

CAPACITY UPGRADE OF GUNUNG SALAK GEOTHERMAL POWER PLANT PROJECT, INDONESIA



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1 PROJECT DETAILS

1.1 Summary Description of the Project

Indonesia, which is situated in the “Ring of Fire”, has great potential for geothermal energy resources that are not yet fully exploited. Until January 2000, from a total geothermal energy reserve of 9,100 MWe¹, only 769.5 MWe² are cumulatively installed in Sumatra, Java-Bali, Sulawesi, and other islands, which accounted for 3.9%³ of the total energy mix. This small proportion of the total energy mix is due to slow development progress in geothermal energy utilization due to the high capital investment required and a high level of risk involved in the project. These factors are the two main concerns for geothermal power plant owners seeking to improve their power plants’ efficiency in order to utilize more geothermal energy resources in the country.

The Gunung Salak Geothermal Power Plant, located in West Java, Indonesia, is owned and operated by PT. Indonesia Power as a subsidiary of PT. PLN (Persero), the Indonesian state-owned electricity company. The power plant consists of 3 power station units, which are unit 1, unit 2, and unit 3. Following are the three units’ commissioning date:

- Unit 1: 12 March 1994
- Unit 2: 12 June 1994
- Unit 3: 16 July 1997

As of 1998, the power plant had three power station units (unit 1, 2, and 3) with designed capacity of 55 MW each. A study⁴ conducted by the Technology Provider revealed that installed capacity in these initial units could be increased to 3 x 60 MW by turbine modification for all units and ejector line replacement for unit 3.

Turbine modification⁵ means to modify first and second stage diaphragms by increasing nozzle size from α_1 to α_2 to allow steam turbine efficiency as shown in Graph 1. An increase in α and β will increase blade velocity (u) that is proportional to turbine power performance, which means achieving higher “flow capability” of the steam turbine and optimising steam efficiency. In the end, the capacity output will also increase.

¹ Sudarman, et. al.; Geothermal Development Progress in Indonesia: Country update 1995-2000; Kyushu-Tohoku, Japan: Proceedings World Geothermal Congress 2000; May 28-June 10, 2000, p. 2.

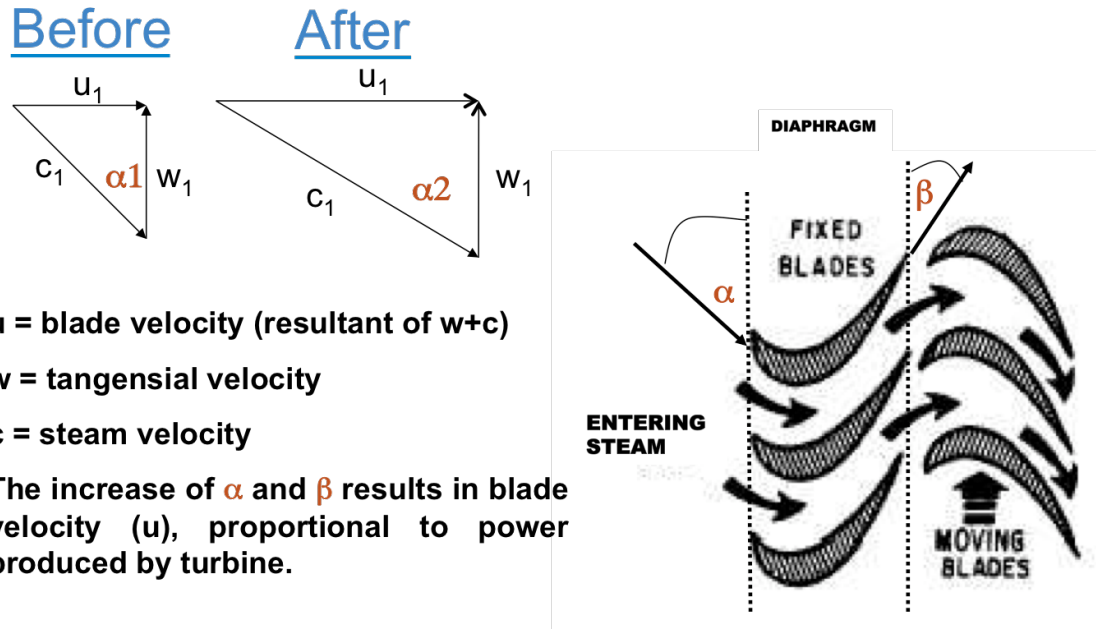
² Sudarman, et. al.; (2000), p. 4.

³ Sudarman, et. al.; (2000), p. 4.

⁴ Minutes of Meeting, Program Up-Rating PLTP, PT. Indonesia Power, date: 27 November 2001

⁵ Contract for Off Shore Materials Supply for Power Up-Rating of Unit 1, 2, and 3 between PT. Indonesia Power and Ansaldo Energia SpA, dated on 22 July 2002, Appendix 1.

Graph 1. Nozzle increase in the diaphragms



Source: PT. Indonesia Power

Ejector line replacement means to replace a smaller line of ejectors with a new design to increase the flow rate of Non-Condensable Gases (NCG) which is caused by an increase of steam flow due the project activity.

The project is comprised of upgrading these three power station units to increase the power plant total installed capacity to 3 x 60 MW.

The key purpose of the project is to increase utilization of geothermal resources in the mountainous areas surrounding Gunung Salak to generate zero emission electricity to be transmitted to the Jawa-Madura-Bali (JAMALI) grid (hereafter referred to as the Grid) through the Bogor Baru PLN main station, with 150 kV transmission line.

The Gunung Salak Geothermal field is owned by Star Energy Geothermal Salak Ltd. (previously owned by Chevron Geothermal Indonesia Ltd.)⁶ and consists of 2 main areas, Awi Bengkok-Ratu and Nirmala area, and supplies steam from its AWI-7, AWI-8, AWI-9, and AWI-11 wells to the Gunung Salak Geothermal power plants under a Steam Sales Contract/SSC (Chevron Geothermal Indonesia is obliged to provide these power plants with the required steam to generate electricity).

An estimate of annual average and total GHG emission reductions and removals.

The additional capacity upgrade of 3 x 5 MW generates 213,959 MWh annually to be exported to the JAMALI grid that would have been otherwise generated from fossil-fuel power plants. The 3 x 60 MW installed capacity generates an estimate of annual average of 104,620 tCO₂ emission

⁶ Major Acquisition by Star Energy Group: Star Energy Consortium have signed Share Sale and Purchase Agreements with Chevron Global Energy Inc, Union Oil Company of California and their relevant affiliates (collectively, "Chevron") for the purchase of Chevron's geothermal operations in Indonesia and Philippines on December 22, 2016. (Source: <http://www.starenergy.co.id/News/Articles/Major-Acquisition-by-Star-Energy-Group.aspx>)

reduction and total GHG emission reductions is 1,046,199 tCO₂ over a crediting period of 10 (ten) years from 1 April 2016 until 31 March 2026.

1.2 Sectoral Scope and Project Type

The project activity is comprised of a capacity upgrade of Gunung Salak Geothermal Power Plant from 3 x 55 MW to 3 x 60 MW. The additional installed capacity of 15 MW at Gunung Salak Geothermal power plant generates and supplies an average of 213,959 MWh p.a. of electricity to the connected JAMALI Grid. The project is owned and developed by PT. Indonesia Power, a subsidiary company of PT. PLN (Persero), a state-owned electricity company. The proposed project will increase the utilization of renewable energy sources, in this case geothermal energy, by modifying turbines and steam gas ejectors. Steam for the project is provided by Chevron Geothermal Indonesia under an Energy Sales Contract (ESC) between PT. PLN (Persero) Pertamina, a state-owned oil and gas company, and Unocal Geothermal of Indonesia (Unocal Geothermal Indonesia was acquired by Chevron Geothermal Indonesia Ltd. Though today, Gunung Salak geothermal fields are owned by Star Energy Geothermal Salak Ltd.).

According to the CDM UNFCCC criteria, one approved GHG program by the VCS Board, the project is classified as large scale and, based on Annex A of the Kyoto Protocol, falls under Sectoral Category 1, Energy Industries (renewable/non renewable).

According to the Voluntary Carbon Standard, the project activity falls under the category of renewable energy (wind, PV, solar thermal, biomass, liquid bio-fuels, geothermal, and run-of-river hydro).

1.3 Project Proponent

Name of the party involved ((host) indicates a host party)	Private and/or public entity (ies) project participants (as applicable)	Kindly indicate if the party involved to be considered as project participant (Yes/No)
Indonesia (host)	PT. Indonesia Power	No

Project proponents contact information as follows:

Project owner:

Organization name	PT. Indonesia Power
Contact person	Eri Prabowo
Title	Director of Operation I
Address	Jl. Jenderal Gatot Subroto Kav. 18, Jakarta 12950, Indonesia
Telephone	+62-21-526 7666
Email	eri.prabowo@indonesiapower.co.id

1.4 Other Entities Involved in the Project

Name of the party involved ((host) indicates a host party)	Private and/or public entity (ies) project participants (as applicable)	Kindly indicate if the party involved to be considered as project participant (Yes/No)
Switzerland	South Pole Carbon Asset Management Ltd. (as carbon credit buyer)	No

Carbon credit buyer:

Organization name	South Pole Carbon Asset Management Ltd.
Contact person	Renat Heuberger
Title	CEO
Address	Technoparkstrasse 1, Zurich 8005, Switzerland
Telephone	+41-43 501 35 50
Email	info@southpole.com

1.5 Project Start Date

The project start date, when the power plant started to operate normally after the capacity upgrade performance test conducted by the technology provider and at the same time the project started to reduce GHG emissions:

- Unit 1: 21 June 2005
- Unit 2: 4 April 2005
- Unit 3: 29 September 2004

Thus, the project start date is 29 September 2004 (as per the Performance Test Report of the unit 3), as the earliest project start date of three units at Gunung Salak Geothermal Power Plant.

1.6 Project Crediting Period

1st Crediting period start date: 1 April 2006.

2nd Crediting period start date: 1 April 2016.

1st Crediting period: 10 years from 1 April 2006 until 31 March 2016.

2nd Crediting period: 10 years from 1 April 2016 until 31 March 2026.

1.7 Project Scale and Estimated GHG Emission Reductions or Removals

Project Scale	
Project	√
Large project	

The project activity is comprised of a capacity upgrade of Gunung Salak geothermal power plant from 3 x 55 MW to 3 x 60 MW. The additional capacity upgrade of 3 x 5 MW generates 213,959 MWh annually to be exported to the JAMALI grid that would have been otherwise generated from fossil-fuel power plants. The 3 x 60 MW installed capacity generates an average of 104,620 tCO₂ emission reduction credits per year.

Emission reduction estimates over a crediting period of 10 (ten) years from 1 April 2016 until 31 March 2026 is provided in the table below:

Years	Estimated GHG emission reductions or removals (tCO ₂ e)
Year 2016 (1 April 2016 - 31 March 2017)	61,793
Year 2017 (1 April 2017 - 31 March 2018)	109,378
Year 2018 (1 April 2018 - 31 March 2019)	109,378
Year 2019 (1 April 2019 - 31 March 2020)	109,378
Year 2020 (1 April 2020 - 31 March 2021)	109,378
Year 2021 (1 April 2021 - 31 March 2022)	109,378
Year 2022 (1 April 2022 - 31 March 2023)	109,378
Year 2023 (1 April 2023 - 31 March 2024)	109,378
Year 2024 (1 April 2024 - 31 March 2025)	109,378
Year 2025 (1 April 2025 - 31 March 2026)	109,378
Total estimated ERs	1,046,199
Total number of crediting years	10
Average annual ERs	104,620

1.8 Description of the Project Activity

By increasing the power plant installed capacity, the project will utilize additional geothermal energy sources for generating electricity. The electricity generated will be exported to the JAMALI grid, displacing electricity from primarily fossil-fuel based power plants that supply the grid.

The following modification⁷ has been undertaken to increase the steam flow, thus increasing the installed capacity of the power plant from 3 x 55 MW to 3 x 60 MW:

- **Turbine modification**, which means to modify first and second stage diaphragms by increasing nozzle size from $\alpha 1$ to $\alpha 2$ to allow steam turbine efficiency as shown in Graph 1.
- **Ejector line replacement**, which means to replace a smaller line of ejectors with a new design to increase the flow rate of Non-Condensable Gases (NCG) that is caused by an increase in steam flow due the project activity.

The project does not modify and/or replace the whole power stations but only parts of their equipment.

In the end, the project does not really change the established technology, which consists of a steam turbine, electrical generators, a gas extraction system, a 150kV switchyard system, and a utility system. The project is using the same hot water-dominated steam characteristic from Gunung Salak Geothermal field, with a condensate re-injection well-system to maintain groundwater supply. However, the project utilizes a higher steam flow due to a capacity increase by modifying steam turbines.

