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Clean Development Mechanism (CDM) Project for Kamojang Unit 4 Geothermal Power Plant

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ABSTRACT

The Geothermal Power Plant Kamojang Unit-4 is owned by PT. Pertamina Geothermal Energy (PGE) which started operation commercial on January 26, 2008. The power plant has an installed capacity of 63 MW and generates an estimated power generation of 473 GWh per annum. The electricity from the power plant is then transmitted to the National Power Grid. The CDM project of the power plant is developed by PGE in collaboration with PT. Perusahaan Listrik Negara (PLN).

Methodologies for baseline and monitoring plan of CDM project used ACM0002 "Consolidated baseline methodology for grid connected electricity generation from renewable sources" version 07. Validation visit for Kamojang Geothermal Project Design Document (PDD) assessment according to the specific requirement of the methodology was conducted on March 10-11, 2008. Common approach on recent trend in CDM development would require more information on financial and industrial situation in the host country, which is critical for additionality argument.

The final PDD is expected to be registered at UNFCCC Executive Board on October 2009. The next milestones on CDM project cycle would be CDM project Implementation & monitoring activities, and subsequently periodic verification and issuance of Certified Emission Reduction (CER). Certified Emission Reduction (CER) sales can make geothermal projects in Indonesia economically viable based on 403,727 tones of CO2e per year emission reduction. This calculation is using emission factor of 0,891 Ton C02e / MWh in JAMALI Interconnected grid.

1. INTRODUCTION

The Kamojang Unit 4 Geothermal Power Plant is located around 40 km South East of Bandung, West Java and about 24 km North West of Garut at an elevation of about 1500 m above sea level. Figure 1 shows Location Map of Kamojang Geothermal Power Plant.

Geothermal Power Plant Unit 1, Unit 2 and Unit 3 are operated by Perusahaan Listrik Negara (PLN) a state electricity company with a total installed capacity of 140 MW. The fourth Unit of Geothermal Power Plant is built and operated by PT. PGE which is known as Kamojang Unit 4 Geothermal Power Plant with a capacity of 63 MW. Plant overview is presented on Figure 2.

The Project commenced construction on February 24, 2006 and finished two years afterward. The commercial operation date was started on January 26, 2008 following a successful 3 x 24 hours Unit Rated Capacity (URC) test conducted on January 22 – 25, 2008.

The key purpose of the project is to utilize the geothermal resources of the mountain areas surrounding Kamojang to generate zero emissions electricity to be transmitted to the Java – Madura – Bali (JAMALI) interconnected power grid (hereafter referred to as the Grid) through the PLN sub-station in the Kamojang geothermal project area, with the existing 150 kV transmission line.

2. CDM PROJECT ACTIVITY

2.1 CDM Cycles

Following to the CDM cycles, The Project Design Document (PDD) of Kamojang CDM Project is being validated by Designated Operational Entity (DOE) to evaluate the Project activity, currently there are some of outstanding items that have to be closed by the Project.

2.2 Project Description

The power plant has installed capacity 63 MW with an estimated power generation of 473 GWh per annum based on the predicted capacity factor of 90% (operating time yearly of 7884 hours).

Steam collected from the Kamojang geothermal field is sent to the Kamojang Unit 4 power plant, where it is separated from condensate and fed into a 63 MW steam turbine (direct steam expansion). Returning condensate from the turbine and steam separator is then collected and re-injected back into the geothermal field area. Electricity produced is sold to the PLN through 150 kV transmission line, located outside the power plant. The Kamojang Geothermal Power Plant process flow diagram is shown schematically in Figure 3

3. METHODOLOGY

The Methodology of Geothermal CDM project is using ACM0002 (version 07) which is applicable as renewable electricity generation plant, in the form of a geothermal power plant which is connected to interconnected power grid and it is not an activity that involves the switching from fossil fuels to renewable energy at the site of the project activity.

4. BASELINE SCENARIO

4.1 Methodology

Baseline scenario applicable for Kamojang unit 4 Power Plant CDM project "Consolidated baseline methodology for grid-connected electricity generation from renewable sources" would be the electricity delivered to the grid by the project activity that would have otherwise been generated by the operation of grid-connected power plants and by the addition of new generation sources (connected to that grid). Therefore the emissions reduction from Kamojang Unit 4 power plant would be the baseline emissions from the above baseline scenario and subtracted by the project's emissions.

The baseline emissions are calculated as the product of the kWh produced by renewable generation unit, times an emission coefficient (baseline emission factor) calculated as a combined margin (CM), consisting of the combination of average of the operating margin (OM) and build margin (BM) according to the procedures prescribed in the "Tool to calculate the emission factor for an electricity system", Version 01, 19 October 2007 (EB35).

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).

