JCM Proposed Methodology Form

Note: This methodology is drafted as the result of the GEC's JCM Feasibility Study Programme in JFY2013. Therefore, this draft methodology is not officially approved by any governments involved in JCM, and is subject to change in the future.

Cover sheet of the Proposed Methodology Form

Form for submitting the proposed methodology

Host Country	Republic of Kenya
Name of the methodology proponents submitting this form	PricewaterhouseCoopers Co., Ltd.
Sectoral scope(s) to which the Proposed Methodology applies	1. Energy industries (renewable - / non-renewable sources)
Title of the proposed methodology, and version number	Installation of geothermal power plants in Kenya Version 1/0
List of documents to be attached to this form (please check):	☐The attached draft JCM-PDD: ☐Additional information
Date of completion	22/02/2014

History of the proposed methodology

Version	Date	Contents revised
01.0	08/10/2013	First edition
02.0	10/01/2014	Second edition
03.0	22/02/2014	Third edition

A. Title of the methodology

Installation of geothermal power plants in Kenya Version 3/0

B. Terms and definitions

Terms	Definitions
NCG	Non Condensable Gases (NCG) are natural components of geothermal fluids, and they are composed mainly of CO, CO2, H2 and CH4. In geothermal projects, NCG flow with the steam into the power plant. A small proportion of the CO2 is converted to carbonate/bicarbonate in the cooling water circuit.
Net electricity generation	Refers to the difference between the total quantity of electricity generated by the power plant/unit and the auxiliary electricity consumption (also known as parasitic load) of the power plant/unit

C. Summary of the methodology

Items	Summary
GHG emission reduction measures	Geothermal plants supply electricity from project activity to the grid, and reduce GHG emission by avoiding CO_2 emissions from fossil fuel power plans.
Calculation of reference emissions	Reference emissions are calculated on the basis of generation of electricity in fossil fuel power plants, which are displaced due to the project activity.
Calculation of project emissions	Project emissions are calculated on the basis of monitored fossil fuel consumption and emissions from the operation of geothermal power plants due to the release of NCGs.
Monitoring parameters	Generated electricity to the grid, fossil fuel consumption and CO_2 and CH_4 in the produced steam are monitored.

D. Eligibility criteria

This methodology is applicable to projects that satisfy all of the following criteria.

Criterion 1	The project activity is the installation or expansion of a geothermal power plant at Kenya.
Criterion 2	Net electricity generated by the project activity is delivered to Kenyan national grid system

E. Emission Sources and GHG types

Reference emissions	
Emission sources	GHG types
CO_2 emissions from electricity generation in fossil fuel power plants that are displaced due to the project activity	CO_2
Project emissions	
Emission sources	GHG types
Fugitive emissions of CH_4 and CO_2 from NCG contained in geothermal steam	CO_2
	CH_4
CO_2 emissions from combustion of fossil fuels for electricity generation in geothermal power plants	CO_2

F. Establishment and calculation of reference emissions

F.1. Establishment of reference emissions

n JCM project activity, the renewable electricity generated from geothermal source will displace an equivalent amount of electricity currently generated by the grid-connected power plants.
JCM project activity will result in greenhouse gas (GHG) emission reductions by displacing fossil fuel-based electricity generation in the Kenyan grid with clean geothermal power.

F.2. Calculation of reference emissions

Reference emissions include only CO_2 emissions from electricity generation in fossil fuel power plants that are displaced due to the project activity. The methodology assumes that all

project electricity generation above reference levels would have been generated by existing grid-connected power plants and addition of new grid-connected power plants. The reference emissions are to be calculated as follows:

$RE_y = RG_{PJ,y} * RF_{grid,CM,y}$

RE_y Reference emissions in year y [tCO_2/y]

$RG_{PJ,y}$ Quantity of net electricity generation that is produced and fed into the grid as a result of the implementation of the JCM project activity in year y [MWh/y]

$RF_{grid,CM,y}$ Combined margin CO_2 emission factor for grid connected power generation in year y calculated the latest emission factor .

$RF_{grid,CM,y} = RF_{grid,OM,y} * 0.5 + RF_{grid,BM,y} * 0.5$

$RF_{grid,OM,y}$ Operating margin CO_2 emission factor for grid connected power generation in year y calculated the latest emission factor .

