Monitoring report form (Version 03.1)

Monitoring report

Title of the project activity	Optimisation of Kiambere Hydro Power Project
Reference number of the project activity	7783
Version number of the monitoring report	1
Completion date of the monitoring report	05/08/2013
Registration date of the project activity	24/10/2012
Monitoring period number and duration of this monitoring period	1st Monitoring Period 01/11/2012 to 30/06/2013 (242 Days)
Project participant(s)	1. **Kenya:** Kenya Electricity Generating Company Ltd. (KenGen) 2. **Netherlands:** International Bank for Reconstruction and Development (IBRD) as the Trustee of the Community Development Carbon Fund (CDCF); Netherlands' Ministry of Infraestructure and the Environment (IenM)
Host Party(ies)	Kenya
Sectoral scope(s) and applied methodology(ies)	1 : Energy industries (renewable - / non-renewable sources) Approved consolidated baseline and monitoring methodology ACM0002/Version 13.0.0: "Consolidated baseline methodology for grid-connected electricity generation from renewable sources"
Estimated amount of GHG emission reductions or net anthropogenic GHG removals by sinks for this monitoring period in the registered PDD	**27,319 tCO2e** in (242 Days**)**
Actual GHG emission reductions or net anthropogenic GHG removals by sinks achieved in this monitoring period	**47,322 tCO2e** in (242 Days**)**

SECTION A. Description of project activity

A.1. Purpose and general description of project activity

The objective of the *Optimisation of Kiambere Hydro Power project* is to rehabilitate the Kiambere Power Plant, including the upgrade of the turbines with new efficient runners at the Kiambere power plant. The old 2 x 72 MW turbines were replaced with new 2 x 84.5 MW turbines with efficient runners. Thus, the upgrade increased the plant's generation capacity by 25 MW from its original capacity of 144 MW to 168 MW. However, of this additional capacity, at present only 20 MW is the contracted capacity to be supplied to the Kenyan grid and hence restricting its generation capacity.

From 2003-2008, the previous 144 MW capacity supplied on average annual electricity amounting to 917.4 GWh to the Kenyan grid. The additional contracted capacity of 20 MW is to supply an estimated annual incremental power of 75.0 GWh to the Kenyan grid. Hence, with this additional contracted capacity, the total electricity supply to the grid from the Kiambere power plant is expected to be 992.4 GWh per year.

The project activity results in greenhouse gas (GHG) emission reductions by displacing fossil fuel-dominated electricity generation in the Kenyan grid with clean hydropower.

The total emission reductions achieved in this monitoring period is **47,322 tCO2e.**

A.2. Location of project activity

The project activity is located at Latitude 0° 38' 24" S (-0.6400) and Longitude 37° 54' 36" E (+37.9100). The Kiambere power station is the last of the five hydropower stations on the Tana River. The Kiambere Hydro Power Project is located, downstream of Kindaruma Power station, along the Tana cascade.

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)**
Government of Kenya (Host)	Kenya Electricity Generating Company Ltd.	No
Government of The Netherlands	International Bank for Reconstruction and Development (IBDR) as Trustees of the Community Development Fund	Yes
Government of The Netherlands	Netherlands' Ministry of Infrastructure and the Environment (IenM)	Yes

A.4. Reference of applied methodology

Approved consolidated baseline and monitoring methodology ACM0002/Version 13.0.0: "Consolidated baseline methodology for grid-connected electricity generation from renewable sources"
This methodology also refers to the latest approved version of the following tools:

- Tool to calculate the emission factor for an electricity system, Version 02.2.1
- Tool for the demonstration and assessment of additionality, Version 06.1.0
- Combined tool to identify the baseline scenario and demonstrate additionality, Version 04.0.0
- Tool to calculate project or leakage CO_2 emissions from fossil fuel combustion, Version 02

A.5. Crediting period of project activity

The crediting period is a 10 year fixed crediting period. The start date of the crediting period is 1/11/2012 and the end date is 31/10/2022.

SECTION B. Implementation of project activity

B.1. Description of implemented registered project activity

The Kiambere Project has an underground powerhouse that is situated 4 km away from the saddle dam where the intake structure is located. The water conveyance is by a 6 m diameter headrace. The previous 144 MW plant, consisted of 2 x 72 MW units, and supplied on average annual electricity of about 917.4 GWh to the Kenyan grid from 2003 to 2008. The Rehabilitation of the Power Plant, which included the upgrading of the turbines with new runners, has increased the plant's generation capacity by 25 MW in the Kiambere Power Station.

The details for the rehabilitation included the following:

- Replacement of the whole turbine with a more efficient, powerful and cavitations-free runner (installed capacity with new runner of 84.5 MW x 2 sets instead of existing 72 MW x 2 sets)
- Replacement of the head cover, guide vanes, bottom ring
- Installation of a new electronic governor and adoption to the existing hydraulic parts of governor
- Installation of new excitation system
- Installation of additional power cable to carry the extra power

Commissioning and plant performance

The project activity was implemented in one stage and the entire project was commissioned prior to achieving the CDM registration status and the commencement of the monitoring period.

- The Optimization of Kiambere Unit 1 was commissioned on the 5th of November 2009 while Unit 2 was commissioned on the 29th of March 2009.
- The entire project plant was commissioned prior to the start of the crediting period; therefore the full project capacity was available prior to commencement of the first monitoring period.
- The rated output of the power plant is in accordance with the project description in the PDD.

During the 1 November 2012 - 30 June 2013 monitoring period, the units generated a total of **753,015 MWh** with an average availability factor of **99.7%.** The two units were on forced outage for a total of **24.59 hours** and planned outage for a total of **12.86 hours**.