Choice of doing ex-post calculation to the grid EF would also be subjected to verification audit, which would produce different emission factor according to actual generation mix in recent years. This would be different than the ex-ante approach to the grid EF calculation that was fixed to the value prior to the operation start. There might be three possibilities to the dynamic of emission factor in JAMALI grid generation mix, the amount of fuel and type of fuel (specific carbon content) consumed in existing power plants, operation of new power plants with different technologies, and possibility of merging two electricity grids into a single interconnection system, namely the JAMALI and Sumatra grid (which has been in agenda of Indonesian electricity system planning).

4.2 Emission Factor

The baseline emissions is defined as the Grid Emissions Factor (grid EF) multiplied by the net Electricity Generation (EG) produced and fed into the grid as a result of the implementation of the CDM project activity. The grid EF can be calculated from the average (the *Combined Margin*, CM) of emissions from the electricity delivered to the grid by the project activity that would have otherwise been generated by the 'business as usual' operation of grid-connected power plants (the *Operating Margin*, OM) and the emissions from addition of new generation sources connected to that grid in the last few years (the *Build Margin*, BM).

The magnitude of baseline emissions in Kamojang unit 4 power plant CDM project would then depend on the annual generation mix in JAMALI grid, this is different than a captive power plant CDM project having rather constant emission factor from its baseline fuel type. Ex-post calculation of JAMALI grid EF can be performed for better adaptation of actual generation mix in the most recent years of emission reduction calculation, compared to the ex-ante approach which must be fixed at the grid EF calculated prior to the CDM project operation.

Calculation of Indonesian grid EF is periodically updated and compiled by Indonesian Designated National Authority (DNA), with technical assistance from the Ministry of Energy and Mineral Resource (Directorate General of Electricity and Energy Utilisation, DJLPE). Historically, calculation up to 2004 generation data yielded 0.728 t.CO_2 / MWh for JAMALI grid EF, and later on it was updated into 0.754 t.CO_2 / MWh. Latest calculation with 2006 generation data has been released by the Indonesian DNA as 0.891 t.CO_2 / MWh, which means there has been more emissions from Power plant units coming on-stream in the later years (which consumes fuel type with higher specific CO_2 emissions). However, Indonesian government had also planned to increase proportion of renewable power generation (the second 10,000 MW government crash program announced in 2008), which if successful would potentially decrease the grid EF in the next five to seven years time. Using ex-ante calculation of grid EF would not be able to capture the dynamics of future development potential of generation mix in JAMALI grid.

Project emissions from a renewable power generation CDM project is typically quite small compared to its baseline emission. Unlike common fossil fueled power plant, renewable power generation is commonly regarded as having zero emission (or CO_2 Neutral). Emissions reduction would then depend largely from the calculation of its grid emission factor in following section.

Key Information and Data Used to Determine the Baseline Scenario, see Table 1

Table 1 – Data for Baseline Emissions

Variable	Value / Unit	Source
Operating Margin Emissions factor (OM)	0.844 tCO_2e / MWh	PLN database (own generation and IPPs*)
Build Margin Emissions Factor (BM)	0.937 tCO_2e / MWh	PLN database (own generation and IPPs)
Combined Margin Emissions Factor (CM)	0.891 tCO_2e / MWh	PLN database (own generation and IPPs)
Generation of the project in year 'y'	473,040 MWh	60 MW x 90% x 24 hours x 365 days

(*) Independent Power Producers

4.2.1 Operating Margin (OM)

The Operating Margin Emission Factor (***EF_{OM}***) can be calculated based on Simple OM and Average OM 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 and the percentage for low-cost / must-run power plants are consistently above 50 % and is not expected to change significantly within the crediting period, percentage of LCMR power plant data is shown in Table 2. Based on this analysis, the Average OM method can be used as basis for the calculation.

The operating margin emission factor for each year '*y*' was calculated using equation 1 (preferred option) of the Tool to calculate the emission factor for an electricity system,

$$EF_{OM,ave,y} = \frac{\sum_{i,m} FC_{i,m,y} \cdot NCV_{i,y} \cdot EF_{CO2,i,y}}{\sum_{m} EG_{m,y}} \quad (1)$$

Where :

$EF_{OM,ave,y}$ Operating margin CO_2 emission factor in year 'y' (tCO_2e / MWh),

$FC_{i,m,y,}$	Amount of fossil fuel type 'i' consumed in power plants / units 'm' in year 'y' (tonne / year)
$NCV_{i,y,}$	Net calorific value (energy content) of fossil fuel type 'i' in year 'y' (GJ / tonne)
$EF_{CO2,i,y,}$	CO_2 emission factor of fossil fuel type 'i' in year 'y' (tCO_2e / GJ)
$EG_{m,y}$	Net electricity generated and delivered to the grid by power plants / units 'm', in year 'y' (MWh)
m	All power plants / units serving the grid in year 'y' (for average OM calculation)
i	All fossil fuel types combusted in power plant / unit 'm' in year 'y'
y	The applicable year during monitoring (ex-post option)

The Average OM Emission Factor ($EF_{OM,2006}$) for the electricity grid is calculated by dividing the total CO_2 emission from consumed fossil fuel from the last three years period of 2004 – 2006 (243,312,048 tCO_2e) shown on Table 2 by its corresponding total generation data for 2004 – 2006 (288,316,859 MWh) including the low-cost / must-run sources. The 2006 Operating Margin Emission Factor is calculated to be **0.844** tCO_2e / MWh.

