



Monitoring report form (Version 03.2)

Monitoring report

Title of the project activity	Afam Combined Cycle Gas Turbine Power Project
Reference number of the project activity	5645
Version number of the monitoring report	01
Completion date of the monitoring report	16/07/2014
Registration date of the project activity	29/10/2012
Monitoring period number and duration of this monitoring period	01/11/2012 – 31/10/2013
Project participant(s)	• Nigerian National Petroleum Corporation (NNPC) • Shell Nigeria (a subsidiary of Royal Dutch/ Shell plc) • Elf Petroleum Nigeria Limited (EPNL, a subsidiary of TOTAL S A) • Agip (a subsidiary of ENI SpA)
Host Party(ies)	Federal Republic of Nigeria
Sectoral scope(s) and applied methodology(ies)	Sectoral Scope 1 AM0029 / Version 03 "Baseline Methodology for Grid Connected Electricity Generation Plants using Natural Gas".
Estimated amount of GHG emission reductions or net anthropogenic GHG removals by sinks for this monitoring period in the registered PDD	550,234 tCO ₂ e
Actual GHG emission reductions or net anthropogenic GHG removals by sinks achieved in this monitoring period	671,550 tCO ₂ e
Actual GHG emission reductions or net anthropogenic GHG removals by sinks achieved during the period up to 31 December 2012(if applicable)	131,292 tCO ₂ e
Actual GHG emission reductions or net anthropogenic GHG removals by sinks achieved during the period from 1 January 2013 onwards (if applicable).	540,257 tCO ₂ e

SECTION A. Description of project activity**A.1. Purpose and general description of project activity**

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Purpose of the project activity:

The purpose of the project activity is to build a 650 MW grid-connected combined-cycle gas turbine (CCGT) fuelled by natural gas which reduces greenhouse gas emissions because the CO₂ volumes emitted for each unit of electricity generated by the CCGT plant are lower than the quantity of CO₂ emissions that would otherwise be emitted by generating the same quantity of electricity from the baseline OCGT plant.

The project activity (construction of a CCGT plant), while the fuel is the same (natural gas) as the OCGT plant, the emission reduction arises from the greatly improved thermal efficiency.

Installed technology and equipment:

The installed technology includes 3 X 150MW Alstom 13E2 gas turbines and 1 X 200MW steam turbine with a heat recovery system. The technology is of an international standard and installed with dry low NOX combustion equipment.

The power plant site is near to existing electricity generation plant that is now non-operational, which existed prior to the start of implementation of the project activity, and which is owned by the Power Holding Company of Nigeria (PHCN), the successor to the National Electric Power Authority (NEPA). This older plant originally comprised four small open-cycle gas turbine (OCGT) units called Afam I-IV, consisting of around 75 MW of installed capacity, which are decrepit, beyond repair and have not been operated for many years. The site also contained an OCGT facility called Afam V, which was commissioned in 2002, consisting of 2 x 137 MW Siemens V94.2s gas turbines. These units are not in operational condition due to inadequate maintenance and poor operating practices.

Relevant dates for the project activity since CDM registration:*Table 1: Key events since CDM registration*

Date (s)	Activities
29/10/2012	Registration of the project activity under the CDM by the UNFCCC Secretariat
01/11/2012	Starting date for crediting

Total emission reduction achieved in this monitoring period

During Monitoring Period No. 01 (from 01/11/2012 to 31/10/2013), the net emission reductions achieved is calculated to be 671,550 tCO₂e in accordance with the formulae presented in Section B.6.3 of the registered PDD (see Section E below for detailed calculations).

A.2. Location of project activity

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Host Party

The Host Party is the Federal Republic of Nigeria.

Region/State/Province, etc.

The project is located in Oyigbo Local Government Area (LGA) of Rivers State.

City/Town/Community, etc.

