

210 MW MUSI HYDRO POWER PLANT, BENGKULU



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1 PROJECT DETAILS

1.1 Summary Description of the Implementation Status of the Project

The 210 MW Musi Hydro Power Plant (hereinafter refer to project activity) is a new run-off-river type hydropower plant located in Bengkulu Province, Indonesia. Total installed capacity is 210 MW, consist of 3 x 70 MW turbines. Annual energy output is expected at 1,140 GWh, harnessing a gross water head of 404.4 m by diverting water at 42.3 m³/sec from the Musi river to the Simpangaur river. The project is owned and developed by PT. PLN (Persero), a state-owned electricity company. The project supplies electricity to the connected Sumatra grid. Below is the technical description of the turbines and generators.

Table 1 - Technical data of the turbine / generator units (specifications are per unit)

Turbines 1, 2, & 3	Brand	VA TECH HYDRO
	Model	Francis turbine
	Rated output	73.6 MW
	Rated head	396.0 m
	Rated speed	500 rpm
	Year of Commissioning	2006
	Serial number	<ul style="list-style-type: none"> • MB9-146/UNIT 1 • MB9-146/UNIT 2 • MB9-146/UNIT 3

Generators 1, 2, & 3	Brand	MITSUBISHI
	Model	Mitsubishi AC Generator
	Rated output	84,500 kVA
	Rated voltage	11,000 V
	Rated current	4,435 A
	Rated frequency	50 Hertz
	Rated speed	500 rpm
	Rated power factor	0.85

The Musi Hydroelectric project was registered as VCS project with ID Number 487. Further background on this project can be found in the Verified Carbon Standard Project Description (VCS PD) Version 3 dated 09 November 2009.

The project area of Musi Hydroelectric Power Plant is situated in Bengkulu Province about 30 km northeast of Bengkulu city, the capital of the province.

Prior to the implementation of the project activity there is no power generation existing at the project location, electricity in grid is generated mainly from fossil fuel sources and is solely distributed to consumers via the electricity grid.

According to the registered VCS-PD, the record on diesel consumption taken from the generator sets operational logbook is included in the project emission calculation of the project activity. The estimated annual CO₂ emissions reduction of the project is 847,020 tCO₂e per year. During this monitoring, total amount of emissions reduction is 1,776,009 tCO₂e with detail as below:

Vintage Year	Emissions Reduction	Unit
01 April 2013 – 31 December 2013	431,044	tCO ₂ e
01 January 2014 – 31 December 2014	516,229	tCO ₂ e
01 January 2015 – 31 December 2015	477,279	tCO ₂ e
01 January 2016 – 31 July 2016	351,457	tCO ₂ e
Total	1,776,009	tCO ₂ e

The project was validated under VCS and final report was issued on 16 November 2009. This monitoring report has been prepared in accordance with the monitoring plan contained in the validated VCS-PD. The VCS-PD will serve as the basis for the verification, certification and issuance of the emission reductions during the monitoring period.

1.2 Sectoral Scope and Project Type

Sectorial scope	: 01. Energy industries (renewable - /non-renewable sources)
Project Type	: I. Renewable energy project
Project Category	: Grid connected electricity generation from renewable sources

1.3 Project Proponent

Project proponents contact information as follows:

Project owner:

Organization name	PT. PLN (Persero)
Contact person	Jurlian Sitanggang
Title	Head of Health, Safety, Security, and Environment Division (Kepala Divisi Keselamatan Kesehatan Kerja Keamanan dan Lingkungan)
Address	Jl. Trunojoyo blok M 1/135, Kebayoran Baru, Jakarta – 12160, Indonesia
Telephone	+62-21-725 1234
Email	jurlian.sitanggang@pln.co.id

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

1.4 Other Entities Involved in the Project

Not applicable, as there are no other entities except PT. PLN (Persero) and South Pole Carbon Asset Management Ltd.

1.5 Project Start Date

As per the VCS policy announcement from the 10 September 2008, the project start date is the date on which the project activity began reducing or removing GHG emissions.

Following are the three units' commissioning date:

- Musi Hydro Power Plant Unit 1: 19 July 2006 (Certificate for Proper Operation or *Sertifikat Laik Operasi*)
- Musi Hydro Power Plant Unit 2: 19 July 2006 (Certificate for Proper Operation or *Sertifikat Laik Operasi*)
- Musi Hydro Power Plant Unit 3: 19 July 2006 (Certificate for Proper Operation or *Sertifikat Laik Operasi*)

Thus, the project start date where project activity starts reducing emissions is 19 July 2006, as the earliest project start date of three units at Musi Hydro Power Plant.

1.6 Project Crediting Period

- HEPP Project starting date : 19 July 2006
- VCS Crediting period start date : 01 August 2006
- VCS crediting period : 10 years (01-Aug-2006 until 31-Jul-2016)

1.7 Project Location

The project area of the Musi Hydroelectric Power Plant is situated in Bengkulu Province about 30 km northeast of Bengkulu city, the capital of the Province. It involves the inter-basin transfer of water from the Musi river in Rejang Lebong Regency to the Simpangaur river in North Bengkulu Regency through a 7.5 km long waterway and an underground powerhouse.

The geographical coordinate of Musi Hydroelectric Power Plant is located on -3.618497 South Latitude and 102.457186 East Longitude. The location of the project site is shown in the following maps:

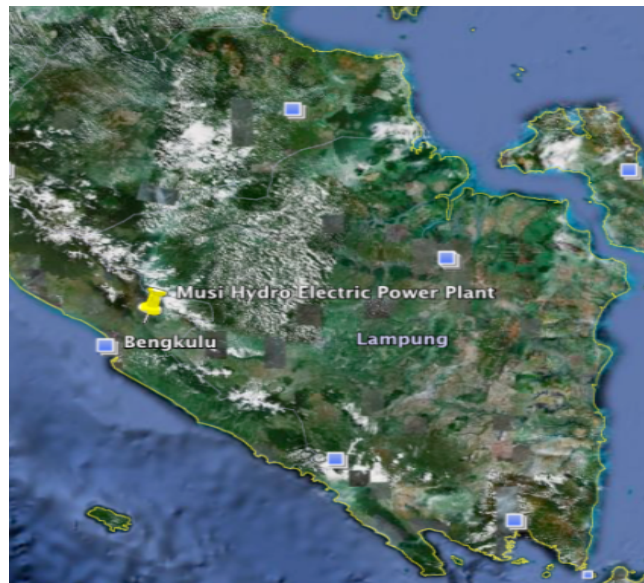


Figure 1 - Location of Musi Hydroelectric Power Plant

1.8 Title and Reference of Methodology

Approved consolidated baseline methodology ACM0002 – “Consolidated baseline methodology for grid-connected electricity generation from renewable sources”, version 10 (EB 47 annex 7).

