

**Draft revision to the approved consolidated baseline methodology ACM0002****Approved consolidated baseline methodology ACM0002  
“Consolidated baseline methodology for  
grid-connected electricity generation from renewable sources”****Sources**

This consolidated baseline methodology is based on elements from the following proposed new methodologies:

NM0001 rev: Vale do Rosario Bagasse Cogeneration (VRBC) project in Brazil whose Baseline study, Monitoring and Verification Plan and Project Design Document were prepared by Econergy International Corporation;

NM0012-rev: Wigton Wind Farm Project in Jamaica whose Baseline study, Monitoring and Verification Plan and Project Design Document were prepared by Ecosecurities ltd;

NM0023: El Gallo Hydroelectric Project, Mexico whose Baseline study, Monitoring and Verification Plan and Project Design Document were prepared by Prototype Carbon Fund (approved by the CDM Executive Board on 14 April 2004);

NM0024-rev: Colombia: Jepirachi Windpower Project whose Baseline study, Monitoring and Verification Plan and Project Design Document were prepared by Prototype Carbon Fund;

NM0030-rev: Haidergarh Bagasse Based Co-generation Power Project in India whose Baseline study, Monitoring and Verification Plan and Project Design Document was submitted by Haidergarh Chini Mills, a unit of Balrampur Chini Mills Limited;

NM0036: Zafarana Wind Power Plant Project in the Arab Republic of Egypt whose Baseline study, Monitoring and Verification Plan and Project Design Document were prepared by Mitsubishi Securities;

NM0043: Bayano Hydroelectric Expansion and Upgrade Project in Panama whose Baseline study, Monitoring and Verification Plan and Project Design Document were prepared by Econergy International Corporation;

NM0055: Darajat Unit III Geothermal Project in Indonesia whose Baseline study, Monitoring and Verification Plan and Project Design Document were prepared by URS Corporation and Amoseas Indonesia Inc.

For more information regarding the proposal and its consideration by the Executive Board please refer to <http://cdm.unfccc.int/methodologies/approved>.

**Applicability**

This methodology is applicable to grid-connected renewable power generation project activities under the following conditions:

- Applies to electricity capacity additions from:
  - Run-of-river hydro power plants; hydro power projects with existing reservoirs where the volume of the reservoir is not increased.
  - Wind sources;
  - Geothermal sources;
  - Solar sources;
  - Wave and tidal sources.



- This methodology is not applicable to project activities that involve switching from fossil fuels to renewable energy at the site of the project activity, since in this case the baseline may be the continued use of fossil fuels at the site;
- The geographic and system boundaries for the relevant electricity grid can be clearly identified and information on the characteristics of the grid is available; and
- Applies to grid connected electricity generation from landfill gas capture to the extent that it is combined with the approved "Consolidated baseline methodology for landfill gas project activities" (ACM0001).

This baseline methodology shall be used in conjunction with the approved monitoring methodology ACM0002 ("Consolidated monitoring methodology for grid-connected electricity generation from renewable sources").

### Project activity

The project activity is grid-connected electricity generation from renewable energy sources. There are a number of different sizes and sub-types of this project activity (Run-of-river hydro power plants; hydro power projects with existing reservoirs where the volume of the reservoir is not increased, wind, geothermal, solar sources, tidal, wave).

### Approach

"Existing actual or historical emissions, as applicable"

or

"Emissions from a technology that represents an economically attractive course of action, taking into account barriers to investment"

### Additionality

*Note: Once approved, the consolidated tools for demonstration of additionality being developed by the Executive Board shall apply. This methodology will therefore only become valid as of the approval by the Board of consolidated tools for demonstration of additionality.*

### Project Boundary

- 1) Project participants shall account only the following **emission sources** for the project activity:
  - For geothermal project activities, fugitive emissions of methane and carbon dioxide from **non-**condensable gases contained in geothermal steam and carbon dioxide emissions from combustion of fossil fuels required to operate the geothermal power plant.

For the baseline determination, project participants shall only account CO<sub>2</sub> emissions from electricity generation in fossil fuel fired power that is displaced due to the project activity.