During this monitoring period the plant was off for forced and planned maintenance as follows:

Month	Forced outage hours	Planned outage hours	Reason
Nov-12	0	0	
Dec-12	1.99	0	Unit 1:Start delay MIV opening Unit 2: Start delay & HPU Service
Jan-13	0	4	Generator cooler replacement
Feb-13	4.03	0	Cooling water pumps failure
Mar-13	0	2.18	Cooling System backwash
Apr-13	0	0	
May-13	0	0	Start delay; lack of indication of mechanical over speed device
Jun-13	18.57	10.68	Unit 1: 23rd June Worn-out carbon bushes. Unit 2: 26th June planned outage for exciter bush inspection 26th June Forced outage Unit

			tripped due to CO2 system for generator tripped
Total	**24.59**	**12.86**	

Average availability for the plant during the monitoring period was therefore:

Month	Availability (%)
Nov-12	100.0
Dec-12	99.7
Jan-13	99.7
Feb-13	99.7
Mar-13	99.9
Apr-13	100.0
May-13	99.9
Jun-13	98.4
Total	**99.7**

The monitoring equipment i.e., the energy meters did not have any problems during the monitoring period.

B.2. Post registration changes

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

>> No request for deviation has been applied from registered monitoring plan or applied methodology

B.2.2. Corrections

>> No corrections have made to the registered monitoring plan or applied methodology

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

>> No permanent changes have made to the registered monitoring plan or applied methodology

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

>> No changes have been made to the project design of registered project activity

B.2.5. Changes to start date of crediting period

>> No changes have been made to the to start date of crediting period

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

>> Changes specific to afforestation or reforestation project activity are not applicable to this project activity

SECTION C. Description of monitoring system

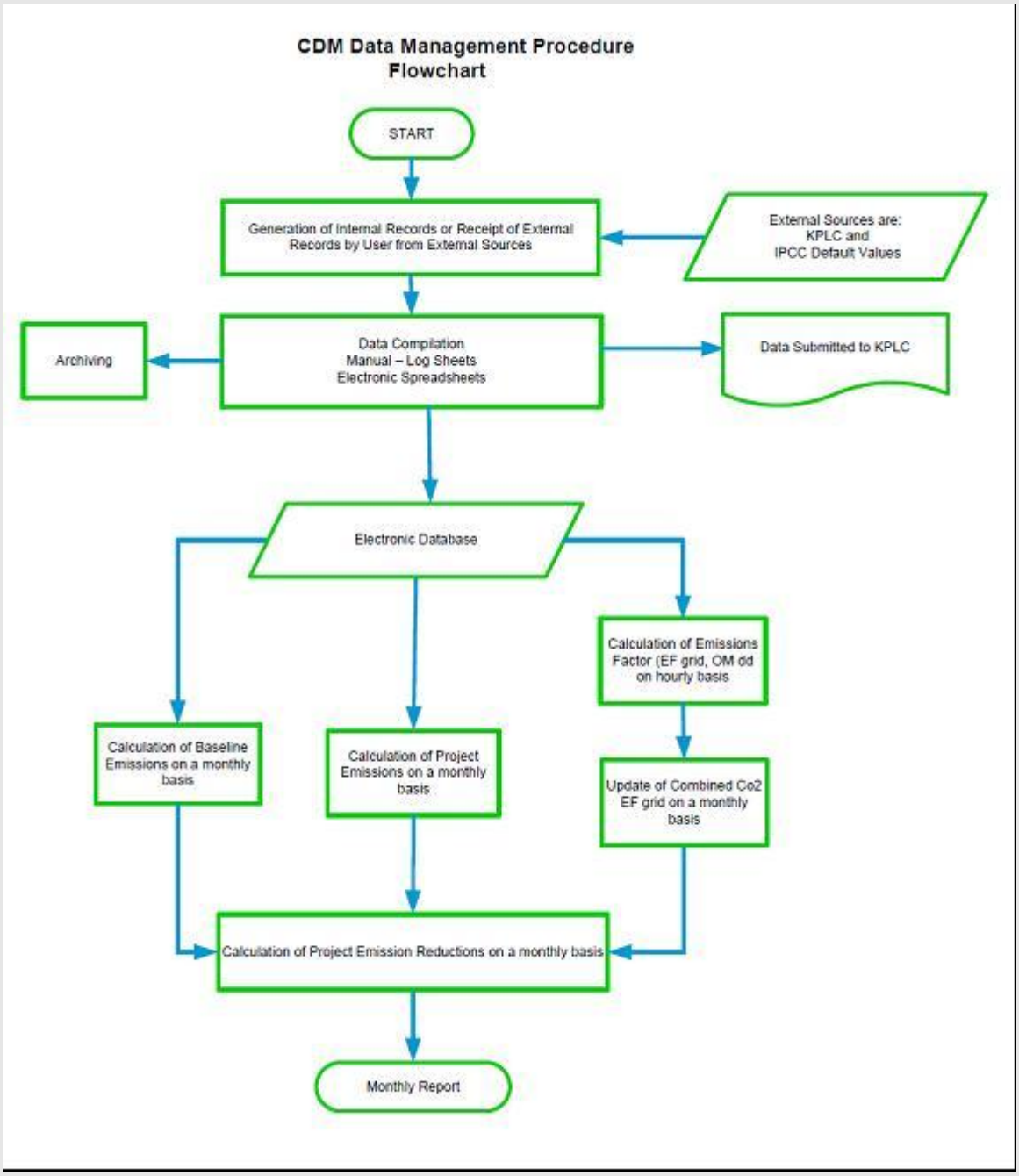
Monitoring will take place from the registration date up to the end of the last crediting period. Since project emissions were not identified in this project activity, and since ACM0002/Version 13.0.0 does not consider emissions due to leakage, there will be no need to monitor the parameters for these cases.

KenGen has developed an elaborated monitoring procedure along with formats for data measurement, storage and equipment calibration. The monitoring methodology is developed to measure and monitor data for the Project.