The power plant is built in Afam area of the community

Physical/Geographical location

The physical location for the project is at geographical coordinates: 04°47'56"N and 07°00'07"E

A.3. Parties and project participant(s)

Party involved ((host) indicates a host Party)	Private and/or public entity(ies) project participants (as applicable)	Indicate if the Party involved wishes to be considered as project participant (Yes/No)
Federal Republic of Nigeria (host)	• Nigerian National Petroleum Corporation (NNPC) • Shell Nigeria (a subsidiary of Royal Dutch/ Shell plc) • Elf Petroleum Nigeria Limited (EPNL, a subsidiary of TOTAL S A) • Agip (a subsidiary of ENI SpA)	No

A.4. Reference of applied methodology

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Approved methodology:

The methodology applied for this project activity is AM0029 "Baseline Methodology for Grid Connected Electricity Generation Plants using Natural Gas" (Version 03). Please see Section B.6.1 of the registered PDD for further explanation of how the baseline and monitoring methodology AM0029 (Version 03) shall be applied for monitoring of the CDM project activity.

Tools:

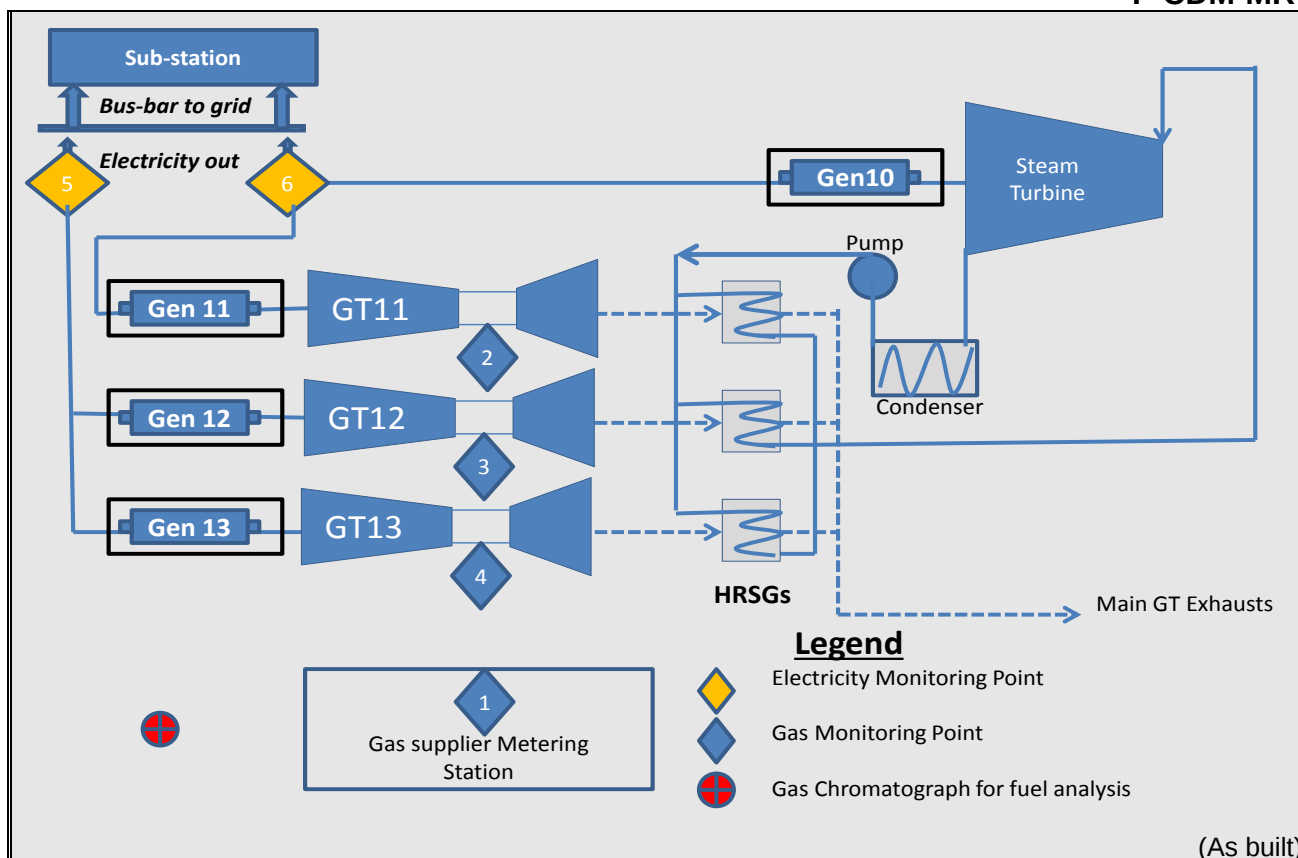
As per the applied methodology, the following specific tools have been applied:

- Tool to calculate the emission factor for an electricity system (version 2.2.1)
- Tool for the demonstration and assessment of additionality (version 6.0)

A.5. Crediting period of project activity

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The crediting period is fixed type at ten years (120 months) from the beginning of project operations. The start date is 01 November 2012. The length of the crediting period is 01/11/2012 – 31/10/2022.



B.2. Post registration changes

B.2.1. Temporary deviations from registered monitoring plan or applied methodology

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B.2.2. Corrections

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No corrections to project information or parameters fixed at validation have been submitted with this monitoring report.

B.2.3. Permanent changes from registered monitoring plan or applied methodology

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No permanent changes from the registered monitoring plan or applied methodology have been submitted with this monitoring report.

B.2.4. Changes to project design of registered project activity

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No changes to the project design of the project activity have been submitted with this monitoring report.

B.2.5. Changes to start date of crediting period

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No changes to the start date of the crediting period have been approved during this monitoring period or submitted with this monitoring report.

B.2.6. Types of changes specific to afforestation or reforestation project activity

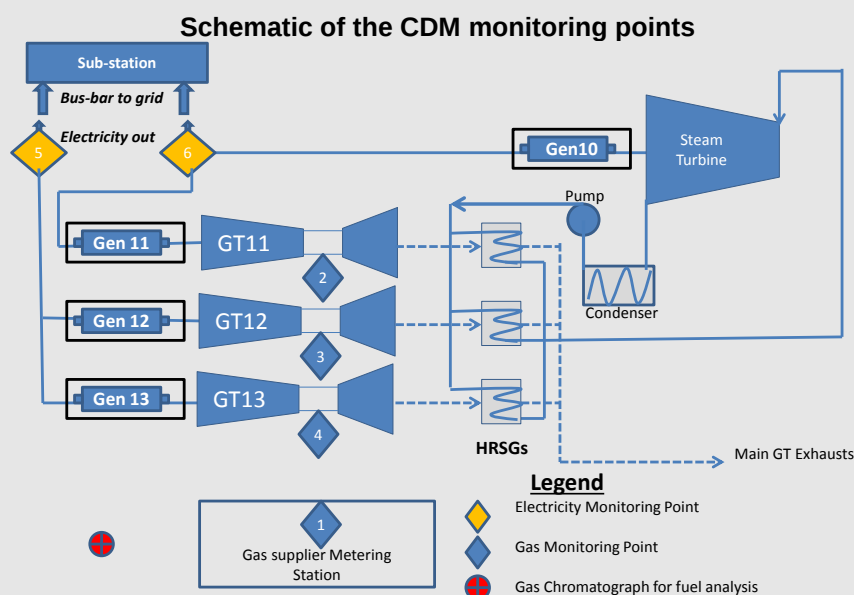
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Not applicable

SECTION C. Description of monitoring system

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The monitoring plan applied for the CDM project activity is as described in Section B.7 and Annex 4 of the registered PDD, as available on the UNFCCC website. As part of the CDM monitoring preparations, the monitoring procedures presented in the PDD have been developed in more detail to reflect the physical infrastructure installed – however, all the monitoring points' variables are similar to that in the PDD. Monitoring procedures are maintained in the SPDC Plant Procedures manual which is updated periodically and maintained at the site. It will be made available to the DOE.