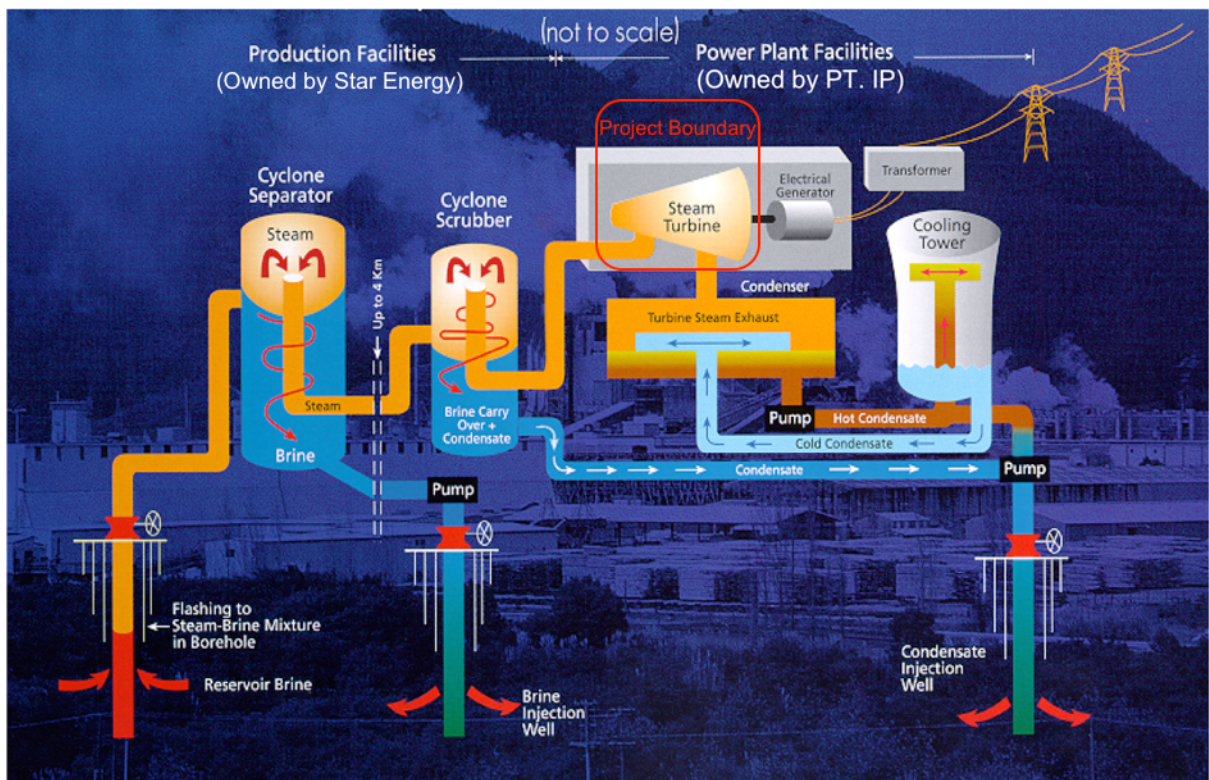
The following are the main technical parameters before and after the project:

Variable	Value		Source
	Before the project	After the project	
Installed capacity of electrical generator (kVA)	• Unit 1: 68,750 kVA • Unit 2: 68,750 kVA • Unit 3: 68,750 kVA	• Unit 1: 68,750 kVA • Unit 2: 68,750 kVA • Unit 3: 68,750 kVA	Report of up rating unit 3, Laporan Major inspection unit 2, Laporan Simple inspection and up rating unit 1
Power factor	0.8	0.8	Report of up rating unit 3, Laporan Major inspection unit 2, Laporan Simple inspection and up rating unit 1
Steam turbine capacity (MW)	3 x 55 MW	3 x 60 MW	Report of up rating unit 3, Laporan Major inspection unit 2, Laporan Simple inspection and up rating unit 1
PPA Unit Rated Capacity/URC (MW)	3 x 55 MW	3 x 60 MW	Energy Sales Contract Amendment Agreement (called ESC hereafter)
Operating time yearly (hours)	7,884 (8,760 x 90%)	7,884 (8,760 x 90%)	Energy Sales Contract Amendment Agreement ⁸

⁷ Contract for Off Shore Materials Supply for Power Up-Rating of Unit 1, 2, and 3 between PT. Indonesia Power and Ansaldo Energia SpA, dated on 22 July 2002.

⁸ However, based on historical data and information, the Gunung Salak Geothermal Power Plant could possibly generate electricity with 95% load factor, which is higher than the assumption used in the VCS PD ex-ante calculation.

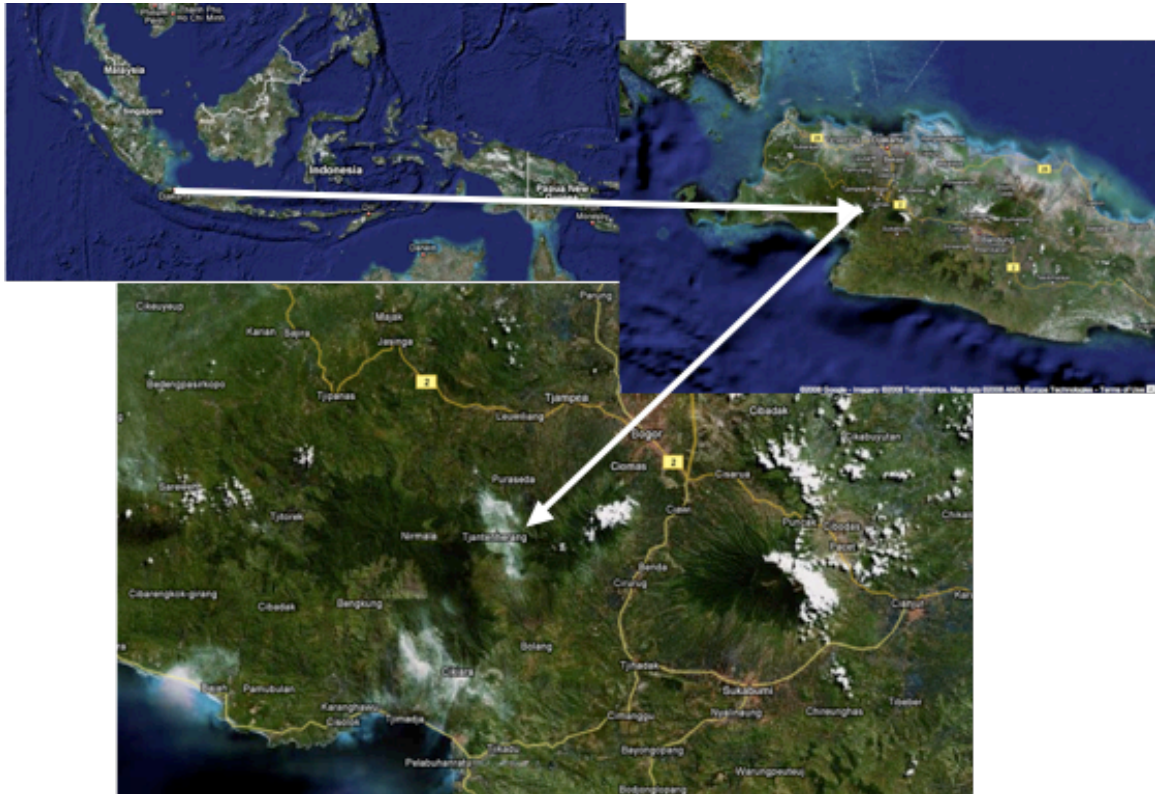
Annual power generation/effective supply to the grid (MWh)	• Unit 1: 411,363 MWh	• Unit 1: 473,040 MWh	*Based on historical and actual data recorded by PT. Indonesia Power **Expected annual power generation after the capacity upgrade (with 90% load factor assumption)
	• Unit 2: 399,102 MWh	• Unit 2: 473,040 MWh	
	• Unit 3: 394,696 MWh	• Unit 3: 473,040 MWh	
	• Total: 1,205,161* MWh	• Total: 1,419,120** MWh	



Source: PT. Indonesia Power

1.9 Project Location

The project site is located in Awibengkong-Ratu area of Gunung Salak Geothermal field surrounded by Halimun Salak national park, which is administratively part of Bogor District and Sukabumi District, West Java Province, Indonesia. The project is located 988 m above sea level, approximately 82 km from Bogor and 58 km from Sukabumi. The exact location is 06° 44' 26" S, 106° 38' 28" E.



Source: Google Earth

1.10 Conditions Prior to Project Initiation

The existing power plant was originally designed for an installed capacity of 165 MW (or 3 x 55 MW), and in the baseline scenario would continue to provide electricity to the JAMALI grid at 1,205,161 MWh/year.

1.11 Compliance with Laws, Statutes and Other Regulatory Frameworks

The project meets all local laws and regulations of the Government of Indonesia. The project activity, in using geothermal power to generate electricity, is a voluntary action that has never been obliged by the Government of Indonesia.

The project has a construction permit, Power Purchase Agreement, Steam Sales Contract, and Environmental Impact Assessment.

1.12 Ownership and Other Programs

1.12.1 Project Ownership

Evidence of project ownership is the proof of title as explained in a letter from the chairman of Indonesian Geothermal Association "*Asosiasi Panasbumi Indonesia (API)*" letter No.: 076/PP-API/2007, dated 18 June 2009. The letter attached in Annex I.

1.12.2 Emissions Trading Programs and Other Binding Limits

Not applicable.

1.12.3 Other Forms of Environmental Credit

The project activity currently has not applied to any other form of environmental credits.

Projects may generate other forms of GHG-related environmental credits, such as renewable energy certificates (RECs), though GHG emission reductions and removals presented for VCU issuance shall not also be recognized as another form of GHG-related environmental credit⁹.

If the project activity will be issued under any recognized program which creates GHG-related environmental credits (such as renewable energy certificates or RECs), the GHG emission reductions or removals from one verification period can be split between the VCS Program and another GHG program¹⁰.

1.12.4 Participation under Other GHG Programs

Not applicable.

1.12.5 Projects Rejected by Other GHG Programs

Not applicable.

1.13 Additional Information Relevant to the Project

Eligibility Criteria

Not applicable.

Leakage Management

According to ACM0002 version 17.0, the leakage of the proposed project is not considered. No leakage is expected.

Commercially Sensitive Information

Not applicable.

Sustainable Development

The project is contributing to sustainable development defined by the Government of Indonesia specifically as follows:

⁹ According to VCS Standard: VCS Version 3, 21 June 2017, v3.7

¹⁰ According to VCS Standard: VCS Version 3, 21 June 2017, v3.7

Social well-being:

- The project contributes to the development of the region by increasing community development and corporate social responsibility of PT. Indonesia Power.
- During the capacity upgrade and operation, there are various kinds of mechanical work, which generates employment on regular and permanent basis.

Economic well-being:

- The project activity generates employment in the local area.
- The project activity is a good investment in a developing region, which otherwise would not have happened in the absence of project activity.
- The generated electricity is fed into regional grids through the local grid, thereby improving the grid frequency and availability of electricity to the local consumers (villagers and sub-urban inhabitants), which will provide new opportunities for industries and economic activities to be setup in the area thereby resulting in greater local employment, ultimately leading to overall development.
- The project activity also leads to diversification of the national energy supply, which is dominated by conventional fuel based generating units.
- The project activity contributes to the economic sustainability around the plant sites, which is encouraging economic power decentralization.

Environmental well-being:

- The project utilizes geothermal power to generate electricity, which otherwise would have been generated through alternate fuel- (most likely fossil fuel-) based power plants, contributing to a reduction in specific emissions (emissions of pollutant/unit of energy generated) including GHG emissions.
- As geothermal power projects produce no end products in the form of solid waste (ash, etc.), they address the problem of solid waste disposal encountered by most other sources of power.
- Being a renewable energy source, geothermal energy is used to generate electricity that contributes to resource conservation.
- Thus, the project causes no negative impact on the surrounding environment; and in the end contributes to environmental well-being.

Technological well-being:

- The project supports technology transfer from other regions or even other countries, as well as contributes to capacity building of the labour force through trainings and practical works.

- The project promotes local products developed in the region, when replacement of spare parts is necessary, and supports renewable technology development especially for geothermal power technology.

In view of the above explanation, the project participants consider that the project activity profoundly contributes to sustainable development.

Further Information

No further information.

2 APPLICATION OF METHODOLOGY

2.1 Title and Reference of Methodology

The project uses the VCS board-approved consolidated baseline and monitoring methodology ACM0002 "Consolidated baseline methodology for grid-connected electricity generation from renewable sources", version 17.0, 13 May 2016.