Sectoral scope 01 - Energy Industries (renewable-/non-renewable sources).

1.9 Other Programs

Emission Trading Programs and Other Binding Limits: The project activity is not included in an emission trading program or any other mechanism that includes GHG allowance trading.

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 credit¹.

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 program².

Participation under Other GHG Programs: The project activity is not registered under any other GHG program.

¹ According to VCS Standard: VCS Version 3, 21 June 2017, v3.7

² According to Registration and Issuance process: VCS Version 3, 21 June 2017, v3.8

1.10 Sustainable Development

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

Social well-being:

- The project contributes to the development of the region by increasing community development and corporate social responsibility of PT. PLN (Persero).
- During both construction and operation, various kinds of mechanical work are required, providing opportunities for part-time and full-time employment.

Economic well-being:

- The project activity generates employment in the local area which is a developing region.
- The generated electricity is fed into regional grids through the local grid, thereby improving the grid frequency and availability of electricity to local consumers (villagers and sub-urban inhabitants). Due to increased grid reliability, new opportunities for industries and economic activities arise along with prospects for local employment and overall development.
- The project activity 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 hydropower to generate electricity, which otherwise would have been generated through alternate fuel- (most likely fossil fuel-) based power plants. It is contributing to a reduction in specific emissions (emissions of pollutant/unit of energy generated) including GHG emissions.
- As hydroelectric power projects produce no end-products in the form of solid waste (ash, etc.), they don't have to cope with the problem of solid waste disposal encountered by most other sources of power.
- Being a renewable energy source, hydro energy is used to generate electricity that contributes to resource conservation.

Technological well-being:

- The project supports high quality equipments transfer from other regions and even other countries, and contributes to capacity building of the labor force through training and practical work.
- The project promotes local products developed in the region, when replacement of spare parts is necessary, and supports renewable technology development especially for hydroelectric power technology.

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

2 IMPLEMENTATION STATUS

2.1 Implementation Status of the Project Activity

From the validated VCS PD Version 3, dated 09 November 2009, the 210 MW installed capacity Musi HEPP generates about 1,140,000 MWh per year. During this monitoring period, the project activity has generated power of 2,390,757 MWh with details as below:

- 01 April – 31 December 2013 : 580,149 MWh
- 01 January – 31 December 2014 : 695,201 MWh
- 01 January – 31 December 2015 : 642,374 MWh
- 01 January – 31 July 2016 : 473,033 MWh

2.2 Deviations

2.2.1 Methodology Deviations

Not applicable as the project activity does not need any deviations of the methodology.

2.2.2 Project Description Deviations

The project developer has requested Deviation of Monitoring Plan for following parameters with details below:

A. Deviation to parameter EG_{PJ,y}

As per validated VCS PD, PP must monitor parameter EG_{PJ,y} as described in the baseline methodology of ACM0002 – Consolidated methodology for grid-connected electricity generation from renewable sources (Version 10, 28th May 2009, EB 47).

Subject	Original Monitoring Plan as per validated VCS PD	Deviation of the Monitoring Plan
QA/QC procedures to be applied:	a. The QA/QC will be conducted through cross-checking with sales electricity receipts. b. Data measured by meters will be cross-checked by electricity sales receipts	a. The QA/QC will be conducted through cross-checking the main meter reading report (Monthly Electricity Protocol report) at the transaction point with the Water Tax payment receipt issued by Bengkulu Province Tax Office (local government). b. Sentence is removed.

Subject	Original Monitoring Plan as per validated VCS PD	Deviation of the Monitoring Plan
	<p>c. The meter (s) will either:</p> <ul style="list-style-type: none"> • be read frequently and jointly by the generation unit and transmission unit, • be read by the project proponent and the data will then be double checked with the electricity sales receipts using comparison meter • only be read by the grid company (transmission department). 	<p>c. The main meter at the transaction point will be read regularly and jointly by the person in charge from PLN Musi HEPP Generation unit and PLN Transmission unit.</p>

B. Deviation to parameter $FC_{PJ,y}$

As per validated VCS PD, PP must monitor parameter $FC_{PJ,y}$ as described in the latest version of the “Tool to calculate project or leakage CO₂ emissions from fossil fuel combustion” (Version 02, 2nd August 2008, EB 41).

Subject	Original Monitoring Plan as per validated VCS PD	Deviation of the Monitoring Plan
Description of measurement methods and procedures to be applied:	<p>Fuel consumption will be recorded monthly, specifically for each fuel (currently only diesel consumption is available).</p> <p>Fuel consumption will be calculated from static graduated level gauges on the fuel injection tanks by using emergency diesel genset, resulted in liters then converted to tonnes using fuel specific density or scientifically proven fuel densities.</p>	<p>-</p> <p>Diesel oil usage based on DG Set Operational Hours (in Litre). Fuel consumption will be calculated from the monitored running hours on monthly operation report of the diesel generators, converted to liters using the default diesel oil consumption per hour, from engine manufacturer datasheet on 100% load. Then, liters shall be converted to tonnes using fuel specific density or scientifically proven fuel densities.</p>
Frequency of monitoring/recording:	-	Fuel consumption will be recorded monthly, specifically for each fuel (currently only diesel consumption is available).

2.3 Grouped Project

Not applicable as the project activity is not part of a grouped project.

2.4 Safeguards

2.4.1 No Net Harm

According to the decree of the Ministry of Environment No. 17/2001, all hydroelectric power plants with a dam height of ≥ 15 meters, or flooded area of ≥ 200 ha or installed capacity of ≥ 50 MW need to undertake an Environmental Impact Assessment (EIA). The Musi Hydroelectric Power Plant project has an installed capacity of total 210 MW electricity, therefore this project requires an EIA.