**Parameters monitored:**

The monitoring methodology requires the following parameters to be monitored during the crediting period:

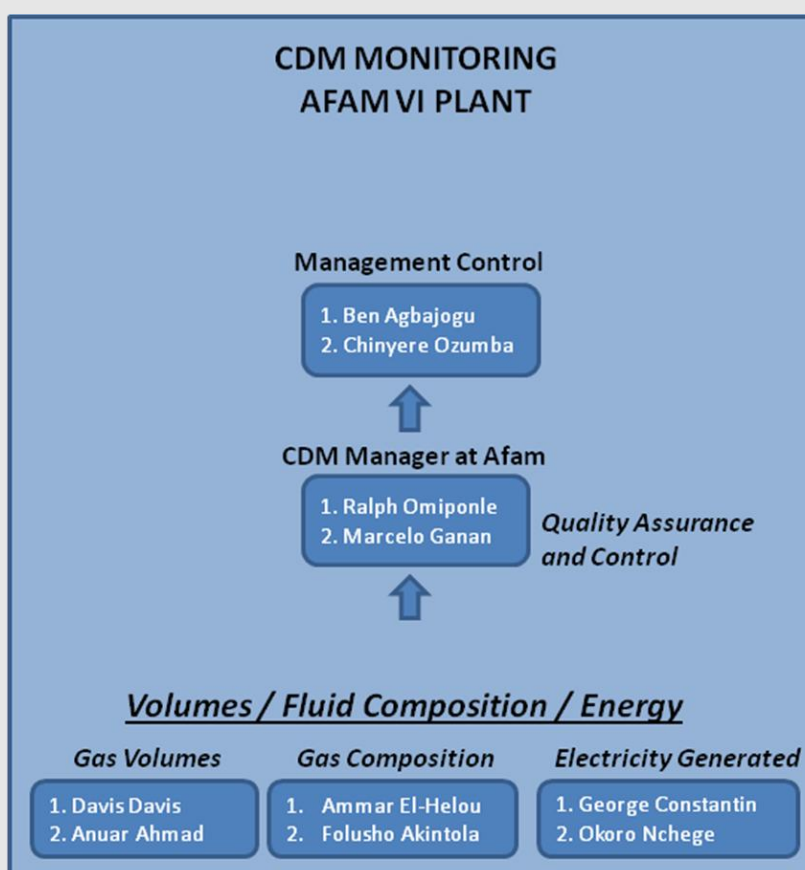
For project emissions:

1. Annual fuel(s) consumption in project activity;
2. Net Calorific Value(s) of the fuel used in the project activity;
3. Fuel emission factors for fuel used in the project activity.

Baseline emissions will be monitored as per the "Tool to calculate emission factor for an electricity system", as applicable. Therefore, according to Option 3 used in the choice of baseline emissions factor, EF_{BL} , parameters $EG_{PJ,Y}$ and $COEF_{BL}$ are been monitored.

Organizational structure and CDM specific responsibilities

The figure below illustrates the key roles and responsibilities during the monitoring period in consideration.



The key roles and CDM related responsibilities of staff at the Afam VI power plant are the following:

- Collection of data, QA, reporting and storage of all primary data
- Periodic maintenance, inspection and calibration of all measurement equipment, including control of meter accuracy and software configurations (e.g. flow computers)

In essence, the key CDM roles of each of three organizational units are:

- Gas Volumes: Responsible for all primary monitoring data related to volumes and assuring that all equipment is maintained within the criteria in the PDD monitoring plan and the procedure's manual.
- Gas Composition: Ensuring gas compositions comply with the standards required by the plant and also meeting the CDM monitoring requirements. Also ensuring that the Gas chromatograph is calibrated at the required frequency and standards
- Electricity Generated: Responsible for all primary monitoring data related to electricity generation and assuring that all equipment is maintained within the criteria in the PDD monitoring plan and the procedure's manual.