4.2.2 Build Margin (BM)

The Build Margin Emission Factor (***$EF_{BM,y}$***) which is based on a sample group '*m*' that consists of either one of the followings : it comprises the larger annual generation five (5) power plants that have been built most recently, or power plant capacity additions that comprise 20 % of the system generation that have been built most recently.

The identified five most recent power plants are, however, comprised of only 8.17 % of total power generation. Therefore sample group '*m*' was expanded to include power plants up to capacity additions that comprise 20 % of system generations. These power plants and its corresponding generation are presented in Table 3 and Table 4. CO_2 emissions from these power plants are calculated using a similar method as described under Operating Margin, but using only 2006 data.

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

$$EF_{BM,y} = \frac{\sum_{i,m} EG_{m,y} \times EF_{EL,m,y}}{\sum_{m} EG_{m,y}} \qquad (2)$$

Where :

$EF_{BM,y}$	Build margin CO_2 emission factor in year 'y' (tCO_2e / MWh),
$EF_{EL,m,y,}$	CO_2 emission factor of power unit 'm' in year 'y' (tCO_2e / GJ)
$EG_{m,y}$	Net electricity generated and delivered to the grid by power plants / units in the sample group 'm' serving the electricity system in year 'y' (MWh)
m	Power plants / units included in the build margin calculation
y	the applicable year during monitoring (ex-post option)

Based on sample group '*m*' identified above (Table 4), the Build Margin Emission Factor is calculated to be **0.937** tCO_2e / MWh by dividing total CO_2 emissions by the total annual generation data.

4.2.3 Combined Margin (CM)

Calculate the combined margin emission factor

$$EF_{grid,CM,y} = \left(\omega_{OM} \cdot EF_{OM,y}\right) + \left(\omega_{BM} \cdot EF_{BM,y}\right) \qquad (3)$$

Where :

$EF_{grid,CM,y,}$	Combined Margin emission factor (tCO_2e/ MWh)
$\omega_{OM,}$	Operation Margin weight, which is 0.5 by default
$EF_{OM,y,}$	Operation Margin emission factor (tCO_2e / MWh)
$\omega_{BM,}$	Build Margin weight, which is 0.5 by default;
$EF_{BM,y}$	Build Margin emission factor (tCO_2e / MWh) and refers to a given year

Combined Margin Emission Factor is calculated to be **0.891** tCO_2e / MWh.

5. ESTIMATION OF EMISSION REDUCTIONS

Calculation of Baseline Emission and Project Emission is to determine Estimation of Emission Reduction. Please note that variable notations are typical to the CDM methodology, which is slightly different to standard physics notations

5.1 Baseline Emissions

$$BE_y = \left(EG_y - EG_{baseline}\right) \cdot EF_{grid,CM,y} \qquad (4)$$

Where ;

BE_y	Baseline emissions in year 'y' (tCO_2e / year)
EG_y	Electricity supplied to the grid (MWh)
$EG_{baseline}$	Baseline electricity supplied to the grid (MWh)
$EF_{grid, CM,y}$	Combined Margin CO_2 emission factor for grid connected power generation in year 'y' (tCO_2e / MWh)

$EG_{baseline}$ was assumed to be zero because Kamojang geothermal power plant unit 4 is neither a modified or retrofit facility nor an additional power unit at an existing grid-connected renewable power plant.

Kamojang unit 4 is a new grid connected renewable power plant; with a separate energy sales contract for its electricity sales to the JAMALI grid system

Electricity supplied annually by the project to the grid (EG_y) = 473,040 MWh.