All data collected as part of monitoring will be archived electronically and be kept at least for 2 years after the end of the last crediting period. KenGen is ISO 9001 certified for all their plants in Kenya and all measurements will be conducted with calibrated measurement equipment according to relevant industry

standards. The Information / Process Flow is as below;

Figure 1: CDM Data Management Procedure flowchart

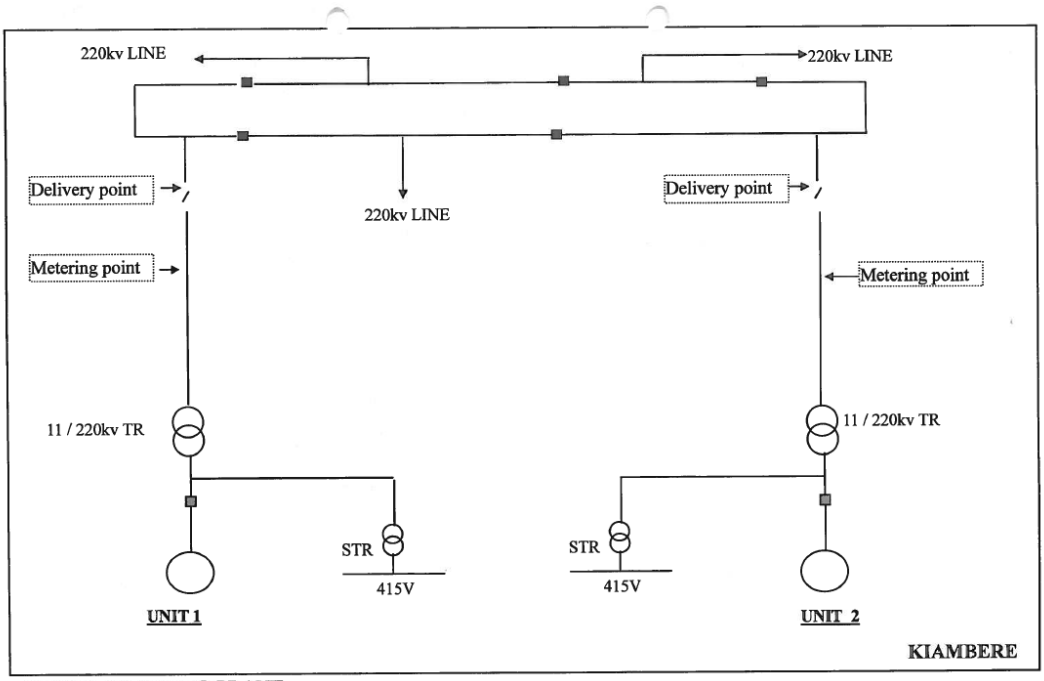


The monitoring system involves the monitoring of the following:

i. Electricity generated and fed into the grid by the proposed CDM project.
ii. Public data on dispatch of electricity by all power units connected to the Kenyan grid and other relevant information from KPLC.

The location of the energy metering points for Kiambere are shown in the diagram below

Figure 2:Single line schematic showing energy metering points for Kiambere power plant



KIAMBERE HYDRO PLANT

NET ENERGY OUTPUT METERING ARRANGEMENT & DELIVERY POINTS

Calibration and Maintenance Procedures

KenGen has established calibration and maintenance procedures. The projects' main monitoring equipment is the energy meters. A Master Calibration Table is devised to record the calibration information for the different equipment (Annex 1).

Monitoring and Data Collection Procedures

The procedures for dispatching, meter testing, reading and correcting inaccuracies are included in the PPA between KenGen and KPLC.

The monitoring occurs as follows:

- The quantity of electricity exported to the grid by the project activity is metered by KenGen and KPLC, and readings of meters are done jointly by them. Readings are double checked by receipts of sales each month. In accordance with the approved methodology, hourly measurement and monthly recording are done. Meters are subject to a regular maintenance regime to ensure accuracy.
- Specific fuel consumption (and hence the amount of fossil fuel consumption) for each thermal power unit in the grid are collected on a yearly basis from the Energy Regulatory Commission
- Net electricity generated and delivered to the grid by each power unit connected to the grid are measured and recorded. Readings of meters are done jointly by KPLC and KenGen, and crosschecked with receipts of sales. Meters are regularly maintained to ensure accuracy.
- CO_2 Combined Margin emission factor of the Kenyan grid are estimated based on KPLC hourly dispatch data, on specific fuel consumption (and hence the amount of fossil fuel consumption) for each thermal power unit in the grid and electricity delivered to grid by each power unit. Accuracy of data reporting by KPLC and KenGen are monitored through consistency in meter readings and sales receipts.

The recording of monitoring data occurs as follows:

- Data is recorded manually by the power plant operators and electronically by the SCADA system.
- Electricity meter readings are recorded hourly from the bulk energy meters onto log sheets and electronic spreadsheets each day. In addition, at the end of each month the total electricity exported

to the grid is calculated in the SCADA system from the first and last meter reading for the month.

- The electricity data is summarized in a monthly report, which is checked and approved by each section's supervisor.

Monitored data required for verification and issuance of CERs is to be kept for two years after the end of the crediting period or the last issuance of CERs, whichever occurs later.

Procedures identified for Calibration of Monitoring equipment and its maintenance

Equipment maintenance procedures are followed by all staff involved in checking and maintaining all on-site meters.

i. KenGen Senior Superintendant and Chief Engineer are responsible for calibration and maintenance of the energy meters, and ensuring that records are retained.

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ii. The monitoring equipment were calibrated as per defined calibration frequency as indicated on the Master calibration table in Annex 1.

Procedures identified for emergencies

Emergency procedures used in case main meter malfunctioning or failure is the back-up metering. The meter shall also be repaired, adjusted or replaced. Details of the procedures are documented in the PPA.