Storage of primary data related to the CDM monitoring:

All data will be recorded in a purpose built MS Excel spreadsheet. Data will be stored on SPDCs' computer server and backed up regularly. This is achieved periodically in a secure and reliable storage for up to two years after the end of the crediting period. Hard copies are kept for a one year period or until electronic copies are available. For data assurance and quality control of primary data, procedures and all relevant CDM information are maintained in a specified site in the gas plant administration building in the office of the CDM Focal Point. The information is kept in structured folders and includes: procedures, manuals and standards for the meters, certifications, and other relevant information. This serves as the documental control point.

SECTION D. Data and parameters

D.1. Data and parameters fixed ex ante or at renewal of crediting period

(Copy this table for each piece of data and parameter.)

Data / Parameter:	$OXID_f$
Unit:	-
Description:	Oxidation factor of natural gas used in the calculation of project emission
Source of data:	2006 IPCC Guidelines for National Greenhouse Gas Inventories default factor for stationary combustion sources.
Value(s) applied:	1
Purpose of data:	Used for calculating CO ₂ emission coefficient for PE
Additional comment:	None

Data / Parameter:	$EF_{BL,CO_2,y}$
Unit:	tCO ₂ /MWh
Description:	Baseline CO ₂ emissions factor
Source of data:	Calculated based on the fuel coefficient and the energy efficiency of the technology, as estimated in the baseline scenario analysis.
Value(s) applied:	0.511 (see section B.6.1)
Purpose of data:	Calculation of baseline emissions.
Additional comment:	None

Data / Parameter:	η_{BL}
Unit:	%
Description:	Energy efficiency of the technology
Source of data:	Conservative default efficiency factor for new gas-fired OCGT units built after 2000, as contained in Annex I of the "Tool to calculate the emission factor of electricity system" v2.2.1
Value(s) applied:	39.5
Purpose of data:	For calculating baseline CO ₂ emission factor for baseline emissions
Additional comment:	None

Data / Parameter:	$COEF_{BL}$
Unit:	tCO _{2e} /GJ
Description:	Fuel emission coefficient
Source of data:	IPCC default emission factor for natural gas.
Value(s) applied:	0.0561
Purpose of data:	For calculating baseline emission
Additional comment:	None

D.2. Data and parameters monitored

(Copy this table for each piece of data and parameter.)

Data / Parameter:	$FC_{f,y}$
Unit:	m ³

Description:	Annual quantity of fuel (natural gas) consumed in project activity
Measured/ Calculated / Default:	Continuous metering of gas supply both at supplier (Okoloma gas plant) and project end for cross verification and measured in standard cubic meters (m ³)
Source of data:	Fuel (natural gas) flow meter reading at Afam plan gas reception facilities.
Value(s) of monitored parameter:	643,488,591
Monitoring equipment:	Elster Instromet 2000
Measuring/ Reading/ Recording frequency:	Continuous
Calculation method (if applicable):	Not applicable
QA/QC procedures:	Natural gas supply metering (Elster Instromet 2000) to the project will be subject to regular (in accordance with stipulation of the meter supplier) maintenance and testing to ensure accuracy.
Purpose of data:	For calculating project emission
Additional comment:	None

Data / Parameter:	FC _{f,2,y}
Unit:	m ³
Description:	Annual quantity of fuel (natural gas) consumed in gas turbine #11
Measured/ Calculated / Default:	Daily meter reading
Source of data:	Fuel (natural gas) flow meter reading at turbine #13 inlet (SM R1-X-K G1600 Elster Instromet meter located at point 4 in figure A4.1)
Value(s) of monitored parameter:	221,783,455
Monitoring equipment:	SM R1-X-K G1600 Elster Instromet meter.
Measuring/ Reading/ Recording frequency:	Daily
Calculation method (if applicable):	Not applicable
QA/QC procedures:	Used to corroborate gas consumption data collected at point 1
Purpose of data:	For calculating project emission.
Additional comment:	None

