sigma_{historical}$ (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)

- $DATE_{BaselineRetrofit}$ (point in time when the existing equipment would need to be replaced in the absence of the project activity)

Their description is as follow:

Table 3. Emission factor of the grid

Data/Parameter	EF
Unit	tCO_2/MWh
Description	Emission factor of the grid
Source of data	Project design document updated at the renewal of the crediting period
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/parameter	This factor is used for baseline emissions calculation.
Additional comments	

Table 4. Global warming potential of methane valid for the second commitment period

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 comments	-

Table 5. Annual average historical net electricity generation delivered to the grid by the existing renewable energy

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 Transactions 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 comments	-

Table 6. Standard deviation of the annual average historical net electricity generation delivered to the grid by the existing renewable energy plant

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 comments	-

Table 7. Point in time when the existing equipment would need to be replaced in the absence of the project activity

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 baseline emissions
Additional comments	- 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*.

D.2. Data and parameters monitored

As per the updated PDD at the renewal of the crediting period and considering that the project activity is capacity addition, the parameters monitored are:

- $w_{steam,CO2}$ (average mass fraction of CO_2 in the produced steam in year y)
- $w_{steam,CH4}$ (average mass fraction of CH_4 in the produced steam in year y)
- $M_{steam,y}$ (Quantity of steam produced in year *y*)
- $EG_{facility,y}$ (Quantity of net electricity generation supplied by the project plant to the grid in year y

Its description is a follow

Table 8. Average mass fraction of dioxide of carbon in the produced steam

Data/Parameter	$w_{steam,CO2}$
Unit	tCO_2/t steam
Description	Average mass fraction of CO_2 in the produced steam in year y
Measured/calculated/ default	Measured
Source of data	Laboratory report of analysis results
Value(s) of monitored parameter	See table below

	Average CO_2 fraction	**Average mass fraction of carbon dioxide in the produced steam**
	mmol / 100 mol H_2O	t CO_2/ t steam
January 2018	496.3960	1.2134E-02
February 2018	496.3960	1.2134E-02
March 2018	496.3960	1.2134E-02
April 2018	511.0702	1.2493E-02
May 2018	511.0702	1.2493E-02
June 2018	511.0702	1.2493E-02
July 2018	557.4908	1.3628E-02
August 2018	557.4908	1.3628E-02
September 2018	557.4908	1.3628E-02
October 2018	603.5218	1.4753E-02
November 2018	603.5218	1.4753E-02
December 2018	603.5218	1.4753E-02
CO_2 molecular weight (g/m)	44	
H_2O molecular weight (g/mol)	18	

Average mass fraction of CO_2 in the produced steam in 2018 = 1.3252E-02(t CO_2/ t steam)

Monitoring equipment	A titrimeter is used in the Geo-chemical Laboratory of LaGeo to determinate the CO_2 fraction. Type: Automatic titrimeter Manufacturer: Mettler Toledo Serial number: 5126290638 Calibration frequency: Biannual Date of calibrations performed, which are valid for the monitoring period: 07/04/2017; 27/11/2017 Accuracy class: ± 0.1 mV (resolution of the voltage signal from the electrode immersed in the solution, see calculation method below) Maintenance: It includes an external and internal cleaning, physical revision of equipment components and auto-test performing as per manufacturer specifications. Following figure shows the titrimeter used in the laboratory.  Figure 7. DL22 Analyzer
Measuring/reading/recording frequency	At least every three months.
Calculation method (if applicable)	The average mass fraction of carbon dioxide in the produced steam is calculated through a laboratory analysis of steam samples in the Geo-chemical Laboratory of LaGeo. CO_2 is determined with a DL22 analyzer from Metter Toledo by a titration method using a standard acid-base (NaOH) at PH 8.3. The solution brand is Titrisol and the used concentration is 0.1 mol in 1 liter; formula certified by Merck. The titration method consists in the measurement of the potential of the electrode immersed in the solution.