Baseline emission factor with combined margin ($EF_{grid,CM,y}$) = 0.891 tCO_2e / MWh

Therefore using the approach above, the baseline emissions will be **421,479** tCO_2e / year

5.2 Project Emissions

Project emissions (PE) for geothermal power plants consist of :

Project emissions of carbon dioxide and methane due to the release of non-condensable gases (NCG) from the steam produced in the geothermal power plant ($PE_{GP,y}$)

Project emissions from combustion of fossil fuels related to the operation of the geothermal power plant ($PE_{FF,y}$)

5.2.1. Fugitive emissions CO_2 and CH_4

Fugitive carbon dioxide and methane emissions due to release of non-condensable gases from the produced steam ($PE_{GP,y}$)

$$PE_{GP,y} = \left(w_{steam,CO2} + w_{steam,CH4} \times GWP_{CH4}\right) \cdot M_{Steam,y} \quad (5)$$

where :

$w_{steam,CO2}$ Average mass fraction of carbon dioxide in the produced steam (non-dimensional)

$w_{steam,CH4}$ Average mass fraction of methane gas in the produced steam (non-dimensional)

GWP_{CH4} Global warming potential of methane valid for the relevant commitment period (tCO_2 / tCH_4)

$M_{Steam,y}$ Quantity of steam produced during the year 'y' (tones / year)

5.2.2. CO_2 emissions from fossil fuel combustion

Carbon dioxide emissions from fossil fuel combustion ($PE_{FF,y}$).

For geothermal CDM projects :

$$PE_{FF,y} = PE_{yFC,j,y} \quad (6)$$

where :

$PE_{FC,j,y}$ CO_2 emissions from fossil fuel combustion in process 'j' during the year 'y' (tCO_2e / year).

This parameter shall be calculated as per the latest version of the Tool to calculate project or leakage CO_2 emissions from fossil fuel combustion, where 'j' stands for the processes required for the operation of the geothermal power plant

Diesel genset is used for emergency power supply to critical instruments only during shutdown and trip operation, where its project emission is calculated using the "Tool to calculate project or leakage CO_2 emissions from fossil fuel combustion" (EB 32 meeting report – Annex 9). The CO_2 emission coefficient $COEF_{i,y}$ is calculated based on net calorific value and CO_2 emission factor of the fuel type 'i',

$$PE_{FF,y} = PE_{FC,j,y} = \sum_i FC_{i,j,y} \times COEF_{i,y}$$
$$COEF_{i,y} = NCV_{i,y} \times EF_{CO2,i,y} \quad (7)$$

where

$PE_{FC,j,y}$ CO_2 emissions from fossil fuel combustion in process 'j' during the year 'y' (tCO_2e / year)

$FC_{i,j,y,}$ Quantity of fuel type 'i' combusted in process 'j' during the year 'y' (mass or volume unit)

$COEF_{i,y}$ CO_2 emissions coefficient of fuel type 'i' in year 'y' (tCO_2e / mass or volume unit)

$NCV_{i,y}$ weighted average net calorific value of the fuel type 'i' in year 'y' (GJ / mass or volume)

$EF_{CO2,i,y}$ weighted average CO_2 emission factor of fuel type 'i' in year 'y' (tCO_2 / GJ)

5.2.3. Calculation of Project Emissions ($PE_{GP,y}$ and $PE_{FF,y}$)

Kamojang geothermal power plant unit 4 utilizes a direct steam expansion turbine from the geothermal field steam supply. It has no supplementary firing for additional steam supply. Estimated amount of NCG is 0.5% of steam weight, where it consists nearly all of CO_2.

$$PE_y = PE_{GP,y} + PE_{FF,y}$$
$$PE_y = \left(w_{steam,CO2} + w_{steam,CH4} \times GWP_{CH4}\right) \cdot M_{Steam,y} + \sum_i FC_{i,j,y} \times NCV_{i,y} \times EF_{CO2,i,y}$$
$$= (0.005 + 0 \times 21) \cdot 3{,}547{,}800 + (5{,}000 \cdot 0.84) \times 0.043 \times 0.074$$
$$= 17{,}752.36 \; tCO_2e / year$$

Project emission is calculated to be 17,752.36 tCO_2e / year

5.3 Emissions Reduction

Emissions reduction calculations are as follows

$$ER_y = BE_y - PE_y - L_y \quad (8)$$

Where :

ER_y Emissions reduction in year 'y' (tCO_2e / year)

PE_y Baseline emissions in year 'y' (tCO_2e / year)

BE_y Project emissions in year 'y' (tCO_2e / year)

L_y Leakage emissions in year 'y' (tCO_2e / year)

According to ACM0002, the leakage of the proposed project is not considered. No leakage is expected therefore L_y would be equal to zero

Emission Reduction is calculated to be 403,727 tCO_2e / year.

6. MONITORING PLAN

To achieve the ultimate objective of carbon credit generation, the Monitoring Plan for this project should be developed properly to ensure that from the start, the project is well organized in terms of the collection and archiving of complete and reliable data.

CDM monitoring in renewable energy is typically routine operation and it would require data restructuring or data reporting structure.

6.1 Monitoring Organization

Prior to the start of the crediting period, the organization 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 CDM project, will have the overall responsibility for the monitoring system on this project, ensuring the 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.