Table 1 - Summary of EIA findings

Identified Environmental impacts	Measures taken
Pre-Construction phase	
<i>Social responsibility</i>	
Community perception related to project consultation, publicizing and resettlement.	Perform discussion with local community, monitor the issues that develop in the community.
Construction phase	
<i>Air and noise pollution</i>	
Increase of air and noise pollution due to increased transportation and operation of heavy equipment.	Restrict the use of heavy equipment operation during the day, build project fence to reduce noise pollution, spray water to avoid dust from construction, control vehicle emission and noise, use protective masks for employees.
<i>Water pollution</i>	
Change in surface water flow due to land clearing and covering.	Create a drainage system to the nearest water body, perform a gradual land covering based on project phase, and execute land clearing only on the project site.
<i>Solid waste</i>	
Construction waste from the transportation of soil material.	Perform continuous cleaning during the construction period to remove debris and deposit them appropriately.
<i>Biodiversity and ecosystems</i>	
Change in biodiversity due to alteration in land and water body conditions.	Reforest and restore the green lands after the construction, maintain the minimum river flow to preserve the natural biodiversity within the river.
<i>Employment impacts</i>	

Identified Environmental impacts	Measures taken
Utilisation of local human resources	Give priority to local employment and hold special training to enhance the local community's skills.
Operation phase	
<i>Water pollution</i>	
Decrease in the quality and quantity of water due to the wastewater from plant's activity and land erosion.	Operate wastewater treatment plant, reforest the watershed area.
<i>Environmental</i>	
Related to the project operation and its supporting facility, solid waste and wastewater from the surrounding settlement.	Build a wastewater treatment facility, execute a solid waste temporary disposal system, create a waste transportation system.
<i>Spatial planning</i>	
Changing in spatial planning structure due to project activity.	Control the development around project activity by enforcing the appropriate planning regulations.
<i>Regional image</i>	
Changing in regional image due to the development in the region.	Planning controls will ensure sensitive development of the region.
<i>Traffic</i>	
Increase traffic activity due to the project's operational activity.	Restore the trans-Sumatra main road and set-up traffic signs.
<i>Health and Safety</i>	
Human resources needed to operate the project and its facilities.	Provide employment opportunities to local human resources following high Health and Safety standards.
<i>Working opportunity and income</i>	
Related to utilisation of local human resources.	Give priority to the admission of local human resources, hold special training to enhance the local community's skills.
<i>Comfort</i>	
Uncomfortable conditions due to vehicle's activity on the access road from and/or to the project.	Maintain the road condition by setting-up traffic signs and planting trees on the road side.
<i>Social responsibility</i>	
Community perception related to project operation	Contribution to the surrounding environment by building school and local health service.

With mitigation controls planned as part of the project construction and EIA process, and the contribution made by the project to sustainable development for 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 are subject to mitigation measures as described above.

2.4.2 Local Stakeholder Consultation

A meeting with relevant stakeholders which was held on 6 May 2003, including the village chief and people who live nearby, within the project boundary of Musi hydro power plant was conducted for the purpose of the EIA. As documented in the EIA, the local stakeholders have perceived that the construction of Musi Hydro has increased their social and economical life due to road construction, additional earning from temporary jobs, and especially due to the additional supply of electricity.

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.

3 DATA AND PARAMETERS

3.1 Data and Parameters Available at Validation

Data / Parameter	$EF_{grid,CM,y}$
Data unit	tCO ₂ /MWh
Description	Grid Emission Factor of Sumatra
Source of data	DNA of Indonesia http://pasarkarbon.dnpi.go.id/web/index.php/komnasmpb/read/14/faktor-emisi-jaringan-listrik-sumatera-dan-jamali-2008.html
Value applied	0.743
Justification of choice of data or description of measurement methods and procedures applied	No measurement required. Data is obtained based on analysis of DNA of Indonesia published information.
Purpose of Data	Calculation of baseline emissions
Comments	The 2008 grid emission factor has been crosschecked with the 2006 value, which was with 0.855 tCO ₂ /MWh significantly higher and therefore less conservative. Hence, following the tool by using the most current data available at submission to validation and in terms of conservativeness the emission factor of 2008 is the appropriate value to be used in the emission reduction calculation.

Data / Parameter	$NCV_{i,y}$
Data unit	GJ/kg
Description	Net calorific value of diesel fuel
Source of data	2006 IPCC Guidelines for National Greenhouse Gas Inventories

Value applied	0.043
Justification of choice of data or description of measurement methods and procedures applied	-
Purpose of Data	Calculation of project emissions
Comments	-

Data / Parameter	ρ_i
Data unit	kg/m ³
Description	Density of diesel fuel
Source of data	Pertamina diesel fuel specification http://www.pertamina.com/index.php?option=com_content&task=view&id=3262&Itemid=697
Value applied	0.815 kg/liter = 815 kg/m ³
Justification of choice of data or description of measurement methods and procedures applied	-
Purpose of Data	Calculation of project emissions
Comments	-

Data / Parameter	EF _{CO₂,i,y}
Data unit	tCO ₂ /GJ
Description	Weighted average CO ₂ emission factor of diesel fuel in year 'y'
Source of data	IPCC default value is used Source: 2006 IPCC Guidelines for National Greenhouse Gas Inventories: Workbook volume 2 chapter 1 (Table 1.4).
Value applied	0.074
Justification of choice of data or description of measurement methods and procedures applied	-
Purpose of Data	Calculation of project emissions
Comments	-

3.2 Data and Parameters Monitored

Data / Parameter	EG _{P,J,y}										
Data unit	kWh										
Description	Net electricity supplied to the grid by the project activity during the year 'y'										
Source of data	Measured by main electricity meter (Actaris type SL 7000) at the project activity site (the switchyard). Electricity Generation (EG) data used for monitoring is the monthly electricity generation delivered to grid summarized in Electricity Transfer Protocol Report signed by both parties of Generation department and Transmission department.										
Description of measurement methods and procedures to be applied	The net electricity sent to the grid measured by a watt-hour meter Actaris type SL 7000 (connected to a digital control system and recorded continuously), which can measure power produced, used and delivered to the grid. The measurement of electricity generation conducted on a continuous basis, where monthly data is recorded and continuous total electricity measurement already available. The measurement results summarized in regular production reports.										
Frequency of monitoring/recording	Monitoring is continuous with monthly recording of data.										
Value applied	<table border="1"> <thead> <tr> <th>Year</th> <th>Net electricity supplied to the grid (MWh)</th> </tr> </thead> <tbody> <tr> <td>01 April 2013 – 31 December 2013</td> <td>580,149</td> </tr> <tr> <td>01 January 2014 – 31 December 2014</td> <td>695,201</td> </tr> <tr> <td>01 January 2015 – 31 December 2015</td> <td>642,374</td> </tr> <tr> <td>01 January 2016 – 31 July 2016</td> <td>473,033</td> </tr> </tbody> </table>	Year	Net electricity supplied to the grid (MWh)	01 April 2013 – 31 December 2013	580,149	01 January 2014 – 31 December 2014	695,201	01 January 2015 – 31 December 2015	642,374	01 January 2016 – 31 July 2016	473,033
Year	Net electricity supplied to the grid (MWh)										
01 April 2013 – 31 December 2013	580,149										
01 January 2014 – 31 December 2014	695,201										
01 January 2015 – 31 December 2015	642,374										
01 January 2016 – 31 July 2016	473,033										
Monitoring equipment	Unit #1 Type: Digital Watt-hour meter type ACTARIS SL7000 (Main Meter) Manufacturer/ Model: Actaris Accuracy class: 0.2s Serial Number: 36027156 Calibration frequency: Every 5 years Date of last calibration and validity:										