QA/QC procedures	Quality is assured following good practices, activity procedures, an internal audit and international standards: • Sampling is performed according to the internal procedures PT-MUE-01. The procedure is based on ASTM Standard Practice E1675 for Sampling 2-Phase Geothermal Fluid and the ASTM Standard Practice E947 for Sampling Single-Phase Geothermal Liquid or Steam for Purposes of Chemical Analysis. • The quality of the results is analyzed in accordance with the procedure PG-MET-008 and the uncertainty of the method has been estimated according to the procedure PG-MET-003. • The Geo-chemical Laboratory of LaGeo is accredited by ISO/IEC 170258. • An internal audit is carried out once a year under the Program of Internal Audit F-ASE-001 of the Geochemistry laboratory. Its objectives cover the evaluation and assessment of all management system in accordance with the requirements of the norm NSR ISO IEC 17025 and it comprises the review of all aspects of the management system implemented in different areas: water, gas and sampling of the laboratory, as per the Quality Control Manual
Purpose of data/parameter	Calculation of activity project emissions.
Additional comments	<u>Data storage</u> Data is archived in electronic and paper <u>Geothermal steam sampling procedure:</u> • Geothermal steam sampling is conducted on-site, at production wells as well as steam field-power plant interface (turbine inlet of Unit 3). There are six sample points: one for each steam line coming from the wells (three lines, four sample points), other located upstream of the separator (demyster) and a sixth point at the turbine inlet, after the separator (demyster). See figure 6 in section C. • Two samples are taken per sampling point and date. Steam samples are collected with glass flasks like the bottle; filled with 50 ml of sodium hydroxide solution. Under vacuum conditions, the solution absorbs the dioxide of carbon forming a calcium carbonate, while the methane remains in its gaseous phase. For the foregoing reason, the technical personnel verify the vacuum existence in the glass flasks to avoid air pollution during sampling. <u>Emergency procedures for the monitoring system</u> There is redundancy in the quantity of sampling points to avoid loss of data in case of a sample fails or a sample point is not available due to maintenance works at well platforms. <u>Procedures for sampling and analysis</u> PT-MUE-001: Procedure for geothermal steam sampling PT-MUE-003: Procedure to prepare glass flasks PT-MUE-004: Procedure for sampling at well pad (two phase line) PT-GAS-POT-001: Procedure for CO_2 determination F-GAS-001: Form to report operation tests of DL22 analyzer F-GAS-002: Form to report CO_2 calculations F-GAS-003: Form to report CO_2 results in mmol F-GAS-006: Form for calculation of geothermal gases F-GAS-004: Form for registration of results IT-GAS-EQ-OPE 002: Manual operation for titrimeter DL22 analyzer

Table 9. Average mass fraction of methane in the produced steam

Data/Parameter	w_{steam,CH_4}
Unit	tCH_4/t steam
Description	Average mass fraction of CH4 in the produced steam in year *y*
Measured/calculated/ default	Measured
Source of data	Laboratory report of analysis results
Value(s) of monitored parameter	(see table below)

	Average CH_4 fraction	**Average mass fraction of methane in the produced steam**
	mmol / 100 mol H_2O	t CH_4/ t steam
January 2018	0.0301	2.68E-07
February 2018	0.0301	2.68E-07
March 2018	0.0301	2.68E-07
April 2018	0.0305	2.72E-07
May 2018	0.0305	2.72E-07
June 2018	0.0305	2.72E-07
July 2018	0.0347	3.08E-07
August 2018	0.0347	3.08E-07
September 2018	0.0347	3.08E-07
October 2018	0.0448	3.99E-07
November 2018	0.0448	3.99E-07
December 2018	0.0448	3.99E-07
CH_4 molecular weight (g/m)	16	
H_2O molecular weight (g/mol)	18	

Average mass fraction of methane in the produced steam in 2018= 3.12E-07t CH_4/ t steam

<table>
<tr>
<td>Monitoring equipment</td>
<td>
The Geo-chemical Laboratory uses a chromatograph with a mass selective detector HP 5973, serial number US81221621.