6.2 Monitoring equipment and installation

6.2.1 Metering of Electricity Supplied To The Grid

This electricity meter will be the revenue meter that measures the quantity of electricity that the project will be paid for. As this meter provides the main CDM measurement, it will be the key part of the verification process. This meter is located in the Kamojang Unit 4 substation.

To ensure maximum availability of CDM data and to introduce quality controls of the CDM data, a cross-check meter will be installed in addition to the revenue meter. This meter will also be located at Kamojang Unit 4 substation, measuring the electricity exported from the project.

Electricity meters will meet the relevant local standards at the time of installation. Before the installation of the meters, it will be factory calibrated by the manufacturer. Records of the meter (type, make, model and calibration documentation) will be retained in the quality control system on-site.

Electricity measurements will be taken in accordance with SOP signed between PGE and PLN P3B-JB (load dispatcher), or other documents which updates and replaces this SOP.

6.2.2 Metering Of Geothermal Steam Flow

Available at local meter and remote (Central Control Room, CCR), all data will be recorded in a Distributed Control System (DCS). Printed report will be submitted to the Operation Steam Field of Area Kamojang for daily steam production report.

6.2.3 Lab Test Of Geothermal Steam Sampling Procedure

Lab officer is responsible for steam sampling procedure and chemical analysis at Kamojang Geothermal Area laboratory. All equipment should be calibrated by the manufacturer according to relevant local standards at the time of installation and maintained in accordance to the manufacturer's recommendations to ensure accuracy of measurements. Records of the meter (type, make, model, calibration and maintenance documentation) should be retained as part of the CDM monitoring system.

6.2.4 Data Recording Procedure

All relevant data should be archived electronically, and backed up regularly. Uncertainty will be considered to achieve conservative results. The Monitoring Plan has been developed to ensure that the project has robust data collection, processing and archiving procedures.

6.2.5 Document Management

The project developer should keep electricity sale and purchase invoices. All written documentation such as specifications, maps, drawings, should be 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 CDM purposes. Monitoring report and supporting workbook will be provided for verification.

7. PROGRESS OF CDM PROJECT

Full CDM progress cycle started with project CDM assessment using applicable methodologies, guidance and documentation procedure (a validation process), which were performed by independent auditor having specific UNFCCC certification. Validation assessment report may then decide whether a CDM project potential can be submitted to the UNFCCC registration process, where project additionality (without CDM incentive, project planning realization would be difficult) and methodological applicability (full compliance with one of the UNFCCC approved methodology) were properly justified

Completing the CDM project cycle would then require periodic verification activities (which would generate the expected carbon revenue). There could also be other risks associated with internal quality assurance, which people tend to disregard quality in routine work as they gathered experience or other maintenance issues specific to the CDM monitoring equipments. This must also be anticipated and well maintained to stay in line with CDM procedures.

The project was started by preparing the PDD on December 2007. It was followed by stake holder consultation in Kamojang on December 10, 2007. The project was initiated by PGE and PLN as agreed in the Kamojang Unit 4 Energy Sales Contract (ESC). The draft PDD was submitted to DOE on February 29, 2008. Site visit was conducted by the DOE on March 10 – 11, 2008 to verify all information which was written in the PDD.

In parallel, the project developer submitted the PDD to Indonesian DNA on March 6, 2008 which then followed by PDD technical meeting on March 17, 2008. The project received Letter of Approval (LOA) from UK DNA on May 21, 2008 and from host DNA on October 7, 2008. On June 6, 2008 project developer received comments on PDD from the DOE.

While writing down this paper, validation of this CDM project is still ongoing. There are some more information and data, which are still needed to be collected and clarified in order to response to all DOE's findings.

8. CONCLUSION

The Methodology which is used to determine all aspects related to the CDM Project should be fitted to the Project CDM itself.

The calculation shows that there is an average increase in emission factor from 2004 to 2007 of about 8% annually, which means there have been more emissions from Power plant installed in National Grid.

Geothermal energy development will play a very importance role in the future to reduce the emission factor of the grid as well as to reduce CO2 emission to environment.

The Kamojang Unit 4 power plant was estimated to contribute to reduce emission of 403,727 tones of CO_2 annually.