$RF_{grid,BM,y}$ Build margin CO_2 emission factor for grid connected power generation in year y calculated the latest emission factor . Operating margin is set by project participants as follows:

A. Grid emission factors published by the Joint Committee
B. Calculation by project participants refer to the latest version of "Tool to Calculate the emission factor or an electricity system" published by the UNFCCC. Taking difficulty of each calculation options into account, project participants can select the option of the "Tool to Calculate the emission factor or an electricity system"

Build Margin is set as an ex-ante. See the "I. Data and parameters fixed ex ante".

G. Calculation of project emissions

For most renewable power generation project activities, $PEy = 0$. However, some project activities may involve project emission that can be significant. These emissions need to be accounted for as project emissions by using the following equation:

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

PE_y Project emissions in year y [tCO_2/y]

$PE_{FF,y}$	Project emissions from fossil fuel consumption in year y [tCO_2/y]
$PE_{GP,y}$	Project emissions from the operation of geothermal power plants due to the release of NCG in year y [tCO_2/y]

$PE_{FF,y} = PFC_{i,y} * NCV_{i,y}$

$PFC_{i,y}$	Project consumption of fossil fuel *i* of the applicable equipment in year y [kl, t, 1000Nm^3/y]
$NCV_{i,y}$	Net calorific value of fossil fuel *i* (diesel, kerosene, natural gas, etc.) in year y [tCO_2/y]

For geothermal projects, which also use fossil fuels for electricity generation, CO_2 emissions from the combustion of fossil fuels must be accounted for as project emissions ($PE_{FF,y}$).

Project participants need to account fugitive emissions of CO_2 and CH_4 due to release of NCG from produced steam. NCG in geothermal reservoirs usually consist mainly of CO_2 and H_2S. They also contain a small quantity of hydrocarbons, including predominantly CH_4. In geothermal power project, NCG flow with the steam into the power plant. A small proportion of the CO_2 is converted to carbonate/bicarbonate in the cooling water circuit. In addition, parts of the NCG are reinjected into the geothermal reservoir. However, as a conservative approach, atmosphere via the cooling tower. Fugitive CO_2 and CH_4 emissions due to well testing and well bleeding are not considered, as they are supposed to be almost the same as the amount before testing and they are negligible.

$PE_{GP,y}$ is calculated as follows:

$PE_{GP,y} = (w_{steam,CO2,y} + w_{steam,CH4,y} * GWP_{CH4}) * M_{steam,y}$

$w_{steam,CO2,y}$	Average mass fraction of CO_2 in the produced steam in year y [tCO_2/t steam]
$w_{steam,CH4,y}$	Average mass fraction of CH_4 in the produced steam in year y [tCH_4/t steam]
GWP_{CH4}	Global warming potential of CH_4 valid for the relevant commitment period [tCO_2/tCH_4]
$M_{steam,y}$	Quantity of steam produced in year y [t steam/y]

H. Calculation of emissions reductions

Emission reductions are calculated as follows:

$ER_y = RE_y - PE_y$

ER_y Emission reductions in year y [tCO_2/y]

RE_y Reference emissions in year y [tCO_2/y]

PE_y Project emissions in year y [tCO_2/y]

I. Data and parameters fixed *ex ante*

The source of each data and parameter fixed *ex ante* is listed as below.

Parameter	Description of data	Source
$RF_{grid,BM,y}$	Operating margin CO_2 emission in year y : 0.4488 [tCO_2/MWh]	The value is calculated using the "Tool to calculate the emission factor for an electricity system version 4.0" KPLC UPDATED ENERGY PURCHASED FOR 2012/13 (GWh) , Annual report 2013 and ERC Gazette notice Energy Act No of 12& Kenya Power Document 'Generating Plants-Capacity and Commissioning Dates'
GWP_{CH4}	Global warming potential of methane valid for the project period: 21 [tCO_2/CH_4]	IPCC, Climate Change 2007: Working Group I: The Physical Science Basis
$NCV_{i.y}$	Net calorific value of fossil fuel *i* (diesel, kerosene, natural gas, etc.) in year y [tCO_2/y]	IPCC guideline 2006