Certificate Number	Calibration Date	Validity	Calibrator ³
2004.21.BTND .349B/12.12	06/07/2012	06/07/2017	<i>Laboratorium Kalibrasi - PT. PLN (Persero) Penelitian dan Pengembangan Ketenagalistrikan</i>

Unit #2
 Type: Digital Watt-hour meter type ACTARIS SL7000 (Main Meter)
 Manufacturer/ Model: Actaris
 Accuracy class: 0.2s
 Serial Number: 36027159
 Calibration frequency: Every 5 years
 Date of last calibration and validity:

Certificate Number	Calibration Date	Validity	Calibrator
2003.21.BTND .349B/12.12	06/07/2012	06/07/2017	<i>Laboratorium Kalibrasi - PT. PLN (Persero) Penelitian dan Pengembangan Ketenagalistrikan</i>

Unit #3
 Type: Digital Watt-hour meter type ACTARIS SL7000 (Main Meter)
 Manufacturer/ Model: Actaris
 Accuracy class: 0.2s
 Serial Number: 36027158
 Calibration frequency: Every 5 years
 Date of last calibration and validity:

Certificate Number	Calibration Date	Validity	Calibrator
1997.21.BTND .349B/12.12	08/07/2012	08/07/2017	<i>Laboratorium Kalibrasi - PT. PLN (Persero) Penelitian dan Pengembangan Ketenagalistrikan</i>

³ *Laboratorium Kalibrasi - PT. PLN (Persero) Penelitian dan Pengembangan Ketenagalistrikan* (Calibration Laboratory - PT. PLN (Persero) Research and Development of Electricity) has been accredited by the National Accreditation Committee (*Komite Akreditasi Nasional / KAN*) with certificate number of LK-007-IDN for Laboratory of Calibration.

	<p><u>Own Consumption (In-House consumption)</u></p> <p>Type: Digital Watt-hour meter type ACTARIS SL7000 (Main Meter) Manufacturer/ Model: Actaris Accuracy class: 0.2s Serial Number: 35008966 Calibration frequency: Every 5 years Date of last calibration and validity:</p> <table border="1" style="width: 100%; border-collapse: collapse;"> <thead> <tr style="background-color: #d9e1f2;"> <th style="text-align: center;">Certificate Number</th> <th style="text-align: center;">Calibration Date</th> <th style="text-align: center;">Validity</th> <th style="text-align: center;">Calibrator</th> </tr> </thead> <tbody> <tr> <td style="text-align: center;">2002.21.BTND .349B/12.12</td> <td style="text-align: center;">06/07/2012</td> <td style="text-align: center;">06/07/2017</td> <td style="text-align: center;"><i>Laboratorium Kalibrasi - PT. PLN (Persero) Penelitian dan Pengembangan Ketenagalistrikan</i></td> </tr> </tbody> </table>	Certificate Number	Calibration Date	Validity	Calibrator	2002.21.BTND .349B/12.12	06/07/2012	06/07/2017	<i>Laboratorium Kalibrasi - PT. PLN (Persero) Penelitian dan Pengembangan Ketenagalistrikan</i>
Certificate Number	Calibration Date	Validity	Calibrator						
2002.21.BTND .349B/12.12	06/07/2012	06/07/2017	<i>Laboratorium Kalibrasi - PT. PLN (Persero) Penelitian dan Pengembangan Ketenagalistrikan</i>						
QA/QC procedures to be applied	<p>The QA/QC conducted through crosschecking the main meter reading report (Monthly Electricity Protocol Report) at the transaction point with water tax payment receipts issued by Bengkulu Province Tax Office (local government).</p> <p>The main meters at the transaction point read regularly and jointly by the person in charge from PLN Musi HEPP Generation Unit and PLN Transmission Unit.</p> <p>Meters at the transaction point are calibrated annually. However, the meters were calibrated once every five-year in period 2005 – 2010 as per required by the national regulation⁴.</p>								
Purpose of data	Calculation of baseline emissions								
Calculation method	<p>Net electricity supplied to grid is calculated as the difference between EG_{export}, EG_{import} and consideration of $EG_{\text{Own Consumption}}$ with formula as below :</p> <p>$(EG_{\text{export}} - EG_{\text{import}}) - EG_{\text{Own Consumption}}$.</p>								
Comments	-								

Data / Parameter	$FC_{i,y}$
Data unit	Ton

⁴ The Ministry of Energy and Mineral Resource's regulation number 37 year 2008 dated November 27, 2008 on the Grid Code Sumatra Electricity Power System, the calibration of kWh meter must be done every 5 (five) years, as stated in the Metering Code section, MC 4.1.1 (Test after metering code commissioning, page 138), available from: <http://jdih.esdm.go.id/peraturan/Permen%20ESDM%2037%202008.pdf> [Accessed 26 July 2017]

Description	<p>Amount of diesel fuel used in the hydropower plant operation in the reported monitoring period.</p> <p>Fuel consumption occurs in case of operation of two emergency diesel generator sets (DG sets) located at Power House and Main Intake.</p>										
Source of data	Calculated – Project Owner – Diesel oil usage based on DG Set Operational Hours Report										
Description of measurement methods and procedures to be applied	Fuel consumption is calculated from the monthly DG Set Operational Hours Report (hours), then converted to ton using fuel specific density or scientifically proven fuel densities.										
Frequency of monitoring/recording	Diesel oil usage based on DG Set Operational Hours has been recorded monthly, specifically for each fuel (currently only diesel consumption is available).										
Value applied	<table border="1" style="margin-left: auto; margin-right: auto;"> <thead> <tr> <th style="text-align: center;">Year</th> <th style="text-align: center;">DG Set Operational Hours (based on actual Diesel operational) [Liter]</th> </tr> </thead> <tbody> <tr> <td style="text-align: center;">01 April 2013 – 31 December 2013</td> <td style="text-align: center;">2,056</td> </tr> <tr> <td style="text-align: center;">01 January 2014 – 31 December 2014</td> <td style="text-align: center; color: red;">117,299</td> </tr> <tr> <td style="text-align: center;">01 January 2015 – 31 December 2015</td> <td style="text-align: center; color: red;">1,259</td> </tr> <tr> <td style="text-align: center;">01 January 2016 – 31 July 2016</td> <td style="text-align: center; color: red;">2,216</td> </tr> </tbody> </table> <p>Based on the Project Description Deviations to parameter FC (Section 2.2.2), fuel consumption has been calculated based on DG set operational hours.</p> <p>Due to the DG set operational hours reports not available in year 2014, 2015, and 2016 the maximum value of previous available 3 months record is taken for conservative estimation.</p>	Year	DG Set Operational Hours (based on actual Diesel operational) [Liter]	01 April 2013 – 31 December 2013	2,056	01 January 2014 – 31 December 2014	117,299	01 January 2015 – 31 December 2015	1,259	01 January 2016 – 31 July 2016	2,216
Year	DG Set Operational Hours (based on actual Diesel operational) [Liter]										
01 April 2013 – 31 December 2013	2,056										
01 January 2014 – 31 December 2014	117,299										
01 January 2015 – 31 December 2015	1,259										
01 January 2016 – 31 July 2016	2,216										
Monitoring equipment	-										
QA/QC procedures to be applied	The operator of Musi HEPP Generation Unit recorded and calculated the diesel operational hours and oil consumption, whenever they operate the Emergency DG set. No equipment is used to measure the diesel oil consumption. The consumption record is checked with the DG set operational hours.										
Purpose of data	Calculation of project emissions										