Data / Parameter:	FC _{f,3,y}
Unit:	m ³
Description:	Annual quantity of fuel (natural gas) consumed in gas turbine #12
Measured/ Calculated / Default:	Daily meter reading
Source of data:	Fuel (natural gas) flow meter reading at turbine #12 inlet (SM R1-X-K G1600 Elster Instromet meter located at point 3 in figure A4.1)
Value(s) of monitored parameter:	172,372,951
Monitoring equipment:	SM R1-X-K G1600 Elster Instromet meter.

Measuring/ Reading/ Recording frequency:	Daily
Calculation method (if applicable):	Not applicable
QA/QC procedures:	Used to corroborate gas consumption data collected at point 1
Purpose of data:	For calculating project emissions.
Additional comment:	None

Data / Parameter:	$FC_{f,4,y}$
Unit:	m^3
Description:	Annually quantity of fuel (natural gas) consumed in gas turbine #13
Measured/ Calculated / Default:	Daily meter reading
Source of data:	Fuel (natural gas) flow meter reading at turbine #11 inlet (SM R1-X-K G1600 Elster Instromet meter located at point2 in figure A4.1)
Value(s) of monitored parameter:	249,332,185
Monitoring equipment:	SM R1-X-K G1600 Elster Instromet
Measuring/ Reading/ Recording frequency:	Daily
Calculation method (if applicable):	Not applicable
QA/QC procedures:	Used to corroborate gas consumption data collected at point 1
Purpose of data:	For calculating project emissions.
Additional comment:	None

Data / Parameter:	$NCV_{f,y}$
Unit:	GJ/m^3
Description:	The net calorific value (energy content) per volume unit of natural gas used in the calculation of project emissions.
Measured/ Calculated / Default:	Gas samples collected using SPDC standard gas sampling protocol and analysed using standard gas chromatography techniques in on-site laboratory.
Source of data:	Based on a fortnightly sampling at the Afam gas custody point
Value(s) of monitored parameter:	0.04654
Monitoring equipment:	On site GC laboratory
Measuring/ Reading/ Recording frequency:	Fortnightly
Calculation method (if applicable):	Not applicable
QA/QC procedures:	The calorific value of the gas will recorded by the project participant and cross checked against measurements made, and provided, by the gas supplier
Purpose of data:	For calculating CO ₂ emission coefficient for project emission.
Additional comment:	None

Data / Parameter:	EF _{CO₂,F,y}
Unit:	tCO ₂ /GJ
Description:	CO ₂ emission factor per unit of energy of natural gas used in the calculation of project emission.
Measured/ Calculated / Default:	Gas samples collected using SPDC standard gas sampling protocol and analysed using standard gas chromatograph techniques in on-site laboratory
Source of data:	Based on a fortnightly sampling at the Afam gas custody point
Value(s) of monitored parameter:	0.03340
Monitoring equipment:	On-site Gas Chromatograph
Measuring/ Reading/ Recording frequency:	Fortnightly
Calculation method (if applicable):	None
QA/QC procedures:	The CO ₂ content of the gas will be recorded by the project participant and cross-checked against measurements made, and provided, by the gas supplier.
Purpose of data:	For calculating CO ₂ emission coefficient for project emission.
Additional comment:	None