<table>
<tr><td>Type</td><td>Chromatographer</td></tr>
<tr><td>Manufacturer</td><td>Hewlett Packard 6890</td></tr>
<tr><td>Serial number</td><td>US00022485</td></tr>
<tr><td>Calibration frequency</td><td>Biannual</td></tr>
<tr><td rowspan="2">Date of calibration/verification</td><td>04/04/2017</td></tr>
<tr><td>23/11/2017</td></tr>
<tr><td>Accuracy class</td><td>Not applicable.

The EPC gas control modules contain flow and/or pressure sensors that are calibrated at the factory. Sensitivity (slope of the curve) is quite stable, but zero offset requires periodic updating to flow calibration.

The equipment is provided with an automatic calibration function that is executed following several steps in order to zeroing flow and pressure sensors.</td></tr>
<tr><td>Maintenance</td><td>The verification of the chromatograph is conducted to clean the mass selective detector and carry out tests of critical points according manufacturer protocol.</td></tr>
</table>

A photograph of the HP 6890 gas chromatograph is shown in the following figure:

Figure 8. HP 6890 gas chromatograph
</td>
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<tr>
<td>Measuring/reading/recording frequency</td>
<td>At least every three months.</td>
</tr>
<tr>
<td>Calculation method (if applicable)</td>
<td>The geothermal steam samples are analyzed in the Geo-chemical Laboratory of LaGeo to determinate methane in gases of geothermal origin. The average mass fraction of CH_4 in the produced steam is determined using a gas chromatographic technique, the gas sample is vaporized and injected onto chromatographic columns and then separated into the gas components.

Methane, CH_4, is analyzed following the internal procedure PT-GAS-CG- 001.
A moving gas (the mobile phase) carries the sample across a stationary phase (the solid support found within a GC column). The inert gas is from American Gas & Cylinder.</td>
</tr>
</table>

QA/QC procedures	Quality is assured following good practices, activity procedures, an internal audit and international standards: • Sampling is performed according to the internal procedure PT-MUE-01. The procedure is based on ASTM Standard Practice E1675 for Sampling 2-Phase Geothermal Fluid for Purpose of Chemical Analysis. • The quality of the results is analyzed in accordance with the procedure PG-MET-008 and the uncertainty of the method has been estimated according to the procedure PG-MET-003. • The Geo-chemical Laboratory of LaGeo is accredited by ISO/IEC 17025. An internal audit is carried out once a year under the Program of Internal Audit F-ASE-001 of the Geochemistry laboratory. Its objectives cover the evaluation and assessment of all management system in accordance with the requirements of the norm NSR ISO IEC 17025 and it comprises the review of all aspects of the management system implemented in different areas: water, gas and sampling of the laboratory, as per the Quality Control Manual.
Purpose of data/parameter	Calculation of activity project emissions
Additional comments	Data storing: Data is archived in electronic and paper. Geothermal steam sampling procedure: • Geothermal steam sampling is conducted on-site, at the platforms of the production wells as well as steam field-power plant interface (turbine inlet of Unit 3). There are six sample points: one for each steam line coming from the wells (three lines), other located upstream of the separator (demyster) and a sixth point at the turbine inlet, after the separator (demyster). See figure 6 in section C. • Two samples are taken per sampling point and date. Steam samples are collected with glass flasks; filled with 50 ml of sodium hydroxide solution. Under vacuum conditions, the solution absorbs the dioxide of carbon forming a calcium carbonate, while the methane remains in its gaseous phase. For the foregoing reason, the technical personnel verify the vacuum existence in the glass flasks to avoid air pollution during sampling. The procedures followed by laboratory personnel for sampling and analysis are: PT-MUE-001: Procedure for geothermal steam sampling PT- MUE-003: Procedure to prepare glass flasks PT-MUE-004: Procedure for sampling at well pad (two phase line) F- GAS-006: Form for calculation of geothermal gases F-GAS-004: Form for register the results F-EQ-001: Template to report the results of the tests PT- GAS-CG-001: Procedure for CH_4 determination IT-GAS-EQ-OPE_001: Manual for Chromatograph operation. Emergency procedures for the monitoring system There is redundancy in the quantity of sampling points to avoid loss of data in case of a sample fails or a sample point is not available due to maintenance works at well platforms.