A draft procedure was identified for internal audits of GHG project compliance with operational requirements however no systematic GHG project compliance audit was undertaken, but regular data checks for accuracy were done.

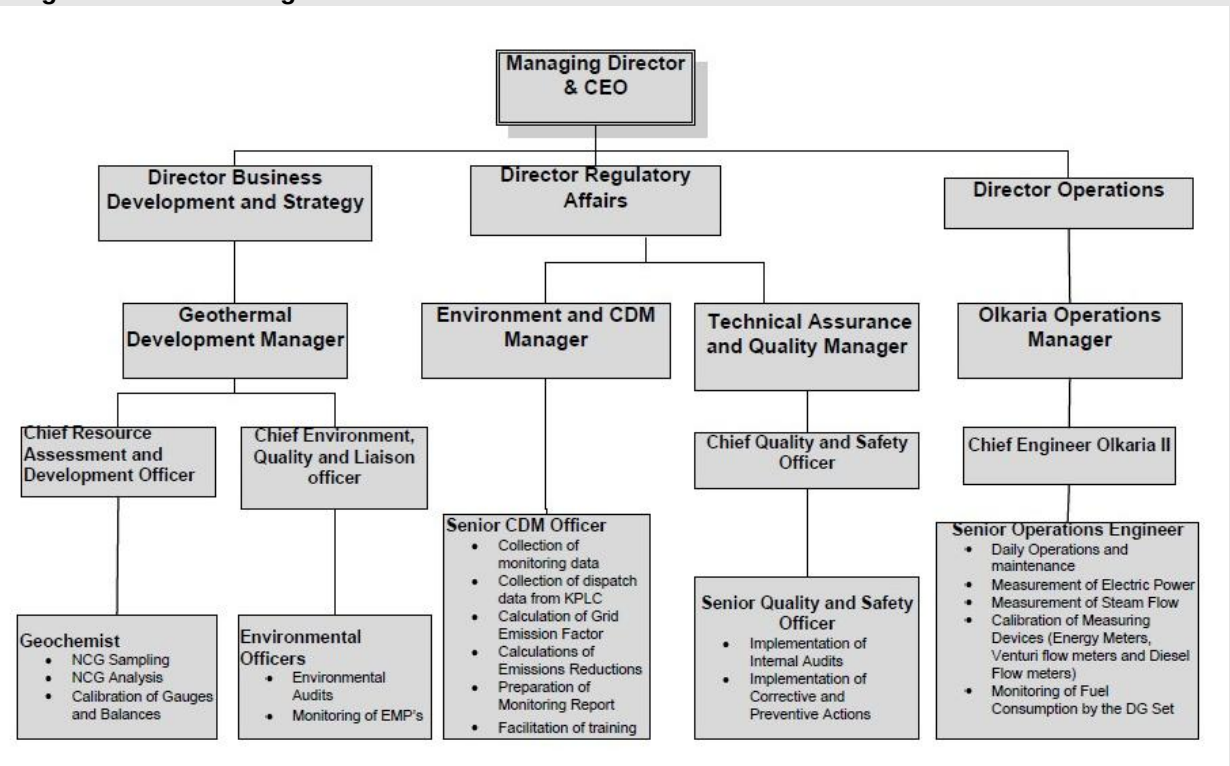
Project training

A formal class room CDM training requirement has not been identified at present as a necessity to power plant operators instead focus was made on providing on-the-job training about CDM data requirements and associated guidance to the operators. However, formal class room type training is planned in the last quarter of the year.

Organizational Structure (KenGen)

The diagram below provides an overview of the general management structure of KenGen as it directly affects the implementation of the proposed CDM project.

Figure 3: KenGen Organizational Structure for CDM



The power plant operators are responsible for recording the daily logs of monitoring parameters. The daily log sheets and monthly reports are checked and signed by the section supervisor to ensure all data has been collated correctly.

Each section supervisor also ensures the maintenance and calibration of measurement equipment as scheduled.

The monthly, daily and quarterly reports are then submitted by each section supervisor to the Chief CDM Officer who prepares the monthly emission reduction calculations. The Chief CDM Officer also prepares the annual and quarterly monitoring reports, which are supervised by the Environment & CDM Manager. The annual monitoring report is archived to make it available for the external audit & verification purposes.

The Environment & CDM Manager ensures implementation of monitoring procedures laid down, and for ensuring that the emission reduction calculations and quarterly and annual monitoring reports are submitted.

Additionally, the specific monitoring and reporting tasks and responsibilities for all project operator staff involved in implementing the Monitoring Plan are documented. The documents are accessible to all persons working on the project.

The following table provides the staff responsibilities for implementing the CDM Project.

Task and Area of Responsibility	*Method Used*	*Frequency*	*Responsible person*
Who operates the monitoring equipment?	Bulk energy meters used for measuring electricity	Half-hourly	Benedict Kagwathi (Chief Engineer)
Who ensures the quality (e.g. calibration responsibilities etc) of the monitoring equipment?	Calibration of energy meters	Every 2 years	Paul Mutuku (Senior Superintendant)
Who collects the required data (emission data, activity data,)?	Data is collected by operators and signed off by responsible persons as indicated in next column	Daily electricity data	James Masinde (Engineer 1)/ Paul Mutuku (Senior Superintendant)
Who calculates the emission reductions and any deviations from projections?	Data is retrieved monthly from the compiled electronic data base. It is then put in the workbook for calculation.	Monthly	Pacifica Achieng (Chief CDM Officer)
Who stores the data (measured calculated, estimated data)?	Electricity data is manually recorded into log sheets which are signed off daily and archived. Data then transferred to electronic database	Half hourly	Paul Mutuku (Senior Superintendant)
	Diesel consumption data logged during use (emergency diesel)	Upon use	Paul Mutuku (Senior Superintendant)
	External data from KPLC is compiled and archived into a database	Weekly	Bianca Gichangi (CDM Officer)
	Copy of workbook with calculated emission reductions and monitoring report archived	Quarterly	Pacifica Ogola (Chief CDM Officer / Bianca Gichangi (CDM Officer)