Data / Parameter:	EG _{PJ,56,y}
Unit:	MWh
Description:	Electricity produced by gas and steam turbines.
Measured/ Calculated / Default:	Continuous metering of electricity supplied by the gas and steam turbines to the bus-bar of the Afam plant.
Source of data:	Electricity meters installed in the plant power export to bus-bar (meter type EDM I MK6E with accuracy class 0.2S. IEC62052-11/62053-22 and meter type EDM I MK6E with accuracy class 0.2S/0.55. IEC62052-11/62053-22) for both the gas and steam turbine.
Value(s) of monitored parameter:	3,269,378
Monitoring equipment:	EDMI MK6E
Measuring/ Reading/ Recording frequency:	Continuous metering of electricity supplied by the gas and steam turbine to the bus-bar of the Afam plant.
Calculation method (if applicable):	Not applicable
QA/QC procedures:	Metered export of electricity to be checked against data on power received by the grid operator (PHCN) at the Afam plant-grid interface points. Accuracy of the meters are to be tested every 180 days as outlined in section 7.3 of the PPA and the calibration of meters needs to be undertaken if electrical energy measured by the system differs by over half a percent (0.5%) from any back-up system.
Purpose of data:	For calculating baseline emission.
Additional comment:	None

D.3. Implementation of sampling plan

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Only 2 parameters have been determined from analysis of samples of physical fluid characteristics of the inlet gas stream. Details descriptions of the sampling design, the amount of collected data, the analysis of collected data and the compliance with relevant requirements are provided for each relevant parameter in Section D.2 above.

SECTION E. Calculation of emission reductions or GHG removals by sinks

E.1. Calculation of baseline emissions or baseline net GHG removals by sinks

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Baseline emissions are calculated in accordance to Equation 2 in the registered PDD and methodology:

$$BE_y = EG_{PJ,y} \cdot EF_{BL,CO_2,y} \quad (\text{Equation 2})$$

AM0029 requires that baseline emissions are calculated by multiplying the electricity generated in the project plant ($EG_{PJ,y}$) with a baseline CO₂ emission factor ($EF_{BL,CO_2,y}$). The methodology requires project participants to use for $EF_{BL,CO_2,y}$ the lowest emission factor among the following three options:

Option 1 – The build margin (BM) as per the “Tool to calculate the emission factor for an electricity system”;

Option 2 – The combined margin (CM) as per the “Tool to calculate the emission factor for an electricity system” using a 50/50 OM/BM weight; and

Option 3 – The emission factor of the technology (and fuel).

As stated in the PDD, the most likely technology that would be used instead of CCGT is OCGT plant and this has therefore been chosen for the calculation of Option 3. As per equation (3) the input parameters for this technology are as follows:

$$EF_{BL,CO_2,y} = \left(\frac{COEF_{BL}}{\eta_{BL}} \right) * 3.6 GJ / MWh \quad (\text{Equation 3})$$

Where:

$COEF_{BL}$ = the fuel emission coefficient (tCO₂e/GJ), (IPCC default emission factor for natural gas) was used.

η_{BL} = the energy efficiency of the technology, 39.5% (conservative default efficiency factor for new gas-fired OCGT units built after 2000, as contained in Annex I of the “Tool to calculate the emission factor of an electricity system” v2.2.1) was applied

The resulting value for EF_{BL,CO_2} is calculated to be **0.511 tCO₂/MWh**

Amount of electricity generated during the monitoring period is determined as 3,269, 378 MWh

For the monitoring period in consideration, the relevant parameter values and the resulting baseline emissions are:

Parameter:	Unit:	Value:
$EG_{PJ,56,y}$	(MWh)	3,269,378
η_{BL}	()	0.395
$COEF_{BL}$	(tCO ₂ e/GJ)	0.0561

BL_y	(tCO ₂)	1,671,604
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E.2. Calculation of project emissions or actual net GHG removals by sinks

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This shall be calculated according to the formulae presented in Section B.6.3 of the registered PDD.