Table 10. Quantity of steam production

Data/Parameter	$M_{steam,y}$
Unit	t steam/yr
Description	Quantity of steam produced during year *y*
Measured/calculated / default	Measured
Source of data	Monthly production report
Value(s) of monitored parameter	Following table shows the quantity of steam production totalized by group of wells (wells in the same platform) and the total quantity of steam produced in 2018.

$M_{steam, y}$	TR-17 well	TR-17A well	TR-18 well
$t_{steam/2018}$	$t_{steam/2018}$	$t_{steam/2018}$	$t_{steam/2018}$
1,964,843	628,769	728,993	607,081

Monitoring equipment	Quantity of steam production is measured by annubar flowmeters. They basically are a Pitot tubes with an electronic pressure transmitter that measure simultaneously differential pressure, static pressure, and process temperature to dynamically calculate fully compensated mass flow. There are three flowmeters installed at the platforms of the wells. The pipes from the wells are connected in three configurations and there is a flowmeter for each one. Next table indicates the wells of each configuration during the monitoring period:

wells	Train TR-17A vertical well) TR-17 A (directional well)	TR-17 B (directional well)	• TR-18 (vertical well) TR-18A (directional well) TR-18B (directional well)

Description of the flowmeters

	Train TR-17A	Train TR-17 B	Train TR-18
	Annubar flowmeter	Annubar flowmeter	Annubar flowmeter
Brand	Rosemount	Rosemount	Rosemount
Model	3095MFA	3095MFA	3095MFA
Serial No.	0020194	0034201	0041393
Installation date	Since plant construction	09/10/2009	22/02/2011
Date of calibrations	11/03/2017	11/03/2017	10/03/2017
	18/05/2017	18/05/2017	17/05/2017
Accuracy class	The performance of the flowmeter is ±0.90% of mass flow rate accuracy.		
Calibration frequency	The calibration frequency is biannual		
	The transmitters of the annubar flowmeters are initially calibrated in-factory by the manufacturer. According to the manufacturer, the electronics of the pressure transmitters of the annubar flowmeters is very stable in operation, allowing up to 10 year calibration cycles		
	Personnel of the Instrumentation Laboratory perform a maintenance management system in order to systematize maintenance activities. This system is based on an internal quality control method, which requires that annubars flowmeters be tested on site when they are installed by first time, and routine activities are carried out biannually to verify meters accuracy and calibrations.		

The description of the data loggers,

	Train TR-17A	Train TR-17 B	Train TR-18
Manufacturer	Pace Scientific	Pace Scientific	Pace Scientific
Model	XR440	XR440	XR440
Serial number	CM215T727	CM215T728	CM215T730
Installation date[9][10]	25/10/2016	25/10/2016	2510/2016
Calibration date in-factory	08/07/2015	08/07/2015	08/07/2015
Accuracy class	±0.25% at 13 bits	±0.25% at 13 bits	±0.25% at 13 bits
Calibration frequency	Each three years	Each three years	Each three years

Measuring/reading/recording frequency	$M_{steam,y}$ is measured continuously and data is registered via a data logger each 15 minutes and the Measurement Technician downs load data daily. $M_{steam,y}$ data is registered daily.
Calculation method (if applicable)	Not applicable.
QA/QC procedures	Quality is assured following good practices and activity procedures.
Purpose of data/parameter	Project emissions calculations.

[9] The instruments used to calibrate the transmitters of the flowmeters are the Fluke 754 and Fluke 744 process calibrators, and Fluke 700PD7 pressure modules and a Hart 375 communication protocol