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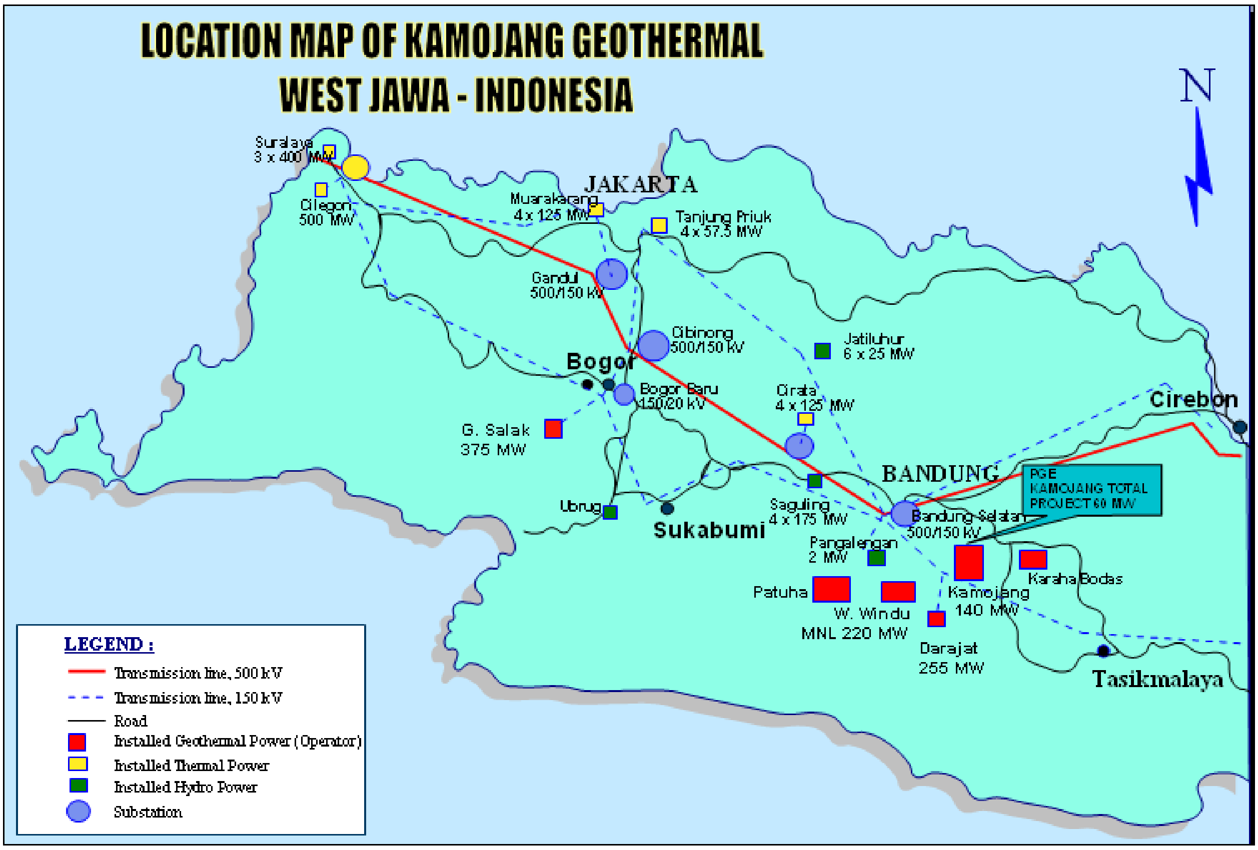