	All records will be checked for completeness, before data and records are stored and archived electronically		
Who undertakes QA/QC?	To include CDM requirements in the current Internal Audit procedures	Half yearly	James Metto (Senior Quality & Safety Officer)
Who trains staff involved in the monitoring system?	Internal Training	At beginning of monitoring period	Environment and CDM Manager (to be recruited)
Who signs off on monitoring reports and achieved ERs?	Signed off before submission to the World bank according to guidelines and contract	Quarterly	Environment and CDM Manager (to be recruited) Chief CDM Officer signs off

KenGen has designated competent staff who will be in charge of, and accountable for, the generation of ERs – including ERPA supervision, monitoring, record keeping, computation of ERs, audits and verification. In addition, KenGen ensures that internal training is made available to its operational staff, if needed, to enable them to undertake all the required tasks in executing the CDM project.

The monthly reports are then submitted to the CDM Officer who prepares the monthly emission reduction calculations and the quarterly monitoring report. The Environment & CDM Manager is responsible for ensuring that the emission reduction calculations and monitoring report are submitted.

SECTION D. Data and parameters

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

Data / Parameter:	$EG_{historical}$
Unit:	**MWh/yr**
Description:	Annual average historical net electricity generation delivered to the grid by the existing facility that was operated at the project site prior to the implementation of the project activity.
Source of data:	KPLC (Kenya Power and Lighting Company Ltd.) and KenGen.
Value(s) applied:	917,400
Purpose of data:	Calculation of baseline emissions
Additional comment:	Measurement procedures are based on electricity meters

Data / Parameter:	$DATE_{BaselineRetrofit}$
Unit:	Date
Description:	Point in time when the existing equipment would need to be replaced in the absence of the project activity
Source of data:	KenGen
Value(s) applied:	31/12/2022
Purpose of data:	Calculation of baseline emissions
Additional comment:	As per provisions in ACM0002/Version 13.0.0. See Section B.6.1 of the PDD on Calculation of $DATE_{BaselineRetrofit}$ for the existing Kiambere plant

Data / Parameter:	$\sigma_{historical}$
Unit:	MWh/yr

Description:	Standard deviation of the annual average historical net electricity generation delivered to the grid by the existing renewable energy plant that was operated at the project site prior to the implementation of the project activity
Source of data:	Calculated from data used to establish $EG_{historical}$
Value(s) applied):	82,248
Purpose of data:	Calculation of baseline emissions
Additional comment:	

Data / Parameter:	$EF_{CO2,i,y}$ and $EF_{CO2,m,i,y}$
Unit:	tCO_2/TJ
Description:	CO_2 emission factor of fossil fuel type *i* in year *y*
Source of data:	2006 IPCC Guidelines for National Greenhouse Gas Inventories, Chapter 1 of Vol. 2 (Energy), Table 1.4, p.1.23,
Value(s) applied):	Automotive Gas Oil (AGO): 67.5; Diesel:72.6; Fuel Oil:75.5; and Kerosene: 70.8
Purpose of data:	Calculation of baseline emissions
Additional comment:	IPCC default values at the lower limit of the uncertainty at a 95% confidence interval

Data / Parameter:	$NCV_{i,y}$
Unit:	TJ/mass or volume
Description:	Net calorific value (energy content) of fossil fuel type *i* in year *y*
Source of data:	2006 IPCC Guidelines for National Greenhouse Gas Inventories, Chapter 1 of Vol. 2 (Energy), Table 1.2, p.1.18
Value(s) applied):	Automotive Gas Oil (AGO): 42.5; Diesel: 41.4; Fuel Oil: 39.8; and Kerosene: 42.4
Purpose of data:	Calculation of baseline emissions
Additional comment:	IPCC default values at the lower limit of the uncertainty at a 95% confidence interval

Data / Parameter:	$EF_{grid,BM,y}$
Unit:	tCO_2/MWh
Description:	Build Margin CO_2 emission factor in year *y*
Source of data:	KPLC Dispatch Centre and IPCC default factors
Value(s) applied):	0.4665 tCO_2/MWh
Purpose of data:	Calculation of baseline emissions
Additional comment:	Calculated once ex-ante for the crediting period Calculated using the latest version of the "Tool to calculate the emission factor for an electricity system." Version 02.2.1

D.2. Data and parameters monitored

Data / Parameter:	$EG_{facility,y}$
Unit:	MWh/yr

Description:	Quantity of net electricity generation supplied by the project activity to the Kenyan Grid in year *y*
Measured/ Calculated / Default:	Measured
Source of data:	KenGen
Value(s) of monitored parameter:	2012: 181,429 2013: 571,586 Total monitoring period (242 days): **753,015 MWh**
Monitoring equipment:	Electricity is measured using meters that comply with industry standards in the country. Energy Meters (Main and backup/check meters) (see Annex 1) <u>Main Meters:</u> - Model: **AINRTAL** - Serial #: **G003083753** - Main/back-up: **Main 1** - Latest calibration events: **23/06/2011 and 15/3/2013** - Validity period of calibration: **2 years** - Meter accuracy: **class 0.2S** - Model: **AINRTAL** - Serial #: **G003083759** - Main/back-up: **Main 2** - Latest calibration events: **23/06/2011 and 15/3/2013** - Validity period of calibration: **2 years** - Meter accuracy: **class 0.2S** <u>Back-up meters</u> - Model: **AINRTAL** - Serial #: **G003086151** - Main/back-up: **Check 1** - Latest calibration events: **23/06/2011 and 15/3/2013** - Validity period of calibration: **2 years** - Meter accuracy: **class 0.2S** - Model: **AINRTAL** - Serial #: **G003083737** - Main/back-up: **Check 2** - Latest calibration events: **23/06/2011 and 15/3/2013** - Validity period of calibration: **2 years** - Meter accuracy: **class 0.2S** - Where calibration is performed: **on site** The main energy meters were used during the monitoring period and accuracy levels according to the test results were ok. No problems were experienced with the monitoring equipment.
Measuring/ Reading/ Recording frequency:	Measuring: Continuously Reading: Continuously Recording: data is aggregated hourly/monthly and yearly
Calculation method (if applicable):	N/A