2.2 Applicability of Methodology

The approved methodology of ACM0002 (version 17.0) is chosen and applicable to the proposed project due to the following reasons:

- The project activity is a modification (retrofit) of an existing geothermal power plant that involves electricity capacity addition from total capacity of 165 MW to 180 MW.
- The project is a renewable electricity generation plant from geothermal energy sources, which is connected to the JAMALI grid.
- The project activity exports its electricity to the clearly identified regional Jawa, Madura, and Bali interconnected power grid (JAMALI grid). The value and characteristics of the grid are also publicly available.
- The proposed project is not an activity that involves fossil fuel switching to renewable energy at the site of the project activity.

Based on the stated reasons above, the applicability criteria of the approved CDM methodology ACM0002 (version 17.0) "Consolidated baseline methodology for grid-connected electricity generation from renewable sources" are met.

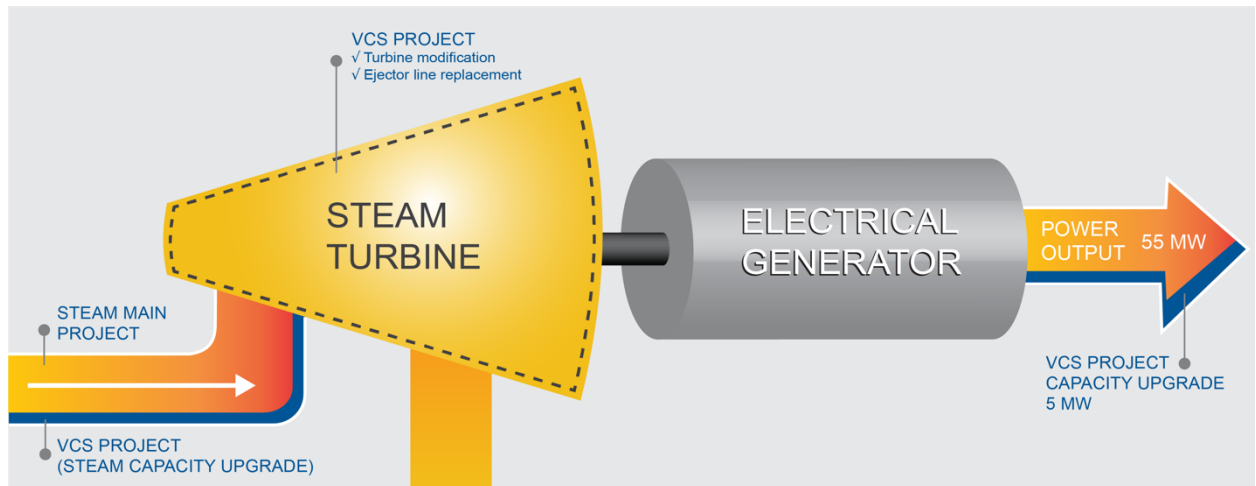
2.3 Project Boundary

The baseline includes the emissions related to the electricity produced by the facilities and power plants displaced by the increased capacity of Gunung Salak geothermal power plant, Indonesia.

This involves emissions from displaced fossil fuel use in power plants connected to the JAMALI grid (see table below).

Source		Gas	Included?	Justification/Explanation
Baseline	CO ₂ emission from electricity generation in fossil fuel-fired power plants that are displaced due to the project activity.	CO ₂	Included	According to ACM0002 only CO ₂ emissions from electricity generation should be accounted for (main emission source).
		CH ₄	Excluded	According to ACM0002 (minor emission source).
		N ₂ O	Excluded	According to ACM0002 (minor emission source).
Project	For dry or flash steam geothermal power plants, emissions of CH ₄ and CO ₂ from non-condensable gases contained in geothermal steam.	CO ₂	Included	According to ACM0002: CO ₂ fugitive emissions from non-condensable gases should be accounted for (main emission source).
		CH ₄	Included	According to ACM0002: CH ₄ fugitive emissions from non-condensable gases should be accounted for (main emission source).
		N ₂ O	Excluded	According to ACM0002 (minor emission source).

The underlying project boundary is defined as the steam attributable to the project's capacity upgrade, as below picture.



To determine the steam that attributable to the project's capacity upgrade hence should be calculated based on specific fuel consumption which known as Specific Steam Consumption (SSC). Specific steam consumption, is the ratio of steam flowrate at separator exit to net power output of the plant¹¹. The SSC has been used as one of the parameters to evaluate the performance of geothermal power plants.

The SSC is calculated as below:

$$SSC = \frac{\text{Steam flowrate (t steam)}}{\text{Net power output of the plant (MWh)}}$$

2.4 Baseline Scenario

The baseline scenario is the electricity that would continue to be generated by the current installed capacity, 3 x 55 MW and exported to the JAMALI Grid.

For the second crediting period, the continued validity of the original baseline should be assessed.

According to the tool "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)", following steps should be adopted:

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

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

There is no mandatory law or regulation, which forced the project proponent to upgrade the geothermal power plant capacity. Also, there are no new national and/or sectoral policies that could affect the baseline scenario during the renewal of the crediting period. According to PLN's Electricity Supply Business Plan (RUPTL PT. PLN (Persero)) year 2017-2026 there is no mandatory for PT.

¹¹ Yildirim, N. Thermodynamic Performance of Single-Flash Geothermal Power Plants from the Point of View of Noncondensable Gas Removal Systems, Proceedings World Geothermal Congress, 2015, <https://pangea.stanford.edu/ERE/db/WGC/papers/WGC/2015/26034.pdf> (accessed, 2017).

Indonesia Power (as a subsidiary of PT. PLN (Persero)) to upgrade the geothermal power plant capacity, except addition of power plants.¹²

Step 1.2: Assess the impact of circumstances

There is no impact of circumstances existing at the time of requesting renewal of crediting period on the current baseline emissions.

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

This sub-step is applicable to the project activity since the baseline is the continuation of the current practice, i.e. the electricity would be supplied by the power grid in the absence of the project activity. It is clear that the power grid as an electricity system would maintain its technical possibility for a much longer time than the crediting period of the project activity.

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

There are some parameters, which are determined at the start of the first crediting period and not monitored during the first crediting period, are not valid anymore. So, the current baseline needs to be updated for the second crediting period according to the tool. This update includes grid emission factor, $EG_{\text{historical}}$, and $\sigma_{\text{historical}}$ as per methodology version 17.0. Methodology addresses the uncertainty of variation of power generation by adjusting the historical electricity generation ($EG_{\text{historical}}$) by its standard deviation ($\sigma_{\text{historical}}$).

Hence, the data and parameters need to be updated. Therefore step 2 is used.

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

Step 2.1: Update the current baseline

The baseline emissions for the second crediting period have been updated, without reassessing the baseline scenario, based on the latest approved version of the methodology. This update was applied in the context of the sectoral policies and circumstances that is applicable at the time of requesting for renewal of the crediting period.

Step 2.2: Update the data and parameters

As mentioned in step 1.4, all parameters regarding the grid emission factor, $EG_{\text{historical}}$, and $\sigma_{\text{historical}}$ calculation are updated in the second crediting period.

Project participants may choose among the following two time spans of historical data to determine $EG_{\text{historical}}$:

¹² Decree of Ministry of Energy and Mineral Resources No. 1415/K/20/MEM2017 dated on 29 March 2017 concerning Ratification of PT. PLN (Persero)'s Electricity Supply Business Plan Year 2017 – 2026.
<https://djke.esdm.go.id/pdf/RUPTL/RUPTL%20PLN%202017-2026.pdf> (accessed, 2017).

- (a) The five last calendar years prior to the implementation of the project activity; or
- (b) The time period from the calendar year following *DATE_{hist}*, up to the last calendar year prior to the implementation of the project, as long as this time span includes at least five calendar years, where *DATE_{hist}* is latest point in time between:
 - (i) The commissioning of the plant/unit;
 - (ii) If applicable: the last capacity addition to the plant/unit; or
 - (iii) If applicable: the last retrofit or rehabilitation of the plant/unit.

The $EG_{\text{historical}}$ has been updated using the option (b)-(i) above.

2.5 Additionality

According to the section 3.8.5 of VCS Standard version 3.6, a full reassessment of additionality is not required when renewing the project crediting period. However, regulatory surplus shall be demonstrated in accordance with Section 4.6.3.

It is confirmed that the proposed project is not mandated by any law, statute or other regulatory framework. There is no mandatory law or regulation, which forced the project proponent to upgrade the geothermal power plant capacity.

There is no any mandatory program from the Government of Indonesia that forces private or public entities to upgrade renewable energy power plants. There are also no additional incentives to upgrade capacity in terms of higher electricity price or other benefits.

2.6 Methodology Deviations

There are no methodology deviations.

3 QUANTIFICATION OF GHG EMISSION REDUCTIONS AND REMOVALS

3.1 Baseline Emissions

Based on ACM0002 version 17.0, the baseline emission (BE_y in tCO_2) is the product of the baseline emission factor ($EF_{\text{grid,CM,y}}$ in tCO_2/MWh) times the electricity supplied by the project activity to the grid ($EG_{\text{PJ,y}}$ in MWh). $EG_{\text{PJ,y}}$ is calculated as a quantity of net electricity generation supplied by the project plants/units to the grid ($EG_{\text{facility,y}}$ in MWh) minus the sum of annual average historical net electricity generation delivered to the grid by the existing renewable energy power plants/units that was operated at the project site prior to the implementation of the project activity ($EG_{\text{historical}}$ in MWh/yr) and standard deviation of the mentioned $EG_{\text{historical}}$ ($\sigma_{\text{historical}}$ in MWh/yr), as follows:

$$BE_y = EG_{\text{PJ,y}} \times EF_{\text{grid,CM,y}}$$

where:

- BE_y = Baseline emissions in year y (t CO₂/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 CO₂ emission factor for grid connected power generation in year y calculated using the latest version of the “Tool to calculate the emission factor for an electricity system” (t CO₂/MWh)

$EG_{PJ,y}$ for a retrofit or rehabilitation or replacement of an existing renewable energy power plant is calculated as follows:

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

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/yr)
- $EG_{facility,y}$ = Quantity of net electricity generation supplied by the project plants/units to the grid in year y (MWh/yr)
- $EG_{historical}$ = Annual average historical net electricity generation delivered to the grid by the existing renewable energy power plants/units that was operated at the project site prior to the implementation of the project activity (MWh/yr)
- $\sigma_{historical}$ = Standard deviation of the annual average historical net electricity generation delivered to the grid by the existing renewable energy power plants/units that was operated at the project site prior to the implementation of the project activity (MWh/yr)
- $DATE_{BaselineRetrofit}$ = Point in time when the existing equipment would need to be replaced in the absence of the project activity (date). This only applies to retrofit or replacement projects

In case $EG_{facility,y} < (EG_{historical} + \sigma_{historical})$ in a year y then $EG_{PJ,y} = 0$

Calculation of $EF_{grid,CM,y}$

The latest of weighted average of the Operating Margin emission factor ($EF_{grid,OMsimple,y}$), Build Margin emission factor ($EF_{grid,BM,y}$), and Combined Margin emission factor ($EF_{grid,CM,y}$) of JAMALI grid of year 2015 already determined and calculated¹³ according to the procedures prescribed in the “Tool to calculate the emission factor for an electricity system, Version 04.0 by the Indonesian

¹³ Based on notification letter number 322/20/DJL.4/2017 dated on February 7th, 2017 from the MEMR.

government under the Directorate General of Electricity - Ministry of Energy and Mineral Resources (MEMR).¹⁴ Even though the “Tool to calculate the emission factor for an electricity system” (Version 05.0) has been issued at the time of renewal of the project crediting period there is not affected to the result of $EF_{grid,CM,y}$.

Step 1: Identify the relevant electricity systems

According to the latest version of the tool, the JAMALI power grid is selected as the project boundary, as the regional interconnected grid covering three islands very close to each other (Java, Madura, and Bali islands) and separated by a relatively long distance from other islands in Indonesia (no interconnection exists to other islands).

The project is located in Gunung Salak geothermal area, and is connected to the existing JAMALI power transmission line for Gunung Salak geothermal power plant units 1, 2, and 3.

The JAMALI power grid is therefore determined as the project boundary.

Both the OM and the BM will be calculated ex-ante.

Step 2: Choose whether to include off-grid power plants in the project electricity system (optional)

Project participants may choose between the following two options to calculate the operating margin and build margin emission factor:

Option I: Only grid power plants are included in the calculation.

Option II: Both grid power plants and off-grid power plants are included in the calculation.

The MEMR chooses only to include the grid power plants in the calculation (Option I), as information of the off-grid power plants are not completely publicly accessible.

Step 3: Select a method to determine the operating margin (OM)

The “Tool to calculate the emission factor for an electricity system” (version 05.0, EB87) offers four methods to calculate the OM and any of the four methods can be used:

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

The MEMR has been considered the methods to determine the operating margin (OM) as following:

- (a) Simple OM: The Low Cost/Must Run (LC/MR) of the power plants cannot be determined.