Calculation method	<ul style="list-style-type: none"> • Converted from hours to litre using the DG Set's Multiply Factor (l/hr) • Converted from litre to ton using the density of diesel.
Comments	<p>The fuel consumption on the project site is taken from the operational of Emergency DG Set. The plant operator recorded the 'DG Set Operational Hours' on the 'Monthly Diesel Oil Usage for Emergency DG Set' (or '<i>Laporan Pemakaian Bahan Bakar Solar Diesel Genset</i>').</p> <p>For this monitoring period, the value applies for Fuel Consumption parameter is taken from the Emergency DG Set Running Hours in monthly basis, converted to liter using the fuel consumption default value (multiply factor) from engine manufacturer datasheet on 100% load. Then litre converted into ton using the density of diesel.</p> <p>Fuel consumption only occur during emergency situation whereas the power plant is not operational and the grid is also not available, a confluence of events which is expected to happen very rarely; at other times the plant run on grid electricity. DG set usage is only for critical instrument/control system during turbine trip, startup and shutdown.</p>

3.3 Monitoring Plan

This section details the steps taken to monitor on a regular basis the GHG emissions reductions from the Musi Hydroelectric Power Plant Project in Indonesia in accordance with ACM0002 version 10.

The Monitoring Plan for this project has been developed to ensure that the project collects and archives complete data from the very start.

3.3.1 Monitoring Period

The monitoring period covers 01 April 2013 to 31 July 2016 (both days included)

3.3.2 Monitoring Organization

The monitoring team has been established and integrated within the existing organization structure of Musi hydropower plant prior to the start of the verification⁵. Clear roles and responsibilities are assigned to all staff involved in the VCS project and the prospect of nominating a VCS Manager have been considered. The VCS Manager has the overall responsibility for the monitoring system on this project.

All other VCS monitoring staff have clearly defined roles and responsibilities. The VCS manager

⁵ PLN Bengkulu Sector has formed the VCS Monitoring Team through the '*Lampiran I Keputusan Manajer PT PLN (Persero) Sektor Pembangkitan Bengkulu Nomor : 007.K/432/MSBKL/2012*' letter (or Management Decision Letter of PT PLN (Persero) Bengkulu Generation Sector Office No : 007.K/432/MSBKL/2012) in January 15, 2012.

will manage the process of training new staff; ensure trained staff performs the monitoring duties as necessary; and ensure that where trained monitoring staff is absent; the integrity of the monitoring system is maintained by other trained staff.

A formal set of monitoring procedures is established prior to the start of the verification. These procedures have detail the organization, control, and the steps required for certain key monitoring system features, including:

- a) VCS staff training
- b) VCS data and record keeping arrangements
- c) Data collection
- d) VCS data quality control and quality assurance
- e) Equipment maintenance
- f) Equipment calibration
- g) Equipment failure

The procedures agreed and signed off by PT PLN (Persero) and South Pole Carbon Asset Management Ltd. Any changes to procedures need to be agreed by both parties. The VCS manager responsible for ensuring that the procedures are followed on site and for continuously improving the procedures to ensure a reliable monitoring system is established.⁶

3.3.3 Monitoring equipment and installation

Considering that the emission factor is calculated *ex-ante* and according to the Monitoring Methodology ACM0002 version 10, the only data to be monitored is electricity supplied to the grid by the project (detailed in section 3.2). The primary instruments include:

Metering of Electricity Supplied to the Grid

The main electricity meter for establishing the net electricity delivered to the grid (detailed in section 3.2) is installed at the Musi power plant. This electricity meter is the main meter (revenue meter), measuring the quantity of electricity supplied (net electricity delivered) to the grid from Musi Power Plant. Net electricity delivered to the grid is the difference of electricity export, electricity import and electricity own consumption. As this meter provides the main VCS measurement, it is the key part of the verification process. The main meter is located at the Musi power station. The main electricity meter reading record (Joint Meter Reading) then recorded on the Monthly Transfer Electricity Protocol Record (METPR).

⁶ The Bengkulu Sector has implemented the key monitoring system as mentioned above by having the PLN monitoring system on their management system.

As part of the PLN management system requirement, Musi HEPP has develop some SOPs as follow:

- SOP to calibrate the Test and Measurement equipment.
- SOP to develop an Electricity Transfer Monthly Protocol Report (BAP)
- SOP to read the Electricity Meter

All those SOPs are in-line with the need for VCS project at Musi HEPP. Therefore, no need to develop a new SOP for VCS Project. Musi VCS Team would continue to follow the SOP during the monitoring period. Newly developed SOP for VCS Monitoring would make available after the activation of the VCS Monitoring team.

The main electricity meter read together by representatives from PT PLN (Persero) Generation Division (PT PLN (Persero) Generation Unit Musi HEPP) and PT PLN (Persero) Load Dispatcher and Transmission Division (PT PLN (Persero) Tanjung Karang Transmission Unit). Since both parties are under the same Head Company (PT PLN (Persero)), no other check meter (comparison meter) installed at the transaction point.

Electricity meters should meet the relevant local standards at the time of installation and calibrated by the manufacturer before installation. The meters installed by the project according to the Indonesian standard “Standard Electricity Meter Equipment”. Records of the meter (type, make, model, and calibration documentation) have been retained in the quality control system on-site.

All equipment calibrated by the manufacturer according to relevant local regulation standards⁷ and maintained to ensure accuracy of measurements. Records of the meter (type, make, model, calibration, and maintenance documentation) retained as part of the VCS monitoring system.

Main Meter Quality Control

The project developer owns the meter and is responsible for its maintenance and calibration, as stated in the SOPs. PLN Transmission Division and its representative are entitled to be present during any test, inspection, maintenance, and replacement of any part of the metering system, which performed by the meter manufacturer on request of the project developer.