QA/QC procedures:	Electricity supplied by the project activity to the grid double checked by receipt of sales. .
Purpose of data:	Calculation of baseline emissions
Additional comment:	

Data / Parameter:	$EF_{grid,OM-DD,y}$
Unit:	tCO_2e/MWh
Description:	Dispatch data analysis Operating Margin CO_2 emission factor
Measured/ Calculated / Default:	Calculated
Source of data:	KPLC Dispatch Centre and IPCC default factors
Value(s) of monitored parameter:	2012: 0.6368 tCO_2e/MWh 2013: 0.6246 tCO_2e/MWh
Monitoring equipment:	N/A
Measuring/ Reading/ Recording frequency:	Yearly
Calculation method (if applicable):	Calculated using the latest version of the "Tool to calculate the emission factor for an electricity system."
QA/QC procedures:	Calculation should be done after KPLC energy balance to ensure data validity.
Purpose of data:	Calculation of baseline emissions
Additional comment:	-

Data / Parameter:	$EG_{n,h}$ and $EG_{m,y}$
Unit:	MWh
Description:	Net electricity generated and delivered to the Kenyan grid by power plant/unit *m* in year *y* or *n* in hour *h*
Measured/ Calculated / Default:	Measured
Source of data:	KenGen and KPLC Dispatch Centre
Value(s) of monitored parameter:	Values are shown in the Grid EF Workbook for 1 November – 31 December 2012 and 1 January – 30 June 2013 for Kiambere using hourly generation data.
Monitoring equipment:	Energy readings from the Dispatch Center
Measuring/ Reading/ Recording frequency:	Measuring: Continuously Reading: Continuously Recording: data is aggregated hourly/monthly and yearly
Calculation method (if applicable):	N/A
QA/QC procedures:	Electricity supplied by the power units to the grid will be double checked by receipt of sales.
Purpose of data:	Calculation of baseline emissions
Additional comment:	

Data / Parameter:	$EG_{PJ,h}$

Unit:	MWh
Description:	Electricity displaced by the project activity in hour *h* in year *y*
Measured/ Calculated / Default:	Electricity displaced by the project activity will be measured every hour and recorded.
Source of data:	KenGen and KPLC Dispatch Centre
Value(s) of monitored parameter:	Values are shown in the Grid EF Workbook for 1 November – 31 December 2012 and 1 January – 30 June 2013 for Kiambere using hourly generation data.
Monitoring equipment:	Electricity is measured using meters that comply with industry standards in the country. Energy Meters (Main and backup/check meters) (see Annex 1) <u>Main Meters:</u> - Model: **AINRTAL** - Serial #: **G003083753** - Main/back-up: **Main 1** - Latest calibration events: **15/3/2013** - Validity period of calibration: **2 years** - Meter accuracy: class **0.2S** - Model: **AINRTAL** - Serial #: **G003083759** - Main/back-up: **Main 2** - Latest calibration events: **15/3/2013** - Validity period of calibration: **2 years** - Meter accuracy: **class 0.2S** <u>Back-up meters</u> - Model: **AINRTAL** - Serial #: **G003086151** - Main/back-up: **Check 1** - Latest calibration events: **15/3/2013** - Validity period of calibration: **2 years** - Meter accuracy: **class 0.2S** - Model: **AINRTAL** - Serial #: **G003083737** - Main/back-up: **Check 2** - Latest calibration events: **15/3/2013** - Validity period of calibration: **2 years** - Meter accuracy: **class 0.2S** - Where calibration is performed: **on site** The main energy meters were used during the monitoring period and accuracy levels according to the test results were ok. No problems were experienced with the monitoring equipment.
Measuring/ Reading/ Recording frequency:	Hourly.
Calculation method (if applicable):	N/A
QA/QC procedures:	

Purpose of data:	Calculation of baseline emissions
Additional comment:	

D.3. Implementation of sampling plan

N/A

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

In accordance with ACM0002: "Consolidated baseline methodology for grid-connected electricity generation from renewable sources" (Version 13.0.0), the baseline emissions are calculated using the methods described in the registered PDD as follows:

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

Where:

BE_y: Baseline emissions (tCO2e/yr)

$EG_{PJ,y}$: Quantity of net electricity generation that is produced and fed into the grid as a result of the implementation of the CDM project activity in year y (MWh/yr)

$EF_{grid,CM,y}$: Combined margin CO2 emission factor for grid-connected power generation in year y (tCO2e/MWh)

Calculation of $EG_{PJ,y}$

$EG_{PJ,y}$ is calculated using the following formula:

$EG_{PJ,v} = EG_{facility,v} - (EG_{historical} + \sigma_{historical})$

Where:

$EG_{facility,y}$: Total electricity generation from existing and added power units supplied to the grid in year y (MWh/yr)

$EG_{historical}$: Annual average historical net electricity generation delivered to the grid by the existing renewable energy plant that was operated at the project site prior to the implementation of the project activity (MWh/yr). This value is fixed ex-ante in the PDD to 917,400 MWh

$\sigma_{historical}$: Standard deviation of the annual average historical net electricity generation delivered to the grid by the existing renewable energy plant that was operated at the project site prior to the implementation of the project activity (MWh/yr). This value is fixed ex-ante in the PDD to 82,248 MWh

Estimation of the CO_2 emission factor of the Kenyan grid ($EF_{grid,CM,y}$)

Following the guidance specified in the "Tool to calculate the emission factor for an electricity system/ Version 02.2.1", the Combined Margin CO_2 emission factor ($EF_{grid,CM,y}$) of the Kenyan grid is estimated as the weighted average of the Operating Margin (OM) emission factor and Build Margin (BM) emission factor. The weights for calculating the Combined Margin are the default 50% for each of the margins.