Figure 1 Location Map of Kamojang Geothermal Power Plant

Figure 2 Plant Overview

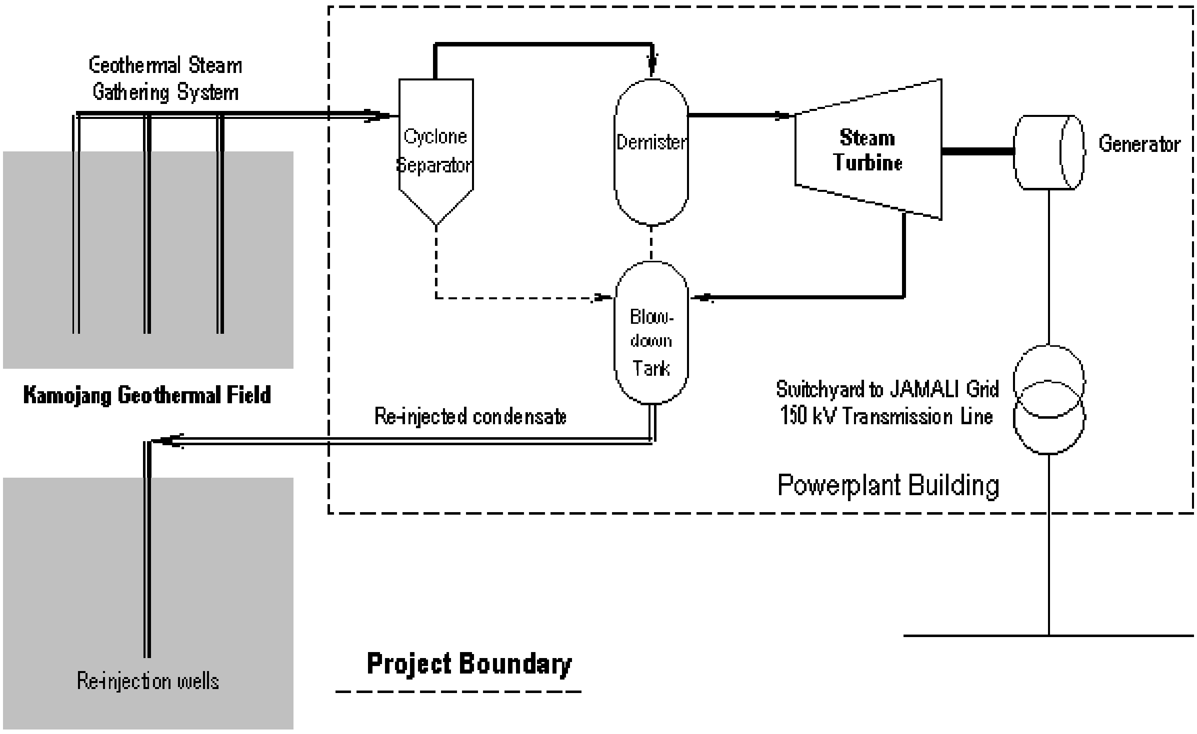

Figure 3 Kamojang Geothermal Power Plant Process Flow

Table 2 – Calculation of Operating Margin Emission Factor (EF_{OM}) at JAMALI grid, and LCMR power plants

Low-cost / must-run power plants in JAMALI grid consist of renewable (hydro and geothermal), and coal power plants (which do not belong to IPP), and all IPP contract power plants, during the last 5 years period (2002 – 2006).

OWNER		operation year	2002	2003	2004	2005	2,006
IP		fuel	GWh				
	Hydro		3,482	2,938	3,223	3,834	2,720
	Diesel	Oil	87	60	66	128	101
	Gas Turbine	Gas	62	-	102	89	102
		Oil	960	1,581	1,812	1,855	1,655
	Geothermal		2,888	2,646	2,825	2,717	2,820
	Steam	Coal	20,205	22,220	21,482	23,248	23,875
		Oil	1,717	2,105	2,017	1,806	1,502
	Combined Cycle	Gas	6,672	7,133	6,677	6,830	5,622
		Oil	3,976	3,860	4,337	5,879	5,855
	TOTAL NET PRODUCTION		**40,049**	**42,543**	**42,541**	**46,385**	**44,253**

Source :Indonesia Power Statistic's 2002,2003,2004,2005 and 2006

		year	2002	2003	2004	2005	2,006
PT PJB		fuel	GWh				
	Hydro		2,380	1,832	2,098	2,339	1,896
	Gas Turbine	Oil	53	41	32	91	47
	Muara Tawar		298	35	170	601	385
	Steam	Coal	4,112	4,722	5,101	4,567	4,929
		Oil	4,928	5,121	5,275	4,862	5,660
		Gas	1,324	1,177	1,030	646	669
		Oil/HSD	15	7	7	5	9
	Combined Cycle	GT/Gas	7,283	6,228	5,235	4,716	4,824
		Oil	481	1,359	2,229	3,101	2,589
		ST	3,944	3,456	2,714	2,112	2,422
	Muara Tawar	ST	1,117	1,281	2,860	2,901	2,614
	TOTAL NET PRODUCTION		**25,935**	**25,259**	**26,751**	**25,941**	**26,044**

Source :Statistik Perusahaan 2002-2006, PT PJB

		year	2002	2003	2004	2005	2,006
		fuel	GWh				
Muara Tawar							
	Gas Turbine	Gas	0	0	900	2,064	1,618
Tanjung Jati B							
	Steam	Coal	0	0	0	0	3,869
Cilegon							
	Combined Cycle	Gas	0	0	0	0	742
	TOTAL GROSS PRODUCTION		**0**	**0**	**900**	**2064**	**6229**
	TOTAL NET PRODUCTION		**-**	**-**	**862**	**1,981**	**5,966**

Source :Indonesia Power Statistic's 2002,2003,2004,2005 and 2006

		year	2002	2003	2004	2005	2,006
IPP		fuel	GWh				
LCMR	Jatiluhur	Hydro	1,048	576	721	884	724
LCMR	Dieng	Geothermal	52	202	316	332	319
LCMR	Salak 4,5,6	Geothermal	1,346	1,566	1,505	1,585	1,534
LCMR	Wayang Windu	Geothermal	925	911	923	933	922
LCMR	Drajat II	Geothermal	770	774	824	761	735
LCMR	Cikarang	GT-Gas	0	508	607	553	403
LCMR	Paiton I	Steam-Coal	6,773	7,794	9,290	9,326	9,116
LCMR	Paiton II	Steam-Coal	6,825	7,556	8,092	9,060	9,109
LCMR	Krakatau	Steam-Coal	0	16	15	1	2
LCMR	Cilacap	Steam-Coal	0	0	0	0	1,937
	TOTAL GROSS PRODUCTION		**17,739**	**19,903**	**22,293**	**23,435**	**24,801**
	TOTAL NET PRODUCTION		**16,992**	**19,013**	**21,343**	**22,498**	**23,752**