¹⁴ Based on notification letter number 1515/03/DLT.3/2017 dated on May 30th, 2017 from the MEMR.

- (b) Simple adjusted OM: The required of hourly LC/MR operation data of the power plants are not available.
- (c) Dispatch data analysis OM: The required of hourly actual operation data of the power plants are not available.
- (d) Average OM: Annual aggregated data from the grid on power generation, fuel type and fuel consumption of the power plants are available, which is calculated as Simple OM.

The Operating Margin Emission Coefficient ($EF_{grid,OM,y}$) can be calculated based on Simple OM or Average OM, with consideration of the restrictions to use each approach. The selection of the most suitable method is based on the analysis of the proportion of low-cost/must-run generation sources in the concerning grid. The OM will be calculated ex-ante.

Step 4: Calculate the operating margin emission factor according to the selected method

The operating margin emission factor for each year 'y' was calculated using equation 3 (preferred option) of the 'Tool to calculate the emission factor for an electricity system', adapted to data available from PLN, which has grouped the power plants according to type as shown in the notification letter number 1515/03/DLT.3/2017 dated on May 30th, 2017 from the MEMR.

$$EF_{grid,OMsimple,y} = \frac{\sum_m EG_{m,y} \times EF_{EL,m,y}}{\sum_m EG_{m,y}}$$

where:

- $EF_{grid,OMsimple,y}$ = Simple operating margin CO₂ emission factor in year y (t CO₂/MWh)
- $EG_{m,y}$ = Net quantity of electricity generated and delivered to the grid by power unit m in year y (MWh)
- $EF_{EL,m,y}$ = CO₂ emission factor of power unit m in year y (t CO₂/MWh)
- m = All power units serving the grid in year y except low-cost/must-run power units
- y = The relevant year as per the data vintage chosen in Step 3

The Operating Margin will be calculated ex-ante, therefore the factor is calculated based on 3 recent years available data, which are 2013, 2014, and 2015 data.

The Operating Margin emission factors for 2013, 2014 and 2015 are calculated separately and then the three- year average is calculated as a full-generation weighted average of the emission factors.

The result of the Operation Margin Emission Factor of JAMALI calculation is 0.786 tCO₂e/MWh.

The operating margin emission factor of the baseline is calculated as a fixed ex-ante value and will not be renewed within the second crediting period of the project activity.

Step 5: Calculate the build margin (BM) emission factor

Once the sample group 'm' is defined, the build margin is calculated ex-ante using the following equation:

$$EF_{grid,BM,y} = \frac{\sum_m EG_{m,y} \times EF_{EL,m,y}}{\sum_m EG_{m,y}}$$

where:

$EF_{grid,BM,y}$	=	Build margin CO ₂ emission factor in year y (t CO ₂ /MWh)
$EG_{m,y}$	=	Net quantity of electricity generated and delivered to the grid by power unit m in year y (MWh)
$EF_{EL,m,y}$	=	CO ₂ emission factor of power unit m in year y (t CO ₂ /MWh)
m	=	Power units included in the build margin
y	=	Most recent historical year for which electricity generation data is available

Based on sample group 'm' identified in the notification letter number 1515/03/DLT.3/2017 dated on May 30th, 2017 from the MEMR, the ex-ante Build Margin Emission Factor is calculated to be 0.999 tCO₂e/MWh by dividing total CO₂ emissions by the total annual generation data.

Step 6: Calculate the combined margin (CM) emission factor

The Baseline Emission Factor is calculated as a Combined Margin, using the weighted average (preferred option) of the Operating Margin and Build Margin.

$$EF_{grid,CM,y} = EF_{grid,OM,y} \times w_{OM} + EF_{grid,BM,y} \times w_{BM}$$

where:

$EF_{grid,BM,y}$	=	Build margin CO ₂ emission factor in year y (t CO ₂ /MWh)
$EF_{grid,OM,y}$	=	Operating margin CO ₂ emission factor in year y (t CO ₂ /MWh)
w_{OM}	=	Weighting of operating margin emissions factor (per cent)
w_{BM}	=	Weighting of build margin emissions factor (per cent)

As per UNFCCC Methodological tool: Tool to calculate the emission factor for an electricity system v05.0, the following default values should be used for w_{OM} and w_{BM} (for all projects except for wind and solar power generation project activities): $w_{OM} = 0.5$ and $w_{BM} = 0.5$ for the first crediting period, and $w_{OM} = 0.25$ and $w_{BM} = 0.75$ for the second and third crediting period, unless otherwise specified in the approved methodology which refers to this tool.

Therefore using the approach above, the ex-ante emission factor ($EF_{grid,CM,y}$) for Jamali Grid will be:

$$\begin{aligned}
 EF_{grid,CM,y} &= EF_{grid,OM,y} \times W_{OM} + EF_{grid,BM,y} \times W_{BM} \\
 &= (0.786 \times 0.25) + (0.999 \times 0.75) \\
 &= 0.946 \text{ tCO}_2/\text{MWh}
 \end{aligned}$$

Calculation of $EG_{historical}$ and $\sigma_{historical}$

$EG_{historical}$ is the average of historical electricity delivered by the existing facility to the grid, spanning all data from the most recent available year (or month, week, or other time period) to the time at which the facility was constructed, retrofit, or modified in a manner that significantly affected output (i.e., by 5% or more), expressed in MWh per year. Project participants may choose among the following two time spans of historical data to determine $EG_{historical}$:

- (a) The five last calendar years prior to the implementation of the project activity; or
- (b) The time period from the calendar year following $DATE_{hist}$, up to the last calendar year prior to the implementation of the project, as long as this time span includes at least five calendar years, where $DATE_{hist}$ is latest point in time between:
 - (i) The commissioning of the plant/unit;
 - (ii) If applicable: the last capacity addition to the plant/unit; or
 - (iii) If applicable: the last retrofit or rehabilitation of the plant/unit.

The $EG_{historical}$ calculation has been chosen using the option (b)-(i) above.

$EG_{historical}$ and $\sigma_{historical}$ for Unit 1

Baseline year	Electricity delivered to the grid before the capacity upgrade (MWh)
	Unit 1
May 1995-April 1996	351,414
May 1996-April 1997	347,201
May 1997-April 1998	384,645
May 1998-April 1999	406,935
May 1999-April 2000	390,902
May 2000-April 2001	371,716
May 2001-April 2002	457,236
May 2002-April 2003	437,297
May 2003-April 2004	345,779
May 2004-April 2005	444,788
$EG_{historical}$ (MWh)	393,791
$\sigma_{historical}$ (MWh)	41,556
$EG_{historical} + \sigma_{historical}$ (MWh)	435,348

$EG_{\text{historical}}$ and $\sigma_{\text{historical}}$ for Unit 2

Baseline year	Electricity delivered to the grid before the capacity upgrade (MWh)
	Unit 2
February 1995-January 1996	373,721
February 1996-January 1997	335,721
February 1997-January 1998	382,828
February 1998-January 1999	328,201
February 1999-January 2000	386,118
February 2000-January 2001	359,457
February 2001-January 2002	437,799
February 2002-January 2003	433,620
February 2003-January 2004	344,641
February 2004-January 2005	419,994
$EG_{\text{historical}}$ (MWh)	380,210
$\sigma_{\text{historical}}$ (MWh)	39,743
$EG_{\text{historical}} + \sigma_{\text{historical}}$ (MWh)	419,954

$EG_{\text{historical}}$ and $\sigma_{\text{historical}}$ for Unit 3

Baseline year	Electricity delivered to the grid before the capacity upgrade (MWh)
	Unit 3
August 1997-July 1998	314,306
August 1998-July 1999	453,576
August 1999-July 2000	393,091
August 2000-July 2001	346,891
August 2001-July 2002	445,491
August 2002-July 2003	366,799
August 2003-July 2004	421,210
$EG_{\text{historical}}$ (MWh)	391,623
$\sigma_{\text{historical}}$ (MWh)	51,982
$EG_{\text{historical}} + \sigma_{\text{historical}}$ (MWh)	443,605

Calculation of DATE_{BaselineRetrofit}

Technical lifetime is defined as the total time for which the equipment is technically designed to operate from its first commissioning. Project participants may take into account the typical average technical lifetime of the type equipment. Documented for specific geothermal industry practice is the typical average technical lifetime of geothermal power plant is 30-50 years.¹⁵

According to Energy Sales Contract (ESC) for steam purchase contract mentioned that the project must be available to supply electricity until year of 2030 (and may elect to extend the term until year of 2040). Based on this, the Project Owner being implemented the Life Cycle Management (LCM) Program. "LCM is a long-term planning method for power reduction optimizing, maintenance cost, and capital investment consistently with the emphasis on the power-plant safety aspects and plant

¹⁵ Matek, B. Geothermal Energy Association Issue Brief: Additional Economic Values of Geothermal Power, 2015, https://geo-energy.org/events/Geothermal%20Energy%20Association%20Issue%20Brief_Economic%20Values%202015_Final.pdf (accessed 2017).

operation period target. LCM emphasizes that most of equipment cannot last forever, therefore refurbish and replacement must be anticipated to maintain function and system performance where it operates.”¹⁶. “The reliability and efficiency are fundamental in providing electricity for the society, because the society needs affordable yet reliable electricity. To realize that, the reliability and efficiency must have strong foundation based on the best practice of asset management. Reliability is realized through commitment to conduct asset management, Life Cycle Management (LCM) of excellent power plant operation and maintenance, as well as continuous improvement supported by expert operators and technicians.”¹⁷. The LCM refers to other study related to estimating the project lifetime of the project, for example study of Remaining Life Assessment (RLA) for major equipments of the power plant which conducted by experts of the third party. Based on the RLA then Project Owner do the maintenance planning such as Simple Inspection (SI), Major Inspection (MI), and Overhaul (OH) which will be accommodated as an long term maintenance strategy in the LCM. One of the example of long term maintenance strategy is to do turbine overhaul in year of 2019 which expected to have power plant life extension for another 20 years.

As a conclusion, the average technical lifetime for all units is 46 years, which means that all units will last during 46 years since its commissioning with regular and proper maintenance.

Therefore $DATE_{BaselineRetrofit}$ is assumed to be:

- Unit 1: 12 March 2040
- Unit 2: 12 June 2040
- Unit 3: 16 July 2043

The table below shows the baseline electricity generation data, calculated from 7-year and 10-year historical average as determined by ACM0002 version 17.0. The table also shows the date when all units at Gunung Salak Geothermal power plant started operation after their capacity upgrade were concluded. The last column shows the date when the technical lifetime ends, which is adopted as point in time when the existing equipment would need to be replaced in the absence of the proposed project ($DATE_{BaselineRetrofit}$).

	$EG_{historical}$ and $\sigma_{historical}$ for (MWh) until $DATE_{BaselineRetrofit}$	Capacity upgrade date (Project start date)	$DATE_{BaselineRetrofit}$
Unit 1	435,348	21 June 2005	12 March 2040
Unit 2	419,954	4 April 2005	12 June 2040
Unit 3	443,605	29 September 2004	16 July 2043
Total	1,298,907	-	-

¹⁶ PT. Indonesia Power, Annual Report 2012, <http://www.indonesiapower.co.id/id/komunikasi-berkelanjutan/Reports/ANNUAL%20REPORT%20PT%20INDONESIA%20POWER%202012.pdf> (accessed 2017)

¹⁷ PT. Indonesia Power, Annual Report 2016, <http://www.indonesiapower.co.id/id/komunikasi-berkelanjutan/Reports/ANNUAL%20REPORT%20PT%20INDONESIA%20POWER%20TAHUN%202016.pdf> (accessed 2017)

As a result, according to ACM0002 version 17.0, the baseline scenario is the electricity that would continue to be generated by the current installed capacity, 3 x 55 MW and exported to the JAMALI Grid.

The basic parameters used for calculating JAMALI grid emission factor to be used in the proposed project are provided in table below:

Variable	Value/Unit	Source
Average Operating Margin Emissions factor	0.786 tCO ₂ e/MWh	PLN database (own generation and IPPs ^(*))
Build Margin Emissions Factor	0.999 tCO ₂ e/MWh	PLN database (own generation and IPPs ^(*))
Combined Margin Emissions Factor (for the second and third crediting period)	0.946 tCO ₂ e/MWh	Calculated as per UNFCCC Methodological tool: Tool to calculate the emission factor for an electricity system v05.0.