The project developer specifies the QC (flow-chart) procedure for calibration of test and measurement equipment (SOP to calibrate the Test and Measurement equipment) to ensure the measurement accuracy of values shown by the instrument / measuring device and test or a measurement system (one of the instrument mentioned on this SOP is the electricity meter). The calibration can be done internally or externally depend on the type of measuring equipment and resource capability. The electricity meter located at the Musi HEPP project site is calibrated by external party. The calibration conducted by *PT. PLN (Persero) Penelitian dan Pengembangan Ketenagalistrikan: Calibration Laboratory*, a Certified Calibration Agency by National Accreditation Committee (*Komite Akreditasi Nasional / KAN*). The PLN Calibration Laboratory applies the Calibration Procedure B1IK0329 – 1 and IEC Standard 687 to calibrate the electricity meter. Periodic calibrations are to be done at least once every five years as per applicable metering standard issued by the Minister of Energy and Mineral Resource of Republic of Indonesia.

The Power Plant Operator periodically check if all tools and equipment work in a good condition as per the SOP⁸. In the event of any broken security seal in the metering system; or when the system fails to register, or if the measurement result is found upon testing to vary more than the allowable error from the standard meter used in the test, then an adjustment shall be made correcting all measurements of energy made by the metering system, as described in the SOP.

No check meter (comparison meter) installed at the transaction point. In case of failure of the main meter, the production meter and the plant own consumption meter (which were also located

⁷ The Ministry of Energy and Mineral Resource's regulation number 37 year 2008 dated November 27, 2008 on the Grid Code Sumatra Electricity Power System, the calibration of kWh meter must be done every 5 (five) years, as stated in the Metering Code section, MC 4.1.1 (Test after metering code commissioning, page 138)

⁸ http://kepuustakaan-presiden.pnri.go.id/uploaded_files/pdf/government_regulation/normal/UU_2_1981_soeharto.pdf

at generation site of each power generation unit) will be use as cross-check meters, measuring the quantity of electricity exported from the project. The difference between electricity produced and consumed on-site shall be valid for claiming carbon credits. In the special case of total failure of all meters no credits will be claimed during such period.

There was no metering devices breakdown or malfunction during the following monitoring period (01 April 2013 – 31 July 2016). All the meters listed above have performed well. However, any plant shut down or any other malfunctions are recorded in the logbook.

Data recording procedure

The procedures for collecting the electricity meter data is outlined in the Standard Operating Procedure as explained below.

The procedures for collecting the electricity meter data outlined in the Standard Operating Procedure signed between the project owner and the Grid Operator (both are under PLN)⁹. All relevant data 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 would develop to ensure that the project has robust data collection, processing, and archiving procedures.

Procedure for Joint Meter Reading (JMR) as per 'Procedure to develop Monthly Electricity Protocol Report' in general view (as described on the registered VCS PD, page 31):

- Joint meter reading by operator from Generation Unit (Unit Pembangkitan / UP) and Transmission Service Unit (Unit Pelayanan Transmisi / UPT P3B) conducted on the first date of each month at 10 A.M.
- Operating and maintenance supervisor (O & M supervisor) responsible for recording the amount of EG imported and exported by Generation unit as the result from kWh meter downloading.
- Operating and maintenance supervisor responsible for constructing the electricity generating protocol report, which includes calculation of net electricity delivered to PLN transmission unit. This report has to be reported and signed by Unit Manager, which further reported to the Sector Manager. VCS manager keep the copy of such report and be notified as well.
- O & M supervisor with other authorized staff from Generation unit extracted the data by downloading via computer from the kWh electronic meter and then record it in the form of Monthly Electricity Protocol (MEP), which signed by both Generating unit (PLN Musi Generation Unit) and PT. PLN P3B Pekalongan Sub-station). The joint meter reading taken at the transaction point is witnessed by the presence of P3B officials as transmission department and the PP representative as generation department.

⁹ Musi HEPP is following the "Prosedur Pembuatan BA Pengiriman Energi Listrik PLTA Musi" or the 'Procedure to develop Musi HEPP Monthly Electricity Protocol Report' as the detail procedure for Electricity Transfer to the Sumatera Grid. This procedure is a further development refer to the General Operational Procedure for PLN generation unit located in the North and South Sumatera, titled "Prosedur tetap transfer tenaga listrik antara PT PLN (Persero) Pembangkitan Sumbagut, PT PLN (Persero) Pembangkitan Sumbagsel dengan PT PLN (Persero) P3B Sumatera"

- The MEP then rechecked by authorized person from PT. P3B (UPT Tanjung Karang / Tanjung Karang Transmission Unit) and PT PLN Generation Sector Office (Bengkulu Sector Office).

After all such information is rechecked and agreed by all related parties, the MEP is signed by all authorized parties from Generation unit and Transmission unit. The report has been sent to PLN KITSBS as headquarter for all power plant units in South Sumatra.

All relevant data 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.

Main Electricity Meter specification:

Serial Number	Type	Factory	Class	Location
MUSI UNIT 1				
36027156	SL 7000 (Digital)	Actaris	0.2s	Main electricity meter 1 (MU 1) → to monitor electricity supply from turbine Musi #1
MUSI UNIT 2				
36027159	SL 7000 (Digital)	Actaris	0.2s	Main electricity meter 2 (MU 2) → to monitor electricity supply from turbine Musi #2
MUSI UNIT 3				
36027158	SL 7000 (Digital)	Actaris	0.2s	Main electricity meter 3 (MU 3) → to monitor electricity supply from turbine Musi #3
MUSI TRANSFORMER 150/20 kV				
35008966	SL 7000	Actaris	0.2s	Code PS to monitor the power plant own consumption (in-house consumption)

Picture of the main meters and own consumption meter (in-house consumption) are shown below:

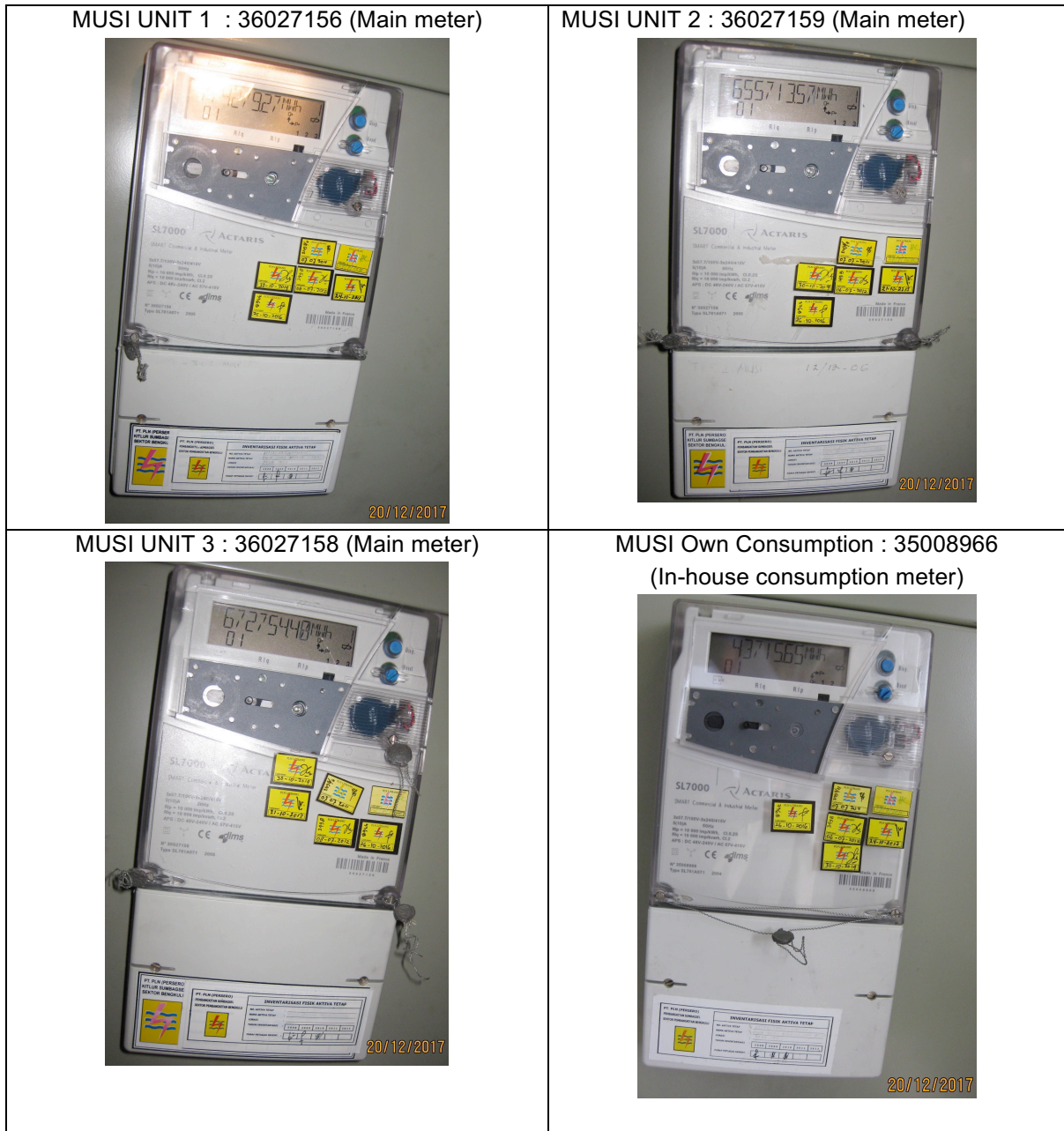


Figure 2 - Picture of main meters main meters and own consumption meter (in-house consumption)

Total diesel oil consumption, from the operational of Emergency DG Set

The fossil fuel consumption is calculated from the total 'Emergency DG set Operational Hours' on monthly basis during the vintage year (operational hour is converted into liter using the fuel consumption default then convert into ton using the density for diesel oil) at the project site. No equipment use to measure the diesel oil consumption. The PP uses total diesel oil consumption record for all activities (MCH, RRD and Intake) at the project site. The calculation is shown on section 4.2.2

VCS data collection and record keeping arrangements

Every month the Operation Supervisor from Musi Generation Unit (member of VCS Team) and Transmission Sub-station read the meter together and record the data on their journal. Based on this reading, a monthly electricity generation report was signed by both the generation department (Musi HEPP Generation Unit) and the transmission department (Tragi Pekalongan).

At the end of each month the monitoring data needs to be filled electronically. The electronic files need to have CD back-up and/or print-out. The project developer needs to keep recorded Monthly Transfer Electricity Protocol Record (METPR). All written documentation such as maps, drawings, the EIA and the Feasibility study, should 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.

4 QUANTIFICATION OF GHG EMISSION REDUCTIONS AND REMOVALS

4.1 Baseline Emissions

4.1.1. Formula used for baseline emissions calculation

The formula used for determination of the baseline emissions are described in section 4.3 of the registered VCS PD Ver. 3 dated 9th November 2009.

Baseline emissions are calculated as follows:

$$BE_y = EG_{PJ,y} \times EF_{grid,CM,y} \tag{1}$$

Parameter	Description	Unit	Value	Source
BE _y	Baseline emission in the reported monitoring period	tCO ₂ /40-months	1,776,330	Equation (1)
EG _{PJ,y}	Quantity of net electricity generation that is produced and fed into the grid as a result of the implementation of the project activity in the reported monitoring period	MWh/40-months	2,390,757	Joint Meter Reading (JMR)
EF _{grid,CM,y}	Combined margin CO ₂ emission factor for grid connected power generation in the reported monitoring period	tCO ₂ /MWh	0.743	Indonesian DNA published grid emission factor for Sumatra.

4.1.2. Baseline emissions calculation

Vintage Month	EG _{PJ,y} (MWh)	BE _y (tCO ₂ /year)
1 – 30 April 2013	50,712	37,679
1 – 31 May 2013	48,281	35,873
1 – 30 June 2013	50,658	37,639

Vintage Month	EG _{PJ,y} (MWh)	BE _y (tCO ₂ /year)
1 – 31 July 2013	74,194	55,126
1 – 31 August 2013	56,540	42,009
1 – 30 September 2013	71,654	53,239
1 – 31 October 2013	85,187	63,294
1 – 30 November 2013	73,335	54,488
1 – 31 December 2013	69,588	51,704
TOTAL BE_y per 2013	580,149	431,050.55
TOTAL BE_y per 2013 (Round Down)	-	431,050.00
1 – 31 January 2014	60,087	44,644
1 – 28 February 2014	61,940	46,021
1 – 31 March 2014	66,220	49,202
1 – 30 April 2014	42,883	31,862
1 – 31 May 2014	45,071	33,488
1 – 30 June 2014	59,355	44,101
1 – 31 July 2014	52,197	38,782
1 – 31 August 2014	59,093	43,906
1 – 30 September 2014	54,361	40,390
1 – 31 October 2014	40,507	30,096
1 – 30 November 2014	72,321	53,734
1 – 31 December 2014	81,166	60,306
TOTAL BE_y per 2014	695,201	516,534.38
TOTAL BE_y per 2014 (Round Down)	-	516,534.00
1 – 31 January 2015	63,889	47,469
1 – 28 February 2015	64,256	47,743
1 – 31 March 2015	80,316	59,675
1 – 30 April 2015	72,912	54,174
1 – 31 May 2015	66,035	49,064
1 – 30 June 2015	60,134	44,679
1 – 31 July 2015	44,695	33,208
1 – 31 August 2015	36,647	27,229
1 – 30 September 2015	27,737	20,608