Source :Indonesia Power Statistic's 2002,2003,2004,2005 and 2006

(table continued…)

	year	2002	2003	2004	2005	2,006
		GWh				
TOTAL NET PRODUCTION IN JAVA BALI SYSTEM (including LCMR)		*82,976*	*86,815*	*91,497*	*96,805*	*100,015*
Low Cost/Must Run		*50,806*	*53,753*	*56,415*	*59,587*	*60,639*
ratio of LCMR		*61.2%*	*61.9%*	*61.7%*	*61.6%*	*60.6%*

2006 Operating Margin emission factor (EF_{OM}) is calculated from the last 3 years period (2004 – 2006) :

	2002	2003	2004	2005	2006
TOTAL GHG REDUCTION (t-CO2)	71,413,378	73,760,415	73,652,044	82,835,880	86,824,124
TOTAL NET PRODUCTION (MWh)	82,976,188	86,815,336	91,496,978	96,805,270	100,014,611
COEFFICIENT EMISSION REDUCTION (t-CO2/MWh)	**0.8606**	**0.8496**	**0.8050**	**0.8557**	**0.8681**

TOTAL GHG REDUCTION in 2004, 2005, 2006	243,312,048	t-CO2
TOTAL NET PRODUCTION in 2004, 2005, 2006	288,316,859	MWh
OPERATING MARGIN	**0.844**	**tCO2/MWh**

Table 3 – JAMALI grid Build Margin sample group 'five power plants that have been built most recently'

No.	Power Plant		fuel type	operation year	Generated Actual Data GWh
	Owner	Power Plant			C
1	**PT Krakatau Daya Listrik**	Krakatau	Steam-Coal	2003	2.2
2	**Muara Tawar**	Block 3	GT-Oil	2004	1,618.0
3		Block 4	GT-Oil	2004	
4	**PT Sumberenergi Sakti Prima**	Cilacap	Steam-Coal	2006	1,937.0
5	**Tanjung Jati B**	Tanjung Jati B	Steam-Coal	2006	3,869.0
6	**Cilegon**	Cilegon	CCGT-Gas	2006	742.0
	TOTAL				**8,168.2**

Table 4 – JAMALI grid Build Margin sample group 'm' powerplants

No.	Power Plant (Owner)	Power Plant	fuel type	operation year	Generated Power GWh net – Actual Data C	Generated Power GWh net – calculation data C=AxBx8760/1000
1	**PT Paiton Energi**	Paiton I	Steam-Coal	1999	9,116.0	
2	**PT Java Power**	Paiton II	Steam-Coal	Nov, 2000	9,109.0	
3	**PT Magma Nusantara L**	Wayangwindu	Geothermal	2001	922.0	
4	**Chevron Texaco Energ**	Darajad	Geothermal	2001	735.0	
5	**PT Geo Dipa Energi**	Dieng	Geothermal	2002	319.0	
6	**PT Indonesia Power**	Pemaron	GT-Oil	2003		201.3
7	**PT Cikarang Listrindo I**	Cikarang	GT-Gas	2003	403.0	
8	**PT Krakatau Daya Listr**	Krakatau	Steam-Coal	2003	2.2	
9	**Muara Tawar**	Block 3	GT-Oil	2004	1,618.0	
		Block 4	GT-Oil	2004		
10	**PT Sumberenergi Sakti**	Cilacap	Steam-Coal	2006	1,937.0	
11	**Tanjung Jati B**	Tanjung Jati B	Steam-Coal	2006	3,869.0	
12	**Cilegon**	Cilegon	CCGT-Gas	2006	742.0	
	TOTAL					**28,973.6**

Table 5 – Calculation of Build Margin Emission Factor (EF_{BM}) at JAMALI grid

BUILD MARGIN

Annual generation of power capacity addition in Jamali grid that comprises of 20% of total generation	28,973.6	GWh
So that the build margin is determined such as follows.		
TOTAL NET PRODUCTION IN JAVA BALI SYSTEM (including LCMR)	100,014.6	GWh
Ratio of 20% power capacity addition MWh to total MWh in year of 2006	29.0%	

TOTAL GHG REDUCTION in 2006	27,161,539	t-CO2
TOTAL NET PRODUCTION in 2006	28,973,560	MWh
BUILD MARGIN	**0.937**	tCO2/MWh