The project activity is on-site combustion of natural gas to generate electricity. The source of project emissions is the fuel used for the project activity (natural gas). The parameters included in the calculations are the volume and composition of the fuel. The CO₂ emissions from electricity generation (PE_y) are calculated as follows:

$$PE_y = \sum FC_{f,y} * COEF_{f,y} \quad (\text{Equation 1})$$

Where:

$FC_{f,y}$ = the total volume of natural gas or other fuel 'f' combusted in the project plant or other start-up fuel (m³ or similar) in year(s) y

$COEF_{f,y}$ = the CO₂ emission coefficient (tCO₂/m³ or similar) in year(s) for each fuel and is obtained as:

$$COEF_{f,y} = \sum NCV_{f,y} * EF_{CO_2,f,y} * OXID_f \quad (\text{Equation 1a})$$

For the monitoring period in consideration, the relevant parameter values and the resulting CO₂ emissions from the project activity due to combustion are:

Parameter:	Unit:	Value:
$Oxid_f$	(--)	1
$EF_{CO_2,f,y}$	(tCO ₂ /GJ)	0.03340
$NCV_{f,y}$	(GJ/m ³)	0.04654
$COEF_{f,y}$	(tCO _{2e} /GJ)	0.0016
$FC_{f,y}$	(m ³)	643 X 10 ⁶
PE_y	(tCO ₂)	1,000,055

E.3. Calculation of leakage

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As stated in the PDD, there is no leakage associated with the project activity, because fugitive upstream CH₄ emissions from gas transformation and distribution apply to both the baseline and project scenario. The project will not give rise to increases fugitive emissions and, based upon a lower gas feed requirement, leakage emissions from arising from fugitive CH₄ emissions may be negative; however, for the purposes of simplicity and conservativeness $LE_{CH_4,y}$ was treated as zero. There will be no LNG consumption in the project activity, so $LE_{LNG,CO_2,y}$ will be zero. Therefore, leakage emissions are calculated to be zero (see Section B.6.1 of the registered PDD for justification).

E.4. Summary of calculation of emission reductions or net anthropogenic GHG removals by sinks

Item	Baseline emissions or baseline net GHG removals by sinks (t CO ₂ e)	Project emissions or actual net GHG removals by sinks (t CO ₂ e)	Leakage (t CO ₂ e)	Emission reductions or net anthropogenic GHG removals by sinks (t CO ₂ e)
Total	1,671,604	1,000,055	0	671,550

E.5. Comparison of actual emission reductions or net anthropogenic GHG removals by sinks with estimates in registered PDD

Item	Values estimated in ex-ante calculation of registered PDD	Actual values achieved during this monitoring period
Emission reductions or GHG removals by sinks (t CO₂e)	550,234	671,550

E.6. Remarks on difference from estimated value in registered PDD

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During the monitoring period in consideration, the actual emission reductions achieved are 18% higher than the estimated emission reduction over the same period (i.e. a period of 365 days in 2012/2013) presented in the registered PDD.

The difference between the estimated and actual operations is largely related to the gas composition and emission factor of fuel used in the PDD calculations which were estimated based on use of literature (for the NCV) and IPCC default value (emission factor of the natural gas fuel). The monitored values are based on the actual gas analysis on the fuel composition carried out in the laboratory.

E.7. Actual emission reductions or net anthropogenic GHG removals by sinks during the first commitment period and the period from 1 January 2013 onwards

Item	Actual values achieved up to 31 December 2012	Actual values achieved from 1 January 2013 onwards
Emission reductions or GHG removals by sinks (t CO₂e)	131, 292	540,257

Document information

<i>Version</i>	<i>Date</i>	<i>Description</i>
03.2	5 November 2013	Editorial revision to correct table in page 1.
03.1	2 January 2013	Editorial revision to correct table in section E.5.
03.0	3 December 2012	Revision required to introduce a provision on reporting actual emission reductions or net anthropogenic GHG removals by sinks for the period up to 31 December 2012 and the period from 1 January 2013 onwards (EB70, Annex 11).
02.0	13 March 2012	Revision required to ensure consistency with the "Guidelines for completing the monitoring report form" (EB 66, Annex 20).
01	28 May 2010	EB 54, Annex 34. Initial adoption.
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