Additional comments	Data storing: The Exploration coordinator is in charge of data storing. The personnel of the Reservoir Engineering Unit analyze the measurement and the resulting information are summarized in the "Daily production report" and in the "Monthly production report", which are available to engineering personnel through LaGeo Intranet. It is reported the total amount of steam production for each well in ktonnes. Measurement procedures (Internal codes): PRA-655-01 Procedure for flow meter reading and data register PROC-627-001: Procedure for Calibration and Revision of Metering equipment. Emergency procedures for the monitoring system: Additionally to annubar flowmeters at platform wells, a venturi flowmeter is installed at the turbine inlet to measure the quantity of geothermal steam flow used for electricity production. This venturi flow meter could be used as backup in case of annubar flowmeters failure and it could be used to verify the data registered by the annubars. The values registered by the annubar flow meters are compared against the data registered by the venturi according to procedure PRG-425- 16, and difference must be around 2% due to the condensation of steam along pipes, being higher the value metered by annubar flowmeters. Since measurement from annubar flowmeters gives a higher value, it is considered more conservative for emissions reductions calculation. On the other hand, the temperature and pressure conditions are registered at production wells to define the steam properties and compare field data against the production models.

Table 11. Quantity of net electricity generation supplied by the project plant to the grid

Data/Parameter	$EG_{facility,y}$
Unit	MWh
Description	Quantity of net electricity generation supplied by the project plant to the grid in year *y*
Measured/calculated/ default	Measured
Source of data	Electricity meters at project site
Value(s) of monitored parameter	There are separate electricity meters for each power unit at the facility, see figure 9, below. Hence, the net electricity supplied to the grid by the project plant is equal to the summation of the net electricity delivered by each power unit existing prior the project activity plus the net electricity provided by the project activity

Month	**Unit 1 MWh**	**Unit 2 MWh**	**Unit 3 MWh**	**Egfacility,2018 MWh**
January 2018	20,259.00	20,637.00	28,275.00	69,171.00
February 2018	18,107.56	18,436.00	25,053.46	61,597.02
March 2018	19,791.16	20,257.00	21,894.74	61,942.90
April 2018	18,915.93	19,345.00	22,404.38	60,665.32
May 2018	19,250.01	19,667.00	28,451.37	67,368.38
June 2018	18,643.97	19,094.00	27,474.88	65,212.85
July 2018	19,308.43	19,784.00	28,440.84	67,533.27
August 2018	15,162.44	19,257.00	27,671.65	62,091.10

September 2018	1,796.89	18,528.00	26,836.61	47,161.50
October 2018	14,526.32	19,325.00	28,466.58	62,317.90
November 2018	14,053.49	18,648.00	28,416.29	61,117.77
December 2018	14,513.06	18,480.00	28,922.71	61,915.76
Total*	**194,328.00**	**231,458.00**	**322,308.00**	**748,094.00**

* Figures are rounded

Monitoring equipment	Measurements are undertaken using two bidirectional electricity meters per power unit. One meter is used as the main and the other as the secondary or back-up. Meters measure the electricity delivery to the grid at the delivery point, receiving the voltage and current signal from the instrument transformers located in the step-up substation. The net electricity supplied to a grid is the difference between the measured quantities of the grid electricity export and the import. Next tables content the general information of all the power units:

Unit 1		
	Main meter	Back-up meter
Type[11]	Electricity meter	Electricity meter
Accuracy class	Meter 0.2 PT 0.3 CT 0.3	Meter 0.2 PT 0.3 CT 0.3
Serial number	128-0119306222	128-0119306323
Verification of meter accuracy frequency	Each two years	Each two years
Calibration date	12/06/2015-26/06/2017	12/06/2015 --26/06/2017

Unit 2		
Type[12]	Main meter	Back-up meter
Accuracy class	Meter 0.2 PT 0.3 CT 0.3	Meter 0.2 PT 0.3 CT 0.3
Serial number	166-0 184 807 735	136-0 125 833 426
Verification of meter accuracy frequency	Each two years	Each two years
Calibration date	07/11/2016-26/06/2017	12/06/2015-26/06/2017

Unit 3 (capacity addition due to the project activity)		
Type[13]	Main meter	Back-up meter
Accuracy class	Meter 0.2 PT 0.3 CT 0.3	Meter 0.2 PT 0.3 CT 0.3
Serial number	146-0 146 292 125	146-0 146 292 226
Verification of meter accuracy frequency	Each two years	Each two years
Calibration date	25/06/2015-26/06/2017	25/06/2015-26/06/2017

[11] The electricity meters are multifunctional, three-phase, bidirectional and equipped with a modem, they record energy in programmable intervals and store the data accumulatively, at least for two months