(*) Independent Power Producers

3.2 Project Emissions

$$PE_y = PE_{FF,y} + PE_{GP,y} + PE_{HP,y}$$

where:

PE_y = Project emissions in year y (t CO₂e/yr)

$PE_{FF,y}$ = Project emissions from fossil fuel consumption in year y (t CO₂/yr)

$PE_{GP,y}$ = Project emissions from the operation of dry, flash steam or binary geothermal power plants in year y (t CO₂e/yr)

$PE_{HP,y}$ = Project emissions from water reservoirs of hydro power plants in year y (t CO₂e/yr)

The project does not involve the fossil fuel consumption (as per ACM0002 version 17.0, for all renewable energy power generation project activities, emissions due to the use of fossil fuels for the backup generator can be neglected) and hydro power, so $PE_{FF,y} = 0$, $PE_{HP,y} = 0$.

$$PE_y = PE_{GP,y}$$

$$PE_{GP,y} = PE_{\text{dry or flash steam},y} + PE_{\text{binary},y}$$

where:

$PE_{GP,y}$ = Project emissions from the operation of dry, flash steam or binary geothermal power plants in year y (t CO₂e/yr)

$PE_{\text{dry or flash steam},y}$ = Project emissions from the operation of dry steam or flash steam geothermal power plants due to release of non-condensable gases in year y (t CO₂e/yr)

$PE_{\text{binary},y}$ = Project emissions from the operation of binary geothermal power plants due to physical leakage of non-condensable gases and working fluid in year y (t CO₂e/yr)

The project is the operation of flash steam geothermal power plant, so $PE_{\text{binary},y} = 0$.

$$PE_{\text{GP},y} = PE_{\text{dry or flash steam},y}$$

$$PE_{\text{dry or flash steam},y} = (w_{\text{steam},\text{CO}_2,y} + w_{\text{steam},\text{CH}_4,y} \times \text{GWP}_{\text{CH}_4}) \times M_{\text{steam},y}$$

where:

$w_{\text{steam},\text{CO}_2,y}$ = Average mass fraction of CO₂ in the produced steam in year y (t CO₂/t steam)

$w_{\text{steam},\text{CH}_4,y}$ = Average mass fraction of CH₄ in the produced steam in year y (t CO₄/t steam)

GWP_{CH_4} = Global warming potential of CH₄ valid for the relevant commitment period (t CO₂e/t CH₄)

$M_{\text{steam},y}$ = Quantity of steam produced in year y (t steam/yr)

3.3 Leakage

According to ACM0002 version 17, the leakage of the proposed project is not considered. No leakage is expected.

3.4 Net GHG Emission Reductions and Removals

Baseline Emissions

$$BE_y = EG_{\text{PJ},y} \times EF_{\text{grid},\text{CM},y}$$

$$EG_{\text{PJ},y} = EG_{\text{facility},y} - (EG_{\text{historical}} + \sigma_{\text{historical}}); \text{until DATE}_{\text{BaselineRetrofit}}$$

Please see the table below for each power station unit calculation including its results and summary of the values used.

Calculation for Gunung Salak unit 1

	2016	2017 - 2025	
Net electricity supplied by Gunung Salak unit 1 to the grid ($EG_{\text{facility},y}$)	471,854	473,040	MWh

	2016	2017 - 2025	
Average electricity supplied by the power plant (Gunung Salak unit 1) to the grid before the project ($EG_{\text{historical}}$ until $DATE_{\text{BaselineRetrofit}}$)	393,791	393,791	MWh
Standard deviation of the average electricity supplied by the power plant (Gunung Salak unit 1) to the grid before the project ($EG_{\text{historical}}$ until $DATE_{\text{BaselineRetrofit}}$)	41,556	41,556	MWh
Baseline emission factor with combined margin ($EF_{\text{grid,CM,y}}$)	0.946	0.946	t CO ₂ e/MWh
Baseline emissions for Unit 1 (BE_y)	34,526	35,647	t CO₂e/year

Calculation for Gunung Salak unit 2

	2016	2017 - 2025	
Net electricity supplied by Gunung Salak unit 2 to the grid ($EG_{\text{facility,y}}$)	452,327	473,040	MWh
Average electricity supplied by the power plant (Gunung Salak unit 2) to the grid before the project ($EG_{\text{historical}}$ until $DATE_{\text{BaselineRetrofit}}$)	380,210	380,210	MWh
Standard deviation of the average electricity supplied by the power plant (Gunung Salak unit 2) to the grid before the project ($EG_{\text{historical}}$ until $DATE_{\text{BaselineRetrofit}}$)	39,743	39,743	MWh
Baseline emission factor with combined margin ($EF_{\text{grid,CM,y}}$)	0.946	0.946	t CO ₂ e/MWh
Baseline emissions for Unit 2 (BE_y)	30,617	50,206	t CO₂e/year

Calculation for Gunung Salak unit 3

	2016	2017 - 2025	
Net electricity supplied by Gunung Salak unit 3 to the grid ($EG_{\text{facility,y}}$)	444,627	473,040	MWh
Average electricity supplied by the power plant (Gunung Salak unit 3) to	391,623	391,623	MWh

	2016	2017 - 2025	
the grid before the project ($EG_{\text{historical}}$ until $DATE_{\text{BaselineRetrofit}}$)			
Standard deviation of the average electricity supplied by the power plant (Gunung Salak unit 3) to the grid before the project ($EG_{\text{historical}}$ until $DATE_{\text{BaselineRetrofit}}$)	51,982	51,982	
Baseline emission factor with combined margin ($EF_{\text{grid,CM,y}}$)	0.946	0.946	t CO ₂ e/MWh
Baseline emissions for Unit 3 (BE_y)	967	27,838	t CO₂e/year

Summary of Baseline Emissions (BE_y)

Year	Vintage	BE_y (tCO ₂ e)		
		Unit 1	Unit 2	Unit 3
2016	1 April 2016 - 31 March 2017	34,526	30,617	967
2017	1 April 2017 – 31 March 2018	35,647	50,206	27,838
2018	1 April 2018 – 31 March 2019	35,647	50,206	27,838
2019	1 April 2019 – 31 March 2020	35,647	50,206	27,838
2020	1 April 2020 – 31 March 2021	35,647	50,206	27,838
2021	1 April 2021 – 31 March 2022	35,647	50,206	27,838
2022	1 April 2022 – 31 March 2023	35,647	50,206	27,838
2023	1 April 2023 – 31 March 2024	35,647	50,206	27,838
2024	1 April 2024 – 31 March 2025	35,647	50,206	27,838
2025	1 April 2025 – 31 March 2026	35,647	50,206	27,838

Project Emissions

$$PE_y = PE_{FF,y} + PE_{GP,y} + PE_{HP,y}$$

$$PE_y = PE_{GP,y}$$

$$PE_{GP,y} = PE_{\text{dry or flash steam},y} + PE_{\text{binary},y}$$

$$PE_{GP,y} = PE_{\text{dry or flash steam},y}$$

$$PE_{\text{dry or flash steam},y} = (w_{\text{steam,CO}_2,y} + w_{\text{steam,CH}_4,y} \times GWP_{\text{CH}_4}) \times M_{\text{steam},y}$$

Please see the table below for each power station unit calculation including its results and summary of the values used.

PE_y Calculation for Gunung Salak unit 1

	2016	2017 - 2025	
W _{steam,CO2,y}	0.003797720	0.003797720	-
W _{steam,CH4,y}	0.000008356	0.000008356	-
GWP _{CH4}	25	25	tCO ₂ /tCH ₄
M _{steam,y}	305,175	288,220	tonnes
PE_y	1,223	1,155	t CO₂e/year

PE_y Calculation for Gunung Salak unit 2

	2016	2017 - 2025	
W _{steam,CO2,y}	0.004805050	0.004805050	-
W _{steam,CH4,y}	0.000007700	0.000007700	-
GWP _{CH4}	25	25	tCO ₂ /tCH ₄
M _{steam,y}	309,693	405,934	tonnes
PE_y	1,548	2,029	t CO₂e/year

PE_y Calculation for Gunung Salak unit 3

	2016	2017 - 2025	
W _{steam,CO2,y}	0.004846173	0.004846173	-
W _{steam,CH4,y}	0.000007023	0.000007023	-
GWP _{CH4}	25	25	tCO ₂ /tCH ₄
M _{steam,y}	308,061	225,081	tonnes
PE_y	1,547	1,130	t CO₂e/year

Therefore, using the approach above, and the historical and actual data recorded by PT. Indonesia Power, the project emission for each power station unit is shown below:

Year	Vintage	PE _y (tCO ₂ e)		
		Unit 1	Unit 2	Unit 3
2016	1 April 2016 - 31 March 2017	1,223	1,548	1,547
2017	1 April 2017 – 31 March 2018	1,155	2,029	1,130
2018	1 April 2018 – 31 March 2019	1,155	2,029	1,130
2019	1 April 2019 – 31 March 2020	1,155	2,029	1,130
2020	1 April 2020 – 31 March 2021	1,155	2,029	1,130
2021	1 April 2021 – 31 March 2022	1,155	2,029	1,130
2022	1 April 2022 – 31 March 2023	1,155	2,029	1,130

Year	Vintage	PE _y (tCO ₂ e)		
		Unit 1	Unit 2	Unit 3
2023	1 April 2023 – 31 March 2024	1,155	2,029	1,130
2024	1 April 2024 – 31 March 2025	1,155	2,029	1,130
2025	1 April 2025 – 31 March 2026	1,155	2,029	1,130

Leakage Emissions

$$L_y = 0$$

The ex-ante emission reductions calculations are as follows:

$$ER_y = BE_y - PE_y - L_y$$

ER calculation for Gunung Salak Unit 1

Year	Vintage	Estimated baseline emissions or removals (tCO ₂ e)	Estimated project emissions or removals (tCO ₂ e)	Estimated leakage emissions (tCO ₂ e)	Estimated net GHG emission reductions or removals (tCO ₂ e)
2016	1 April 2016 – 31 March 2017	34,526	1,223	0	33,303
2017	1 April 2017 – 31 March 2018	35,647	1,155	0	34,493
2018	1 April 2018 – 31 March 2019	35,647	1,155	0	34,493
2019	1 April 2019 – 31 March 2020	35,647	1,155	0	34,493
2020	1 April 2020 – 31 March 2021	35,647	1,155	0	34,493
2021	1 April 2021 – 31 March 2022	35,647	1,155	0	34,493
2022	1 April 2022 – 31 March 2023	35,647	1,155	0	34,493
2023	1 April 2023 – 31 March 2024	35,647	1,155	0	34,493
2024	1 April 2024 – 31 March 2025	35,647	1,155	0	34,493
2025	1 April 2025 – 31 March 2026	35,647	1,155	0	34,493
Total		355,354	11,616	0	343,738

ER calculation for Gunung Salak Unit 2

Year	Vintage	Estimated baseline emissions or removals (tCO ₂ e)	Estimated project emissions or removals (tCO ₂ e)	Estimated leakage emissions (tCO ₂ e)	Estimated net GHG emission reductions or removals (tCO ₂ e)
2016	1 April 2016 – 31 March 2017	30,617	1,548	0	29,069
2017	1 April 2017 – 31 March 2018	50,206	2,029	0	48,178
2018	1 April 2018 – 31 March 2019	50,206	2,029	0	48,178
2019	1 April 2019 – 31 March 2020	50,206	2,029	0	48,178
2020	1 April 2020 – 31 March 2021	50,206	2,029	0	48,178
2021	1 April 2021 – 31 March 2022	50,206	2,029	0	48,178
2022	1 April 2022 – 31 March 2023	50,206	2,029	0	48,178
2023	1 April 2023 – 31 March 2024	50,206	2,029	0	48,178
2024	1 April 2024 – 31 March 2025	50,206	2,029	0	48,178
2025	1 April 2025 – 31 March 2026	50,206	2,029	0	48,178
Total		482,475	19,806	0	462,669

ER calculation for Gunung Salak Unit 3

Year	Vintage	Estimated baseline emissions or removals (tCO ₂ e)	Estimated project emissions or removals (tCO ₂ e)	Estimated leakage emissions (tCO ₂ e)	Estimated net GHG emission reductions or removals (tCO ₂ e)
2016	1 April 2016 – 31 March 2017	967	1,547	0	-580
2017	1 April 2017 –	27,838	1,130	0	26,708

Year	Vintage	Estimated baseline emissions or removals (tCO ₂ e)	Estimated project emissions or removals (tCO ₂ e)	Estimated leakage emissions (tCO ₂ e)	Estimated net GHG emission reductions or removals (tCO ₂ e)
	31 March 2018				
2018	1 April 2018 – 31 March 2019	27,838	1,130	0	26,708
2019	1 April 2019 – 31 March 2020	27,838	1,130	0	26,708
2020	1 April 2020 – 31 March 2021	27,838	1,130	0	26,708
2021	1 April 2021 – 31 March 2022	27,838	1,130	0	26,708
2022	1 April 2022 – 31 March 2023	27,838	1,130	0	26,708
2023	1 April 2023 – 31 March 2024	27,838	1,130	0	26,708
2024	1 April 2024 – 31 March 2025	27,838	1,130	0	26,708
2025	1 April 2025 – 31 March 2026	27,838	1,130	0	26,708
Total		251,512	11,720	0	239,792