The Operating Margin method selected is the Dispatch Data Analysis OM. In terms of vintage of data, Option 1 is selected to estimate the Build Margin *ex-ante*.

The margins calculation is done according to the following steps as indicated in the tools methodology:

Calculation of the Dispatch Data Analysis OM ($EF_{grid,OM-DD,y}$)

$EF_{grid,OM-DD,y}$ is determined based on the grid power units that are actually dispatched at the margin during each hour *h* where the project is displacing grid electricity. The emission factor is calculated as shown below using various equations in the tool.

(10) $EF_{grid,OM-DD,y} = \frac{\sum_h EG_{PJ,h} \cdot EF_{EL,DD,h}}{EG_{PJ,y}}$	Where: ***$EF_{grid,OM-DD,y}$*** Dispatch data analysis operating margin CO_2 emission factor in year *y* (tCO_2/MWh) ***$EG_{PJ,h}$*** Electricity displaced by the project activity in hour *h* of year y (MWh) ***$EF_{EL,DD,h}$*** CO_2 emission factor for grid power units in the top 10% of the dispatch order in hour *h* in year *y* (tCO_2/MWh) ***$EG_{PJ,y}$*** Total electricity displaced by the project activity in year *y* (MWh)
As the hourly fuel consumption data is not available, the hourly emissions factor is calculated based on the energy efficiency of the grid power unit and the fuel type used, as follows: ***(12)*** $EF_{EL,DD,h} = \frac{\sum_n EG_{n,h} \times EF_{EL,n,y}}{\sum_n EG_{n,h}}$	***$EF_{EL,DD,h}$*** CO_2 emission factor for grid power units in the top 10% of the dispatch order in hour *h* in year *y* (tCO_2/MWh) *$EF_{EL,n,y}$* CO2 emission factor of grid power unit n in year y (tCO2/MWh) ***$EG_{n,h}$*** Net electricity generated and delivered to the grid by grid power unit *n* in hour *h* (MWh) ***n*** Grid power units in the top 10% of the dispatch ***h*** Hours in year *y* in which the project activity is displacing grid electricity ***y*** Year in which the project activity is displacing grid electricity
Following the Tool, the $EF_{EL,n,y}$ is calculated using option A1 of the simple OM: ***(2)*** $EF_{EL,m,y} = \frac{\sum_i FC_{i,m,y} \cdot NCV_{i,y} \cdot EF_{CO2,i,y}}{EG_{m,y}}$	EFEL,m,y = CO2 emission factor of power unit m in year y (tCO2/MWh). FCi,m,y = Amount of fossil fuel type i consumed by power unit m in year y (Mass or volume unit);); this is based on the specific fuel consumption (ton/MWh) data available for each power plant. NCVi,y = Net calorific value (energy content) of fossil fuel type i in year y (GJ/mass or volume unit) EFCO2,i,y = CO2 emission factor of fossil fuel type i in year y (tCO2/GJ) EGm,y = Net quantity of electricity generated and delivered to the grid by power unit m in year y (MWh) m = All power units serving the grid in year y except low-cost/must-run power units i = All fossil fuel types combusted in power unit m in year y y = The relevant year as per the data vintage chosen in Step 3

As indicated above, ***n*** refers to the set of power units (*n*) falling within the top 10% of the system dispatch. To determine the set of power units (*n*), obtain from a national dispatch center: a) the grid system dispatch order of operation for each grid power unit of the system including power units from which electricity is imported; and b) the amount of power (MWh) that is dispatched from all grid power units in the system during each hour *h* that the project activity is displacing electricity. At each hour *h*, stack each grid power unit's generation using the merit order. The set of grid power units (*n*) consists of those power units at the top of the stack (i.e., having the least merit), whose combined generation comprises 10% of total generation

from all power units during that hour (including imports to the extent they are dispatched).

For purposes of estimating the dispatch data analysis OM emission factor (***EF*** $_{grid,OM\text{-}DD,y}$), data during the year 2012-2013 will be used. The methodology requires using the year in which the project activity actually displaces grid electricity. The data necessary for calculating the OM is obtained from KPLC, and is calculated in accordance with the above mentioned procedure. The calculated $EF_{grid,\ OM\text{-}DD,\ y}$ for 2012 is 0.6368 tCO $_2$/MWh and that of 2013 is 0.6246 tCO2/MWh.

Calculation of the ex-ante BM ($EF_{grid,BM,y}$)

The Build Margin emission factor is the generation-weighted average emission factor (tCO_2/MWh) of all power units *m* during the most recent year *y* for which power generation data is available, calculated ex-ante and once during the crediting period. As per the registered PDD, the built margin value calculated ex-ante is. 0.4665 tCO2/MWh

Calculation of the Combined Margin emission factor ($EF_{grid,CM,y}$)

(14)	$EF_{grid,CM,y} = EF_{grid,OM,y} \times W_{OM} + EF_{grid,BM,y} \times W_{BM}$	Where: W_{OM} Weighting of operating margin emission factor (%) W_{BM} Weighting of build margin emissions factor (%) The default values of 50%-50% are used for the crediting period.

The combined margin calculated for the Kenya grid in 2012 is 0.5517 tCO2/MWh.