Vintage Month	EG _{PJ,y} (MWh)	BE _y (tCO ₂ /year)
1 – 31 October 2015	24,759	18,396
1 – 30 November 2015	40,576	30,148
1 – 31 December 2015	60,418	44,891
TOTAL BE_y per 2015	642,374	477,283.78
TOTAL BE_y per 2015 (Round Down)	-	477,283.00
1 – 31 January 2016	70,023	52,027
1 – 28 February 2016	71,225	52,920
1 – 31 March 2016	88,282	65,593
1 – 30 April 2016	70,946	52,713
1 – 31 May 2016	60,066	44,629
1 – 30 June 2016	57,387	42,638
1 – 31 July 2016	55,104	40,942
TOTAL BE_y per 2016	473,033	351,463.70
TOTAL BE_y per 2016 (Round Down)	-	351,463.00
TOTAL BE_y per 2013 – 2016	-	1,776,330

4.2 Project Emissions

4.2.1. Formula used for project emissions calculation

The formula used for determination of the baseline emissions are described in section 4.3 of registered VCS PD Ver. 3 dated 9th November 2009.

Project emissions are calculated as follows:

$$PE_y = PE_{FF,y} + PE_{GP,y} + PE_{HP,y} \quad (2)$$

Parameter	Description	Unit	Value	Source
PE _y	Project emission in the reported monitoring period	tCO ₂ e/yr	Calculated	Equation (2)
PE _{FF,y}	Project emissions from fossil fuel consumption in the reported monitoring period	tCO ₂ /yr	Calculated	“Tool to calculate project or leakage CO ₂ emissions from fossil fuel combustion”
PE _{GP,y}	Project emissions from the operation of geothermal power plants due to the release of	tCO ₂ /yr	0	Not applicable Project activity is not a geothermal

Parameter	Description	Unit	Value	Source
	non-condensable gases in the reported monitoring period			powerplant.
PE _{HP,y}	Project emissions from water reservoirs in the reported monitoring period	tCO ₂ /yr	0	Not applicable (Power density is greater than 10 W/m ²)

$$PE_{FF,y} = PE_{FC,j,CO_2}$$

$$PE_{FC,j,CO_2} = \sum FC_{i,j,y} \times COEF_{i,y} \quad (3)$$

Parameter	Description	Unit	Value	Source								
PE _{FC,j,CO₂}	CO ₂ emissions from fossil fuel combustion in process j during year y	tCO ₂ /y	321.00 <table border="1"> <tr><td>2013</td><td>6</td></tr> <tr><td>2014</td><td>305</td></tr> <tr><td>2015</td><td>4</td></tr> <tr><td>2016</td><td>6</td></tr> </table>	2013	6	2014	305	2015	4	2016	6	Equation (3)
2013	6											
2014	305											
2015	4											
2016	6											
FC _{i,j,y}	Quantity of fuel type i combusted in process j during the year y	ton/y	100.11 <table border="1"> <tr><td>2013</td><td>1.68</td></tr> <tr><td>2014</td><td>95.60</td></tr> <tr><td>2015</td><td>1.03</td></tr> <tr><td>2016</td><td>1.81</td></tr> </table>	2013	1.68	2014	95.60	2015	1.03	2016	1.81	Measured in litre than converted into ton with formula as below: Fuel Consumption (litre) x Fuel Density (0.815 kg/litre)
2013	1.68											
2014	95.60											
2015	1.03											
2016	1.81											
COEF _{i,y}	CO ₂ emission coefficient of fossil fuel type i in year y	tCO ₂ /ton	3.1863	Equation (4)								
i	Fuel types combusted in process j during year y	-	i= Diesel oil	Musi HEPP								

COEF_{i,y} is calculated using option B. Option B calculates COEF_{i,y} based on net calorific value and CO₂ emission factor of fuel type i, as follows:

$$COEF_{i,y} = NCV_{i,y} \times EF_{CO_2,i} \quad (4)$$

Parameter	Description	Unit	Value	Source
COEF _{i,y}	CO ₂ emission coefficient of fossil fuel type i in year y	tCO ₂ / ton fuel	3.1863	Equation (4)
NCV _{i,y}	Weighted average net calorific value of fuel type i in year	TJ/ton fuel	Diesel Fuel: 0.043	IPCC 2006 default for diesel oil
EF _{CO₂,i}	Weighted average CO ₂ emission factor of fuel type i	tCO ₂ /TJ	Diesel Fuel: 74.1	IPCC 2006 default for diesel oil

	in year y			
i	Fuel types combusted in process j during year y	-	i=Diesel oil	Musi HEPP

4.2.2. Project emissions from the consumption of fossil fuels

Year	Fuel Consumption (Litre)	Fuel Consumption (ton)
2013 (Apr – Dec)	2,056	1.68
2014 (Jan – Dec)	117,299	95.60
2015 (Jan – Dec)	1,259	1.03
2016 (Jan – Jul)	2,216	1.81
TOTAL	122,830	100.11

4.3 Leakage

No leakage emissions are considered. The main emissions potentially giving rise to leakage in the context of electric sector projects are emissions arising due to activities such as power plant construction and upstream emissions from fossil fuel use (e.g. extraction, processing, transport). These emissions sources are neglected.

$$LE_y = 0$$

4.4 Net GHG Emission Reductions and Removals

4.4.1. Formula used for emission reductions calculation

Emission reductions are calculated as follows:

$$ER_y = BE_y - PE_y \tag{5}$$

Parameter	Description	Unit	Value	Source
BE_y	Baseline emissions in the period y	tCO ₂ e	Calculated	Equation (1)
PE_y	Project emissions in the period y	tCO ₂ e	Calculated	Equation (2)
ER_y	Project emission in the period y	tCO ₂ e	Calculated	Equation (3)

4.4.2. Emission reductions calculation

Year	Baseline emissions or removals (tCO ₂ e)	Project emissions or removals (tCO ₂ e)	Leakage emissions (tCO ₂ e)	Net GHG emission reductions or removals (tCO ₂ e)
Vintage 2013 : 01/04/2013 - 31/12/2013	431,050	6	0	431,044
Vintage 2014 : 01/01/2014 - 31/12/2014	516,534	305	0	516,229
Vintage 2015 : 01/01/2015 - 31/12/2015	477,283	4	0	477,279
Vintage 2016 : 01/01/2016 - 31/07/2016	351,463	6	0	351,457
Total	1,776,330	321	0	1,776,009