[12] The electricity meters are multifunctional, three-phase, bidirectional and equipped with a modem, they record energy in programmable intervals and store the data accumulatively, at least for two months

[13] The electricity meters are multifunctional, three-phase, bidirectional and equipped with a modem, they record energy in programmable intervals and store the data accumulatively, at least for two months

	 Figure 9. Electricity meters at the control center of the facility. For each unit there is a back up and a main meter, from left to right, in this array.
Measuring/reading/recording frequency	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. Continuous measurement and at least monthly recording. 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 downloaded 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. Continuous measurement and at least monthly recording
Calculation method (if applicable)	.
QA/QC procedures	1. Verification of the meter's accuracy: The equipment used to measure the electricity delivered to the grid is audited at least each two years by private companies accredited by the national dispatch center (UT). Audits are performed 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. 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/parameter	These data will be used to calculate the baseline emissions.
Additional comments	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.

D.3. Implementation of sampling plan

Not applicable

SECTION E. Calculation of emission reductions or net anthropogenic removals

E.1. Calculation of baseline emissions or baseline net removals

According to the updated PDD, baseline emissions are calculated as follows:

$$BE_y = EG_{PJ,y} * EF_{grid,CM} \quad \text{Eq. 1}$$

Where:

BE_y	=	Baseline emissions in year *y* (tCO_2/yr)	=	See table 12 below
$EG_{PJ,y}$	=	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)	=	See explanation below
$EF_{grid,CM,y}$	=	Emission factor, fixed ex-ante according to the PDD	=	0.569 t CO_2/MWh
y	=	year	=	2018

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:

$$EG_{PJ,y} = EG_{facility,y} - (EG_{historical} + \sigma_{historical}) \text{ ; until } DATE_{BaselineRetrofit} \qquad \text{Eq. 2}$$

And

$EG_{PJ,y} = 0$; 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)	=	294,347 See table 12 below
$EG_{facility,y}$	=	Quantity of net electricity generation supplied by the project plant to the grid in year *y*. In the updated PDD, this parameter is interpreted as the total electricity generation of the existing plant and the added unit (Because there are meters separately for each power units this parameter is the sum of the data read for units 1, 2, and 3). (MWh)	=	748,094
$EG_{historical}$	=	Fixed ex ante as 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)	=	440,843
$\sigma_{historical}$	=	Fixed ex ante as the 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)	=	12,904
$DATE_{BaselineRetrofit}$	=	Fixed ex ante as the point in time (date) when the existing equipment would need to be replaced in the absence of the Project Activity	=	2029

Then, the baseline emissions defined in equations 1 and 2 are computed using the spreadsheet called “Emission Reductions Calculation UIII_2018-V1.xls” according to the internal procedure **PRG-425-15** as follow:

Step 1. Calculation of the net electricity delivered by capacity addition (unit 3)
In the sheet “electricity data”, entry the data from the electricity meter of the unit 3, in hourly form, in order to calculate the monthly values

Step 2. Calculation of $EG_{facility,y}$
In the xls, entry the amount of electricity generated by Units 1 and 2, which are the power units of the existing plant previous to the implementation of the project activity. Also, entry the amount of the electricity generated by the power unit 3 that is provided by the project activity. Data is in a monthly form.

Step 3. Calculation of $EGP_{J,y}$
The quantity of net electricity generation that is produced and fed into the grid as a result of the implementation of the CDM Project Activity is computed automatically by the spreadsheet.

Step 4. Baseline emissions calculation
The baseline emissions of the project are calculated automatically annually of the monitoring period in the sheet called “BE_y”, whose results are shown in the following table

Following a deductive approach, the results are:

Table 12. Baseline emissions

Parameter as per the updated PDD	BE_{2018}	=	$EG_{PJ,2018}$		$EF_{grid,CM,2018}$
Description	Baseline emissions		Quantity of net electricity generation that is produced and fed into the grid as a result of the implementation of the CDM project activity		Emission factor
Unit	t CO_2		MWh		t CO_2/MWh
	167,483		294,347		0.569