The combined margin calculated for the Kenya grid in 2013 is 0.5455 tCO2/MWh

Accordingly,

BE$_{y\ 2012}$ = 14,821 MWh x 0.5517 tCO_2e/MWh = 8,176 tCO2e
BE$_{y\ 2013}$ = 71,762 MWh x 0.5455 tCO_2e/MWh = 39,146 tCO2e

The tables below provide the monthly totals for the main baseline parameters:

Table 1: Baseline Emissions

Month	EG ($_{PJ,m}$)	BE(m)
	MWh/m	tCO_2e/m
November 2012	10,095	5,569
December 2012	4,726	2,607
January 2013	12,269	6,693
February 2013	3,926	2,142
March 2013	11,504	6,275
April 2013	10,437	5,693
May 2013	18,924	10,323
June 2013	14,702	8,020
Total	**86,583**	**47,322**

Please refer to the ER calculation spread sheet for the monthly electricity supplied to the grid data.

E.2. Calculation of project emissions or actual net GHG removals by sinks

Based on ACM0002/Version 13.0.0, the project emissions (PEy) are equal to zero.

PE$_y$ = 0 tCO_2e

The project activity is a replacement of an existing hydropower plant and does not result in new reservoir or

an increase of existing reservoir.

E.3. Calculation of leakage

In accordance with ACM0002/Version 13.0.0 no leakage emissions are considered for the project activity.

LE_y=0 tCO_2e

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

Emission reductions (ERy) are calculated as follows based on Equation (11):

$$ER_y = BE_y - PE_y$$

Where:

ER_y Emission reductions in year *y* (tCO_2/yr)
BE_y Baseline emissions in year *y* (tCO_2/yr)
PE_y Project emissions in year *y* (tCO_2/yr)

PEy = 0 tCO_2e

Item	Baseline emissions or baseline net GHG removals by sinks (t CO_2e)	Project emissions or actual net GHG removals by sinks (t CO_2e)	Leakage (t CO_2e)	Emission reductions or net anthropogenic GHG removals by sinks (t CO_2e)
Nov 2012	5,569	0	0	5,569
Dec 2012	2,607	0	0	2,607
Jan 2013	6,693	0	0	6,693
Feb 2013	2,142	0	0	2,142
Mar 2013	6,275	0	0	6,275
Apr 2013	5,693	0	0	5,693
May 2013	10,323	0	0	10,323
June 2013	8,020	0	0	8,020
Total	**47,322**	**0**	**0**	**47,322**

E.3. Calculation of leakage

>> No leakage emissions are considered as per the approved methodology (ACM0002/Version 13.0.0).

LE_y=0 tCO_2e

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 ($t CO_2e$)	41,204 tCO_2e/yr (for 365 days) 1 Nov 2012 – 30 June 2013 (242 Days): 41,204 tCO_2e/yr x242/365 = **27,319 tCO_2e**	**47,322** tCO2e

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

The emission reductions achieved during the monitoring period (**47,322 tCO2e)** were higher than the emission reductions estimated in the PDD due to high availability of the generation plant during the monitoring period (**99.7%**) which is higher than the estimated PDD value of 93%.

As such, a small deviation of the electricity generation could represent a high percentage of increase or decrease of the incremental generation when compared with the expected value. If we annualize the electricity generated in the monitored period, the total generation is 1,129GWh, which is only 5% higher than the 1,075 GWh of the PDD.

It is important to mention that given that this is a Rehabilitation Project and that it is just accounting for the incremental generation of the project. As such, a small deviation of the electricity generation could represent a high ***percentage of increase or decrease*** of the incremental generation when compared with the expected value. Considering that project electricity generation depends on plant availability and water availability, any changes to these two parameters affect either the increase or decrease in ER generation. In fact, since the commissioning date of the project, it has been only in the year 2012 and 2013 that the project has generated above the historical values. The previous years it was significantly below, thus generating negative ERs. The table below shows these values:

Yr	Energy (MWh)	% deviation EG from EGhist + std dev + Est. incr. gen	% deviation actual incr. from incr estimated in the PDD	Plant availability (%)	Comments
2009	557,339	-48%	-690%	65	The plant availability and generation was low since unit 1 was being upgraded
2010	820,044	-24%	-340%	97	High availability and less generation mainly due to dispatch and low hydrology
2011	760,795	-29%	-419%	96	High availability and less generation mainly due to dispatch and low hydrology

Considering changes that could happen to electricity generation due to seasonal variations (and hence water availability) and plant availability due to better maintenance practices (as happened during the monitoring period), the incremental electricity generation and hence increase in emission reductions during the monitoring period follows the typical hydro plant operation.

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 CO_2e)	**November - December 2012 8,177 tCO2e**	**January 1 – June 30 2013 39,146 tCO2e**

ANNEX 1: Calibration status of monitoring equipment (Energy Meters) during the monitoring period

The main energy meters were used during the monitoring period and accuracy levels according to the test results were ok. No problems were experienced with the monitoring equipment. Calibration status of the energy meters are summarized below:

Equipment	Meter Serial No.	Meter Type	Manufacturer	Calibration Frequency	Date of last calibration	Date of last calibration	Class /Accuracy	Remarks
Main 1	G003083753	AINRTA	ABB	Biennial	23/06/2011	15/3/2013	0.02S	Meter testing for accuracy according to the PPA Pass
Main 2	G00308375	AINRTA	ABB	Biennial	23/06/2011	15/3/2013	0.02S	Meter testing for accuracy according to the PPA Pass
Check meter 1	G003086151	AINRTA	ABB	Biennial	23/06/2011	15/3/2013	0.2S	Meter testing for accuracy according to the PPA Pass
Check meter 2	G003083737	AINRTA	ABB	Biennial	23/06/2011	15/3/2013	0.2S	Meter testing for accuracy according to the PPA Pass

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Document information

Version	*Date*	*Description*
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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