Therefore, using the calculation above the total GHG emission reductions for the 10-year crediting period is 1,046,199 tCO₂e or 104,620 tCO₂e/year, as shown in the summary below:

Year	Vintage	Estimated net GHG emission reductions or removals - Unit 1 (tCO ₂ e)	Estimated net GHG emission reductions or removals - Unit 2 (tCO ₂ e)	Estimated net GHG emission reductions or removals - Unit 3 (tCO ₂ e)	Total Estimated net GHG emission reductions or removals (tCO ₂ e)
2016	1 April 2016 – 31 March 2017	33,303	29,069	-580	61,793
2017	1 April 2017 – 31 March 2018	34,493	48,178	26,708	109,378
2018	1 April 2018 –	34,493	48,178	26,708	109,378

Year	Vintage	Estimated net GHG emission reductions or removals - Unit 1 (tCO ₂ e)	Estimated net GHG emission reductions or removals - Unit 2 (tCO ₂ e)	Estimated net GHG emission reductions or removals - Unit 3 (tCO ₂ e)	Total Estimated net GHG emission reductions or removals (tCO ₂ e)
	31 March 2019				
2019	1 April 2019 – 31 March 2020	34,493	48,178	26,708	109,378
2020	1 April 2020 – 31 March 2021	34,493	48,178	26,708	109,378
2021	1 April 2021 – 31 March 2022	34,493	48,178	26,708	109,378
2022	1 April 2022 – 31 March 2023	34,493	48,178	26,708	109,378
2023	1 April 2023 – 31 March 2024	34,493	48,178	26,708	109,378
2024	1 April 2024 – 31 March 2025	34,493	48,178	26,708	109,378
2025	1 April 2025 – 31 March 2026	34,493	48,178	26,708	109,378
Total		343,738	462,669	239,792	1,046,199

4 MONITORING

4.1 Data and Parameters Available at Validation

Data / Parameter	EG _{historical}
Data unit	MWh
Description	Average net electricity delivered to the grid before the project activity until DATE _{BaselineRetrofit}
Source of data	Project Owner-PLN revenue meter (electricity sales) Meter No. Unit #1: PS 0512A040-01 with class of accuracy 0.2 Unit #2: PS 0512A041-01 with class of accuracy 0.2 Unit #3: PS 0512A042-01 with class of accuracy 0.2

	On 1 October 2008, the electricity sales flow meter was replaced by PT 0806A117-01 / PT 0806A118-01 / PT 0806A119-01.										
Value applied	<table border="1"> <thead> <tr> <th></th><th>$EG_{\text{historical}}$ until $DATE_{\text{BaselineRetrofit}}$ (MWh)</th></tr> </thead> <tbody> <tr> <td>Unit 1</td><td>393,791</td></tr> <tr> <td>Unit 2</td><td>380,210</td></tr> <tr> <td>Unit 3</td><td>391,623</td></tr> <tr> <td>Total</td><td>1,165,624</td></tr> </tbody> </table> The data above is based on an average of historical net electricity generation data recorded by PT. Indonesia Power since 1998-2004 for Unit 3 and 1996-2005 for Units 1 and 2.		$EG_{\text{historical}}$ until $DATE_{\text{BaselineRetrofit}}$ (MWh)	Unit 1	393,791	Unit 2	380,210	Unit 3	391,623	Total	1,165,624
	$EG_{\text{historical}}$ until $DATE_{\text{BaselineRetrofit}}$ (MWh)										
Unit 1	393,791										
Unit 2	380,210										
Unit 3	391,623										
Total	1,165,624										
Justification of choice of data or description of measurement methods and procedures applied	Electricity produced is measured by a watt-hour meter (connected to a digital control system and recorded continuously), which can measure both power delivered to the grid and received from the grid. Therefore, net electricity export is measured. The measurement of electricity generation is conducted on a continuous basis, where hourly and daily total electricity measurement will be available. The measurement results is summarised transparently in regular production reports.										
Purpose of Data	Calculation of baseline emissions										
Comments	Standard Operation Procedure signed between PT. Indonesia Power and PT PLN (load dispatcher) or other documents, which update or replace this SOP.										

Data / Parameter	$\sigma_{\text{historical}}$								
Data unit	MWh								
Description	Standard deviation of average net electricity delivered to the grid before the project activity until $DATE_{\text{BaselineRetrofit}}$								
Source of data	Statistical calculation of standard deviation of $EG_{\text{historical}}$								
Value applied	<table border="1"> <thead> <tr> <th></th><th>$\sigma_{\text{historical}}$ until $DATE_{\text{BaselineRetrofit}}$ (MWh)</th></tr> </thead> <tbody> <tr> <td>Unit 1</td><td>41,556</td></tr> <tr> <td>Unit 2</td><td>39,743</td></tr> <tr> <td>Unit 3</td><td>51,982</td></tr> </tbody> </table>		$\sigma_{\text{historical}}$ until $DATE_{\text{BaselineRetrofit}}$ (MWh)	Unit 1	41,556	Unit 2	39,743	Unit 3	51,982
	$\sigma_{\text{historical}}$ until $DATE_{\text{BaselineRetrofit}}$ (MWh)								
Unit 1	41,556								
Unit 2	39,743								
Unit 3	51,982								

	<table> <tr> <td>Total</td><td>133,281</td></tr> </table> The data above is based on an average of historical net electricity generation data recorded by PT. Indonesia Power since 1998-2004 for Unit 3 and 1996-2005 for Units 1 and 2.	Total	133,281
Total	133,281		
Justification of choice of data or description of measurement methods and procedures applied	Statistical calculation		
Purpose of Data	Calculation of baseline emissions		
Comments	-		

Data / Parameter	DATE _{BaselineRetrofit}												
Data 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	- Energy Sales Contract (ESC) for steam purchase contract mentioned that the project must be available to supply electricity until year of 2030 (and may elect to extend the term until year of 2040). - Geothermal industry practice is the typical average technical lifetime of geothermal power plant is 30-50 years (Matek, B. Geothermal Energy Association Issue Brief: Additional Economic Values of Geothermal Power, 2015, https://geo-energy.org/events/Geothermal%20Energy%20Association%20Issue%20Brief_Economic%20Values%202015_Final.pdf (accessed, 2017) / http://geo-energy.org/geo_basics_plant_cost.aspx (accessed, 2017)) - As a conclusion, the average technical lifetime for all units is 46 years, which means that all units will last during 46 years since its commissioning with regular and proper maintenance.												
Value applied	<table><tr><td></td><td>Commissioning Date</td><td>DATE_{BaselineRetrofit}</td></tr><tr><td>Unit 1</td><td>12 March 1994</td><td>12 March 2040</td></tr><tr><td>Unit 2</td><td>12 June 1994</td><td>12 June 2040</td></tr><tr><td>Unit 3</td><td>16 July 1997</td><td>16 July 2043</td></tr></table> The DATE_{BaselineRetrofit} comes from commissioning date of each unit added by the average technical lifetime of 46 years.		Commissioning Date	DATE _{BaselineRetrofit}	Unit 1	12 March 1994	12 March 2040	Unit 2	12 June 1994	12 June 2040	Unit 3	16 July 1997	16 July 2043
	Commissioning Date	DATE _{BaselineRetrofit}											
Unit 1	12 March 1994	12 March 2040											
Unit 2	12 June 1994	12 June 2040											
Unit 3	16 July 1997	16 July 2043											
Justification of choice of data or description of	-												

measurement methods and procedures applied	
Purpose of Data	Calculation of baseline emissions
Comments	-

Data / Parameter	GWP _{CH4}
Data unit	tCO ₂ /tCH ₄
Description	Global warming potential of methane, valid for the relevant commitment period
Source of data	IPCC
Value applied	Default value for the second commitment period = 25 tCO ₂ /tCH ₄ (Updated required for source of global warming potentials from the IPCC's Second Assessment Report to the IPCC's Fourth Assessment Report)
Justification of choice of data or description of measurement methods and procedures applied	-
Purpose of Data	Calculation of project emissions
Comments	-

Data / Parameter	EF _{grid,OM,y}
Data unit	tCO ₂ /MWh
Description	EF _{grid,OM,y} is the average operating margin CO ₂ emission factor of power plant connected to the JAMALI electricity grid in 3 recent years available data, calculated using average OM method for each year in which the project generation occurs. During the crediting period, this factor is calculated based on ex-ante emissions by using year 2013, 2014 and 2015 data.
Source of data	Directorate General of Electricity - Ministry of Energy and Mineral Resources (MEMR), Republic of Indonesia
Value applied	EF _{grid,OM,y} = 0.786 tCO ₂ /MWh
Justification of choice of data or description of measurement methods and procedures applied	No measurement required. Data is obtained based on analysis of MEMR published information.
Purpose of Data	Calculation of baseline emissions
Comments	All data relevant for the calculation of EF _{grid,OM,y} are updated annually. This includes each associated fuel emission factor and corresponding net calorific values, is re-defined annually.

Data / Parameter	$EF_{grid,BM,y}$
Data unit	tCO ₂ /MWh
Description	$EF_{grid,BM,y}$ is the build margin CO ₂ emission factor of power plants in the sample group 'm' connected to the JAMALI electricity grid in year 'y'. During the crediting period, this factor is calculated based on ex-ante emissions by using year 2015 data.
Source of data	Directorate General of Electricity - Ministry of Energy and Mineral Resources (MEMR), Republic of Indonesia
Value applied	$EF_{grid,BM,y} = 0.999$ tCO ₂ /MWh
Justification of choice of data or description of measurement methods and procedures applied	No measurement required. Data is obtained based on analysis of MEMR published information.
Purpose of Data	Calculation of baseline emissions
Comments	All data relevant for the calculation of $EF_{grid,BM,y}$ are updated annually. This includes each associated fuel emission factor and corresponding net calorific values, as well as sample group "m" power plants (its associated generation and fuel consumption data), is re-defined annually.

Data / Parameter	$EF_{grid,CM,y}$
Data unit	tCO ₂ /MWh
Description	$EF_{grid,CM,y}$ is the combined margin CO₂ emission factor of power plants connected to the JAMALI electricity grid in year 'y', calculated ex-ante based on the weighted average of $EF_{grid,OM,y}$ and $EF_{grid,BM,y}$. As per UNFCCC Methodological tool: Tool to calculate the emission factor for an electricity system v05.0, the following default values should be used for w_{OM} and w_{BM} (for all projects except for wind and solar power generation project activities): $w_{OM} = 0.5$ and $w_{BM} = 0.5$ for the first crediting period, and $w_{OM} = 0.25$ and $w_{BM} = 0.75$ for the second and third crediting period, unless otherwise specified in the approved methodology which refers to this tool.
Source of data	Calculation
Value applied	$EF_{grid,CM,y} = 0.946$ tCO ₂ /MWh
Justification of choice of data or description of measurement methods and procedures applied	No measurement required. Data is obtained based on analysis of MEMR published information.
Purpose of Data	Calculation of baseline emissions

Comments	-
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4.2 Data and Parameters Monitored

Data / Parameter	M _{steam,y}																											
Data unit	t steam																											
Description	Quantity of steam produced during the year 'y'																											
Source of data	Project Owner-main steam line flow meter Instrument No. Unit #1: 1LBA01CF001-B01, class of accuracy 0.25% Unit #2: 2LBA01CF001-B01, class of accuracy 0.25% Unit #3: 3LBA01CF001-B01, class of accuracy 0.25%																											
Description of measurement methods and procedures to be applied	The measurement of steam quantities will be conducted on a continuous basis, where daily total flow measurement will be available. The measurement results will be summarised transparently in regular production reports.																											
Frequency of monitoring/recording	Steam flow is hourly measured and recorded in paper format. Subsequently, the data is aggregated yearly in electronic format.																											
Value applied	<table><tr><td></td><td colspan="2">Steam produced during the year 'y' (t steam/year)</td></tr><tr><td></td><td>2016</td><td>2017-2025</td></tr><tr><td>Unit 1</td><td>3,944,432</td><td>3,617,179</td></tr><tr><td>Unit 2</td><td>3,716,473</td><td>3,617,179</td></tr><tr><td>Unit 3</td><td>3,633,958</td><td>3,617,179</td></tr></table> The data above is total steam flow for all units based on actual data recorded by PT. Indonesia Power, except for 2017-2025 that comes from assumptions using operating period of 7,884 hour/year (90% load factor) times 458.80 t steam/hour for each unit. Steam quantities based on underlying project boundary (steam attributable to the project's capacity upgrade) <table><tr><td></td><td colspan="2">Steam produced during the year 'y' (t steam/year)</td></tr><tr><td></td><td>2016</td><td>2017-2025</td></tr><tr><td>Unit 1</td><td>305,175</td><td>288,220</td></tr><tr><td>Unit 2</td><td>309,693</td><td>405,934</td></tr></table>		Steam produced during the year 'y' (t steam/year)			2016	2017-2025	Unit 1	3,944,432	3,617,179	Unit 2	3,716,473	3,617,179	Unit 3	3,633,958	3,617,179		Steam produced during the year 'y' (t steam/year)			2016	2017-2025	Unit 1	305,175	288,220	Unit 2	309,693	405,934
	Steam produced during the year 'y' (t steam/year)																											
	2016	2017-2025																										
Unit 1	3,944,432	3,617,179																										
Unit 2	3,716,473	3,617,179																										
Unit 3	3,633,958	3,617,179																										
	Steam produced during the year 'y' (t steam/year)																											
	2016	2017-2025																										
Unit 1	305,175	288,220																										
Unit 2	309,693	405,934																										