Table 13. Calculation of Quantity of net electricity generation that is produced and fed into the grid as a result of the implementation of the CDM project activity

Parameter as per the updated PDD	$EG_{PJ,2018}$		$EG_{facility,2018}$		$EG_{historical}$		$\sigma_{historical}$
Brief description	Quantity of net electricity generation that is produced and fed into the grid as a result of the implementation of the CDM project activity		Quantity of net electricity generation supplied by the project plant to the grid		Annual average historical net electricity generation delivered to the grid by the existing energy plant (U1 & U2)		Standard deviation of $EG_{historical}$
Unit	MWh		MWh		MWh		MWh
Results	294,347	=	748,094	-	440,843	-	12,904

Table 14. Calculation of Quantity of net electricity generation supplied by the project plant to the grid

Parameter	$EG_{facility,2018}$		Unit 1		Unit 2		Unit 3 (capacity addition)
Unit	Quantity of net electricity generation supplied by the project plant to the grid						
Results	748,094	=	194,328	+	231,458	+	322,308

E.2. Calculation of project emissions or actual net removals

Project emissions, PE*y*, are calculated according to the internal procedure **PRG-425-15**. This procedure describes the steps to calculate the PE*y* using the spreadsheet called "Emission Reductions Calculation UIII_2018-V1.xls". The spreadsheet was designed according to the version 14 of the ACM0002 methodology

As per methodology ACM0002, version 14, the project emissions consist of the fugitive carbon dioxide and methane emission due to the release of non-condensable gases from the produced steam, which are greenhouse gases plus project emissions from combustion of fossil fuel.

$PE_y = PES_y + PEFF_y$ Eq. 3

Where:

PE_y	=	Project emissions (t CO_2 e)
PES_y	=	Project emissions due release of CO_2 and CH_4 from geothermal steam (t CO_2 e)
$PEFF_y$	=	Project emissions due combustion of fossil fuels (t CO_2 e)
y	=	2018

<u>Because project emissions due combustion of fossil fuels are negligible, PEFFy is zero and PEy results equal to PES*y*.</u>

Therefore:

The project emissions, CO_2 emissions and CH_4 emissions are calculated from the fractional content of CO_2 emissions and CH_4 in the geothermal steam as follows:

$$PES_y (t\ CO_2\ e) = (w_{Main,CO_2} + w_{Main,CH4} * GWP_{CH_4}) * M_{s,y}$$

Where:

PES_y	=	Project emissions due release of CO_2 and CH_4 from geothermal steam (t CO_2 e)
w_{Main,CO_2}	=	Average mass fraction of carbon dioxide in the produced steam
w_{Main,CH_4}	=	Average mass fraction of methane in the produced steam
GWP_{CH_4}	=	Global warming potential of methane (default value 25 tCO_2/tCh_4)
$M_{s,y}$	=	Quantity of steam produced during the year (t)
y	=	2018

Then, PE_y are computed using the spreadsheet called “Emission Reductions Calculation UIII_2018-V1.xls” through the following steps:

Step 1. Entry variables $w_{Main,CO2}$, $w_{Main,CH4}$, $GWPCH_4$ and $M_{steam,y}$ in sheet PE_y of “Emission Reductions Calculation UIII_2018-V1.xls”

Step 2. Project emissions are calculated automatically annually of the monitoring period in the sheet called “PE_y”, whose results are shown in the following table.

Table 15. Calculation of project emissions during the monitored period

Description	Project Emissions due to release of CO_2 and CH_4 from the produced steam	Project emissions from combustion of fossil fuels	Project emissions
Unit	t CO_2 e	t CO_2 e	t CO_2 e
Total	26,054	0	26,054

E.3. Calculation of leakage emissions

The project activity does not imply emissions outside its boundaries, therefore leakages are zero and therefore:

Ly = Leakages occurred during the monitored period = zero

E.4. Calculation of emission reductions or net anthropogenic removals

	Baseline GHG emissions or baseline net GHG removals ($t\ CO_2e$)	Project GHG emissions or actual net GHG removals ($t\ CO_2e$)	Leakage GHG emissions ($t\ CO_2e$)	GHG emission reductions or net anthropogenic GHG removals ($t\ CO_2e$)		
				Before 01/01/2013	From 01/01/2013	Total amount
Total	167,483	26,054	0	0	141,429	141,429

E.5. Comparison of emission reductions or net anthropogenic removals achieved with estimates in the registered PDD

Amount achieved during this monitoring period ($t\ CO_2e$)	Amount estimated ex ante for this monitoring period in the PDD ($t\ CO_2e$)
141,429	150,171

E.5.1. Explanation of calculation of "amount estimated ex ante for this monitoring period in the PDD"

Emission reductions, ERs, are calculated according to the internal procedure PRG-425-15. This procedure describes the steps to calculate the ERs using the spreadsheet called "Emission Reductions Calculation UIII_2018-V1.xls", which was designed according PDD and the methodology ACM0002 (version 14).

According to PDD, the leakages are negligible and there are not emissions due fuel consumption in the power plant[14]; therefore, the emission reductions are calculated as the difference between the baseline emissions minus the project activity emissions, as equation 5 indicates.

Where:

ER_y	=	Emission reductions given in tonnes of carbon dioxide equivalent in the monitored period.
BE_y	=	Baseline missions given in tonnes of carbon dioxide equivalent in the monitored period.
PE_y	=	Project emissions equal to sum of the fugitive carbon dioxide and methane emission due to the release of non-condensable gases from the produced steam.
y	=	2018

Equation 5 is calculated automatically for each month in the sheet called "ER_y" of the spreadsheet "Emission Reductions Calculation UIII_2018-V1.xls" and the results for the monitoring period are presented in the next table

E.6. Remarks on increase in achieved emission reductions

The emission reductions achieved during this monitoring period represents aprox the 94% of the value estimated in the ex-ante calculation of the registered PDD.

The decrement on emissions reduction is due to programmed and non-programmed outlines in the power units.

E.7. Remarks on scale of small-scale project activity

not applicable

[14] The energy for ancillary services and the activities related to the operation of the power unit is self-supplied through the step-down transformer when the power unit is online, otherwise ancillary services demand is supplied by the grid. Additionally, there is a battery to feed critical loads

Document information

Version	Date	Description
07.0	31 May 2019	Revision to: • Ensure consistency with version 02.0 of the "CDM project standard for project activities" (CDM-EB93-A04-STAN); • Add a section on remarks on the observance of the scale limit of small-scale project activity during the crediting period; • Add "changes specific to afforestation or reforestation project activity" as a possible post-registration changes; • Clarify the reporting of net anthropogenic GHG removals for A/R project activities between two commitment periods; • Make editorial improvements.
06.0	7 June 2017	Revision to: • Ensure consistency with version 01.0 of the "CDM project standard for project activities" (CDM-EB93-A04-STAN); • Make editorial improvements.
05.1	4 May 2015	Editorial revision to correct version numbering.
05.0	1 April 2015	Revisions to: • Include provisions related to delayed submission of a monitoring plan; • Provisions related to the Host Party; • Remove reference to programme of activities; • Overall editorial improvement.
04.0	25 June 2014	Revisions to: • Include the Attachment: Instructions for filling out the monitoring report form (these instructions supersede the "Guideline: Completing the monitoring report form" (Version 04.0)); • Include provisions related to standardized baselines; • Add contact information on a responsible person(s)/ entity(ies) for completing the CDM-MR-FORM in A.6 and Appendix 1; • Change the reference number from *F-CDM-MR* to *CDM-MR-FORM*; • Editorial improvement.
03.2	5 November 2013	Editorial revision to correct table in page 1.
03.1	2 January 2013	Editorial revision to correct table in section E.5.
03.0	3 December 2012	Revision required to introduce a provision on reporting actual emission reductions or net GHG removals by sinks for the period up to 31 December 2012 and the period from 1 January 2013 onwards (EB 70, Annex 11).
02.0	13 March 2012	Revision required to ensure consistency with the "Guidelines for completing the monitoring report form" (EB 66, Annex 20).
01.0	28 May 2010	EB 54, Annex 34. Initial adoption.

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