	<table><tr><td>Unit 3</td><td>308,061</td><td>225,081</td></tr></table>	Unit 3	308,061	225,081																	
Unit 3	308,061	225,081																			
	Steam quantities based on underlying project boundary are calculated based on the Specific Steam Consumption (SSC).																				
Monitoring equipment	<table><tr><td></td><td colspan="3">Steam flow meter</td></tr><tr><td></td><td>Type</td><td>Accuracy Class</td><td>Serial Number</td></tr><tr><td>Unit 1</td><td> - Endress+Hausser FMD78 - GE PanaFlow MV82 </td><td> 0.25% 2% </td><td> - H400C50109D 4987429-2 </td></tr><tr><td>Unit 2</td><td> - Endress+Hausser FMD78 - GE PanaFlow MV82 </td><td> 0.25% 2% </td><td> - E303CC0109D 4987429-1 </td></tr><tr><td>Unit 3</td><td> - Endress+Hausser FMD78 </td><td> 0.25% </td><td> - D404420109D </td></tr></table>		Steam flow meter				Type	Accuracy Class	Serial Number	Unit 1	- Endress+Hausser FMD78 - GE PanaFlow MV82	0.25% 2%	- H400C50109D 4987429-2	Unit 2	- Endress+Hausser FMD78 - GE PanaFlow MV82	0.25% 2%	- E303CC0109D 4987429-1	Unit 3	Endress+Hausser FMD78	0.25%	D404420109D
	Steam flow meter																				
	Type	Accuracy Class	Serial Number																		
Unit 1	- Endress+Hausser FMD78 - GE PanaFlow MV82	0.25% 2%	- H400C50109D 4987429-2																		
Unit 2	- Endress+Hausser FMD78 - GE PanaFlow MV82	0.25% 2%	- E303CC0109D 4987429-1																		
Unit 3	Endress+Hausser FMD78	0.25%	D404420109D																		
QA/QC procedures to be applied	Meters will be calibrated according to the national standard of Java-Madura-Bali (JAMALI) Grid Code ¹⁸ that described calibration period of installed meters in power plants connected to JAMALI Grid is once per 5 years, or Standard Operational Procedures by PT. Indonesia Power or other documents which update or replace this national standard (whichever occurs earliest).																				
Purpose of data	Calculation of project emissions																				
Calculation method	Specific Steam Consumption (SSC) calculation: SSC = $\frac{\text{Steam flowrate (t steam)}}{\text{Net power output of the plant (MWh)}}$ <table><tr><td></td><td>Steam flowrate year 2016 (t steam)</td><td>Net power output of the plant (MWh)</td><td>SSC (t steam/MWh)</td></tr><tr><td>Unit 1</td><td>3,944,432</td><td>471,854</td><td>8.359</td></tr><tr><td>Unit 2</td><td>3,716,473</td><td>452,327</td><td>8.216</td></tr></table>		Steam flowrate year 2016 (t steam)	Net power output of the plant (MWh)	SSC (t steam/MWh)	Unit 1	3,944,432	471,854	8.359	Unit 2	3,716,473	452,327	8.216								
	Steam flowrate year 2016 (t steam)	Net power output of the plant (MWh)	SSC (t steam/MWh)																		
Unit 1	3,944,432	471,854	8.359																		
Unit 2	3,716,473	452,327	8.216																		

¹⁸ This complies with the Minister of Energy and Mineral Resources Regulation No. 3 issued in 2007 (<http://portal.djmbp.esdm.go.id/sijh/permen-esdm-03-2007.pdf>) regarding Java-Madura-Bali (JAMALI) Grid Code.

	Unit 3	3,633,958	444,627	8.173
	The net power output of the plant for year 2016 above is based on actual data recorded by PT. Indonesia Power, which is Gross Production subtract Own Consumption.			
		Steam flowrate year 2017- 2025 (t steam)	Net power output of the plant (MWh)	SSC (t steam/MWh)
	Unit 1	3,617,179	473,040	7.647
	Unit 2	3,617,179	473,040	7.647
	Unit 3	3,617,179	473,040	7.647
	The net power output of the plant for year 2017-2025 comes from an assumption using 90% load factor for each unit.			
	Steam quantities based on underlying project boundary calculation is SSC times the attributable electricity generation to VCS Project ($EG_{PJ,y}$)			
		SSC year 2016 (t steam/MWh)	Attributable electricity generation to VCS Project ($EG_{PJ,y}$) (MWh)	Steam quantities based on underlying project boundary (t steam)
	Unit 1	8.359	36,507	305,175
	Unit 2	8.216	32,373	309,693
	Unit 3	8.173	1,022	308,061
		SSC year 2017-2025 (t steam/MWh)	Attributable electricity generation to VCS Project ($EG_{PJ,y}$) (MWh)	Steam quantities based on underlying project boundary (t steam)
	Unit 1	7.647	37,692	288,220
	Unit 2	7.647	53,086	405,934
	Unit 3	7.647	29,435	225,081

	.
Comments	Continuous measurement, subsequently, the data will be aggregated monthly.

Data / Parameter	$W_{\text{steam},\text{CO}_2,y}$
Data unit	t CO ₂ /t steam
Description	Average mass fraction of CO ₂ in the produced steam in year y
Source of data	The Non-Condensable Gases (NCG) data taken from steam sampling as prescribed in the Monitoring Methodology ACM0002 version 17.0
Description of measurement methods and procedures to be applied	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 (as applicable to sampling phase steam only). The Non-Condensable Gases (NCG) sampling and analysis will be performed every three months.
Frequency of monitoring/recording	Every three months
Value applied	Unit 1: 3.798×10^{-3} or 0.3797720% Unit 2: 4.805×10^{-3} or 0.4805050% Unit 3: 4.846×10^{-3} or 0.4846173%
Monitoring equipment	-
QA/QC procedures to be applied	Gunung Salak Geothermal Laboratory QA/QC Procedure
Purpose of data	Calculation of project emissions
Calculation method	-
Comments	-

Data / Parameter	$W_{\text{steam},\text{CH}_4,y}$
Data unit	t CH ₄ /t steam
Description	Average mass fraction of CH ₄ in the produced steam in year y
Source of data	The Non-Condensable Gases (NCG) data taken from steam sampling as prescribed in the Monitoring Methodology ACM0002 version 17.0
Description of measurement methods	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

and procedures to be applied	Fluid for Purposes of Chemical Analysis (as applicable to sampling phase steam only). The Non-Condensable Gases (NCG) sampling and analysis will be performed every three months.
Frequency of monitoring/recording	Every three months
Value applied	Unit 1: 8.356×10^{-6} or 0.0008356% Unit 2: 7.700×10^{-6} or 0.0007700% Unit 3: 7.023×10^{-6} or 0.0007023%
Monitoring equipment	-
QA/QC procedures to be applied	Gunung Salak Geothermal Laboratory QA/QC Procedure
Purpose of data	Calculation of project emissions
Calculation method	-
Comments	-

Data / Parameter	$EG_{\text{facility},y}$															
Data unit	MWh															
Description	Net electricity delivered to the grid by the project activity															
Source of data	Project Owner-PLN revenue meter (electricity sales)															
Description of measurement methods and procedures to be applied	Electricity produced will be measured by a watt-hour meter (connected to a digital control system and recorded continuously), which can measure both power delivered to the grid and received from the grid. Therefore, net electricity export will be measured. The measurement of electricity generation will be conducted on a continuous basis, where hourly and daily total electricity measurement will be available. The measurement results will be summarised transparently in regular production reports.															
Frequency of monitoring/recording	The measurement of electricity generation is conducted on a continuous basis, where hourly and daily total electricity measurement is available.															
Value applied	<table><tr><td></td><th colspan="2">$EG_{\text{facility},y}$</th></tr><tr><td></td><th>2016</th><th>2017-2025</th></tr><tr><td>Unit 1</td><td>471,854</td><td>473,040</td></tr><tr><td>Unit 2</td><td>452,327</td><td>473,040</td></tr><tr><td>Unit 3</td><td>444,627</td><td>473,040</td></tr></table>		$EG_{\text{facility},y}$			2016	2017-2025	Unit 1	471,854	473,040	Unit 2	452,327	473,040	Unit 3	444,627	473,040
	$EG_{\text{facility},y}$															
	2016	2017-2025														
Unit 1	471,854	473,040														
Unit 2	452,327	473,040														
Unit 3	444,627	473,040														

Monitoring equipment	Steam flow meter			
		Type	Accuracy Class	Serial Number
	Unit 1	Schneider Electric ION 8600	0.2	PT 0806A119-01
	Unit 2	Schneider Electric ION 8600	0.2	PT 0806A118-01
	Unit 3	Schneider Electric ION 8600	0.2	MT 1006A500-01
QA/QC procedures to be applied	The QA/QC will be conducted through cross checking with sales electricity receipts. Meters will be calibrated according to the Standard Operational Procedures signed between PT. Indonesia Power and PLN (load dispatcher) or other documents, which update or replace this SOP. Data measured by meters will be cross checked by electricity sales receipt. The meter (s) will either: i) be read frequently jointly by the project developer and the grid company ii) be only read by the project developer and data will be double checked with the electricity sales receipts iii) be only read by the grid company			
Purpose of data	Calculation of baseline emissions			
Calculation method	$EG_{\text{facility}} = EG_{\text{exp}} - EG_{\text{imp}}$			
Comments	Standard Operation Procedure signed between PT. Indonesia Power and PT PLN (load dispatcher) or other documents, which update or replace this SOP			

4.3 Monitoring Plan

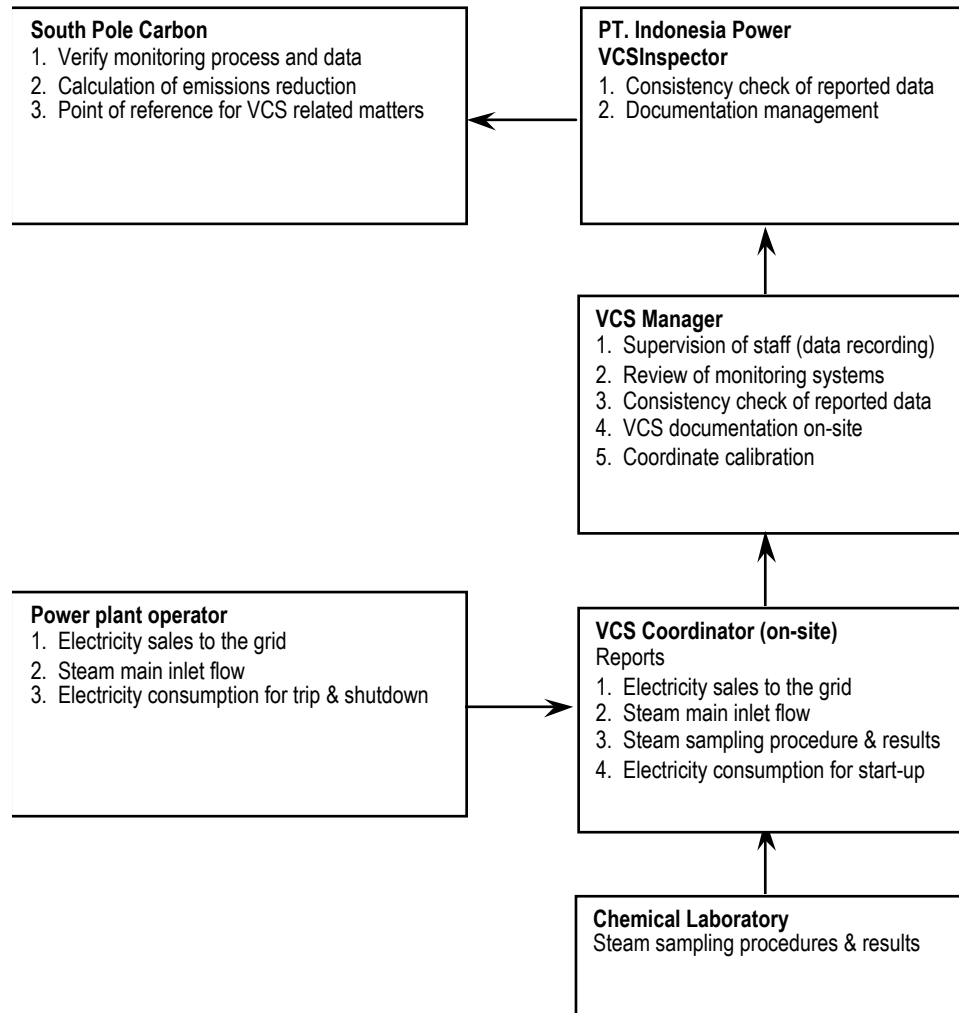
This section presents the steps taken to monitor on regular basis the GHG emission reductions from the capacity upgrade project at Gunung Salak geothermal power plant in Indonesia.

The purpose of the monitoring plan is to present reliable and complete data and to ensure that all actual project data is well organised in term of collection and archiving.

1. Monitoring organisation

Prior to the start of the crediting period, the organisation of the monitoring team will be established. Clear roles and responsibilities will be assigned to all staff and the power plant manager involved in the VCS project, who will have overall responsibility for the monitoring system in the project, ensuring trained staff perform the monitoring duties and that where trained monitoring staff are absent, the integrity of the monitoring system is maintained by other trained staff. Initial training will be conducted and regular checks performed to ensure adequacy of monitoring data.

Monitoring Organisation Chart



QA

The project developer has created procedures that will ensure consistent quality of all data collection, recording, storage, and reporting. The project developer has assigned a VCS manager, the overall person responsible for the VCS monitoring process. The VCS manager cooperates with on-site VCS coordinator and collects all the monitored data required for the VCS. Monthly reports are prepared for the power plants manager who has overall quality control.

2. Monitoring equipment and installation

Metering of electricity supplied to the grid

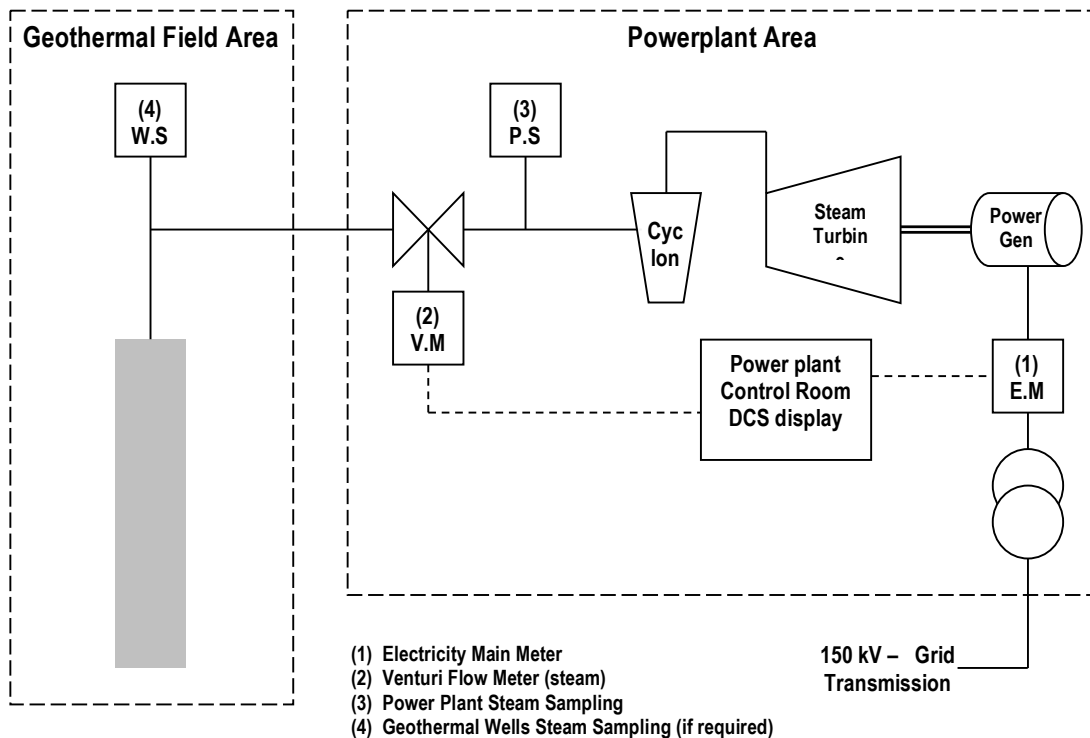
The electricity meter will be the revenue meter that measures the quantity of electricity for which the project will be paid. As this meter provides the main measurement in the methodology, it will be a key part of the verification process. This meter is located at the Gunung Salak substation.

To ensure maximum data availability and to introduce data quality controls, a crosscheck meter will be installed in addition to the revenue meter. This meter will also be located at the Gunung Salak substation, measuring electricity exported from the project.

The electricity meter shall meet relevant local standards at the time of installation. Therefore, the meters must be factory calibrated at the manufacturer before its installation and will be checked repeatedly once per 2 years during its operation. Project owner will install the meters at the project site. Records of the meter (type, maker, model, and calibration documentation) are retained in the quality control system on-site.

Electricity measurements will be taken in accordance with SOP signed between PT. Indonesia Power and PT. PLN (load dispatcher), or other documents which update or replace this SOP.

Monitoring Equipments



Metering of geothermal steam flow

Data is available at the local meter and remotely (Central Control Room, CCR) of power plant. All data will be recorded in a Steam Log Sheet manually. The daily Steam Log Sheet report will be submitted to VCS Coordinator for monthly steam production report.

Lab test of geothermal steam sampling procedure

The Lab officer is responsible for steam sampling procedures and chemical analysis at Gunung Salak Geothermal Area laboratory. The report will be submitted to the VCS Coordinator and subsequently reported to the Manager of Gunung Salak power plants units 1, 2, and 3.

All equipment will be calibrated by the manufacturer according to relevant local standards at the time of installation and maintained in accordance with the manufacturer's recommendations to ensure accuracy of measurements. Records of the meter (type, make, model, calibration, and maintenance documentation) will be retained as part of the VCS monitoring system.

3. Data recording procedure

All relevant data will be archived electronically and backed up regularly. Uncertainty will be considered to achieve conservative results. Moreover, it will be kept for the full crediting period, plus two years after the end of the crediting period or the last issuance of VCUs for this project activity (whichever occurs later). The Monitoring Plan has been developed to ensure that the project has robust data collection, processing, and archiving procedures.

Other data for VER procedures will be managed by the VCS Coordinator and subsequently reported to the power plant manager.

4. Document management

The project developer will keep electricity sale and purchase invoices. All written documentation such as specifications, maps, and drawings, will be stored for the crediting period and two years afterwards, and be made available to the verifier so that the reliability of the information may be checked.

The document management system will be developed to ensure adequate document control for VER purposes. Monitoring report and supporting workbook will be provided for verification.

5 SAFEGUARDS

5.1 No Net Harm

According to adjusted Gunung Salak geothermal power plant's Environmental Impact Assessment (EIA), a revised RKL/RPL (Environment Management Plan and Environment Monitoring Plan) for the additional installed capacity 3 x 5 MW.

The report clearly recognizes that impacts, if any, have been taking into account before and after the project activity as summarized in the letter No. 660.1/1801/II/2007 from the provincial Environmental Agency (BPLHD) of West Java to the project owner due capacity upgrade activity.

A summary of the environmental impacts of the project activity is described below:

Identified Environmental impacts	Measures taken
Operational Phase	
<i>Air Pollution</i>	
An increase H ₂ S gas concentration	Maintain sound operation of turbine and its system together with a fan and blower in the cooling tower.
<i>Noise Pollution</i>	
An increase of noise	Install a noise buffer and cover made from soundproof material for turbine and its system
<i>Water Pollution</i>	
Surface water body pollution	Re-inject waste water (condensates) from cooling tower to abandoned geothermal wells
Post-operational phase	
Re-construction of power plant	Will be planned 3 or 5 years before operational phase ends
Transportation of ruins	Will be planned 3 or 5 years before operational phase ends
Re-vegetation of power plant ex-location	Will be planned 3 or 5 years before operational phase ends

- Deterioration of air quality

During operational phase, some deterioration of air quality is expected to occur, especially an increase in H₂S gas released into the ambient air. The H₂S gas comes from the cooling tower during power plant operation, which emits non-condensable gases (NCG), and from the vent valve and scrubber if broken down.

To reduce this impact there will be regular maintenance and check ups for the turbine and system to prevent any H₂S gas leakage. In addition, the cooling tower must also be maintained regularly to decrease non-condensable gases (NCG) emission.

- Increased noise pollution

Increased noise pollution is expected from the turbine and its system during power plant operation. To reduce the impact the project owner has installed a soundproof buffer and cover surrounding the turbine and its system to prevent any noise pollution to the environment.

- Deterioration of surface water quality

Minor deterioration of surface water quality due to the project activity is expected because of wastewater coming from the cooling tower.

To prevent any further increase, the project owner has managed to re-inject waste water (condensates) to abandoned geothermal wells.

Considering the mitigation controls planned as part of the project activity, EIA process and the contribution made by the project to the sustainable development of the local and national area, the project is expected to have an overall positive impact on the local and global environment. All negative environmental impacts will be described in the mitigation and monitoring plans.

5.2 Environmental Impact

Based on Ministerial Decree No. KEP-17/MENLH/2001, an Environmental Impact Assessment (EIA) has to be conducted for electric power development activities in the Exploitation and Development of Geothermal power plants equal to and/or greater than 55 MW in capacity, in order to assess environmental impacts that will occur from these geothermal field activities, and to prepare mitigation strategies to address impacts, if any.

The Gunung Salak geothermal power plant has two EIAs that include 3 power station units of 55 MW each. One EIA is approved by the Department of Mining and Energy in 1991 that covers only Gunung Salak unit 1 and 2, and in 1996 a second EIA was developed and approved for Gunung Salak unit 3.

Due to the capacity upgrade of Gunung Salak Geothermal Power Plant from 3 x 55 MW to 3 x 60 MW, the project owner together with Research Agency of Padjajaran University conducted a study to adjust the EIAs by submitting a revised RKL/RPL (Environment Management Plan and Environment Monitoring Plan), and presented the results to the provincial EIA commission. The revised RKL/RPL, which was approved in 23 July 2007, covers the additional installed capacity 3 x 5 MW.

5.3 Local Stakeholder Consultation

A meeting with relevant stakeholders, including the village chief and people who live nearby, within the project boundary of Gunung Salak geothermal power plant was conducted on September 25th, 2008 at Raudhatul Jannah Mosque, Parung Kuda, near the power plant. The stakeholder meeting was held together with the power plant's Ramadhan (fasting month) festival to inform the local stakeholders that the capacity upgrade project at the power plant would be registered as one of carbon credit projects. The local stakeholders who attended the meeting have no objections to the proposed activity. Furthermore, as documented in the revised EIA¹⁹, the local stakeholders have perceived that Gunung Salak Geothermal Power Plant establishment has increased their social and economical life due to road construction, additional earning from temporary jobs, health services, and other pro-community activity.

The stakeholder meeting on September 25th, 2008 was documented and recorded like attendance list, pictures, and other relevant documentation, which will be made available to DOE and sent separately.

Outcome: No negative comments were received from the local stakeholders during the meeting. They did not object to the project activity because the project will not negatively impact the surrounding environment or people.

¹⁹ The revised EIA is prepared to cover all environmental and social issue after the capacity upgrade of Gunung Salak geothermal power plant from 3x55 MW to 3x60 MW.

5.4 Public Comments

N/A

APPENDIX I: LETTER FROM THE CHAIRMAN OF INDONESIA GEOTHERMAL ASSOCIATION

**Asosiasi Panasbumi Indonesia (API)**
(Indonesia Geothermal Association)

Sekretariat: d/a MKI/API
Jl. Jend. Gatot Subroto Kav. 18 Jakarta 12950
Telp : 021-5252379, 5253787 Fax : 021-5255939

No : 076 /PP-API/2007
Attach : -

Jakarta, June 18th 2009

To:
Mr. M. P. Kanal
TUV Nord India Pvt Ltd
India

Subject: Gunung Salak Geothermal Power Plant

Dear Sir or Madam,

PT. Indonesia Power is a power generation company that owns and operates Gunung Salak Geothermal Power Plant in West Java, Indonesia.

PT. Indonesia Power has modified its turbines at Gunung Salak Geothermal Power Plant, in 2004 for unit #3 and in 2005 for units #1 and #2, in order to increase its installed capacity from 3x55 MW to 3x60 MW respectively.

This capacity upgrade project activity is the first that is conducted at a geothermal power plant in Indonesia. So far, geothermal power plant owners chose to increase the installed capacity by constructing new units.

Best regards,

Indonesian Geothermal Association
Chairman

Dr. Ir. Surya Dharma, MBA.