- 2) The **spatial** extent of the project boundary includes the project site and all power plants connected physically to the electricity system that the CDM project power plant is connected to.



For the purpose of determining the build margin (BM) and operating margin (OM) emission factor, as described below, a (regional) **project electricity system** is defined by the spatial extent of the power plants that can be dispatched without significant transmission constraints. Similarly, a **connected electricity system**, e.g. national or international, is defined as a (regional) electricity system that is connected by transmission lines to the project electricity system and in which power plants can be dispatched without significant transmission constraints. In determining the project electricity system, project participants should justify their assumptions.

Electricity transfers from connected electricity systems to the project electricity system are defined as **electricity imports** and electricity transfers to connected electricity systems are defined as **electricity exports**.

For the purpose of determining the Build Margin (BM) emission factor, as described below, the spatial extent is limited to the project electricity system, except where recent or likely future additions to transmission capacity enable significant increases in imported electricity. In such cases, the transmission capacity may be considered a build margin source, with the emission factor determined as for the OM imports below.

For the purpose of determining the Operating Margin (OM) emission factor, as described below, use one of the following options to determine the CO<sub>2</sub> emission factor(s) for net electricity imports ( $COEF_{i,j,imports}$ ) from a connected electricity system within the same host country(ies):

- (a) 0 tCO<sub>2</sub>/MWh, or
- (b) the emission factor(s) of the specific power plant(s) from which electricity is imported, if and only if the specific plants are clearly known, or
- (c) the average emission rate of the exporting grid, if and only if net imports do not exceed 20% of total generation in the project electricity system, or
- (d) the emission factor of the exporting grid, determined as described in steps 1,2 and 3 below, if net imports exceed 20% of the total generation in the project electricity system.

For imports from connected electricity system located in another country, the emission factor is 0 tons CO<sub>2</sub> per MWh.

Electricity exports should not be subtracted from electricity generation data used for calculating and monitoring the baseline emission rate.

### Baseline

**For project activities that do not modify or retrofit an existing electricity generation facility,<sup>†</sup> the baseline scenario is the following:**

**Electricity delivered to the grid by the project** would have otherwise been generated by the operation of grid-connected power plants and by the addition of new generation sources, **as reflected in the combined margin (CM) calculations described below.**



For project activities that modify or retrofit an existing electricity generation facility, the guidance provided by EB08 shall be taken into account.<sup>1</sup>

For projects activities that modify or retrofit an existing electricity generation facility, **the baseline scenario is the following:**

In the absence of the CDM project activity, the existing facility would continue to provide electricity to the grid ( $EG_{\text{baseline}}$ , in MWh/year) at historical average levels ( $EG_{\text{historical}}$ , in MWh/year), until the time at which the generation facility would be likely be replaced or retrofitted in the absence of the CDM project activity ( $DATE_{\text{BaselineRetrofit}}$ ). From that point of time onwards, the baseline scenario is assumed to correspond to the project activity, and baseline electricity production ( $EG_{\text{baseline}}$ ) is assumed to equal project electricity production ( $EG_y$ , in MWh/year), and no emission reductions are assumed to occur.

$$\begin{aligned} EG_{\text{baseline}} &= EG_{\text{historical}} && \text{until } DATE_{\text{BaselineRetrofit}} \\ & (1) \\ EG_{\text{baseline}} &= EG_y && \text{on/after } DATE_{\text{BaselineRetrofit}} \end{aligned}$$

#### Where

$EG_{\text{historical}}$  is the **straight**-average of historical electricity delivered by the existing facility to the grid, spanning all data from the most recent available year (or month, week or other time period) to the time at which the facility was constructed, retrofit, or modified in a manner that significantly affected output (i.e., by 5% or more), expressed in MWh per year. A minimum of 10 years (120 months) of historical generation data is required in the case of hydro facilities. For other facilities, a minimum of 3 years data is required<sup>2</sup>. In the case that ten years (or three in the case of non hydro project activities) years of historical data (or three years in the case of non hydro project activities) is are not available -- (e.g., due to recent retrofits or exceptional circumstances as described in footnote 2) -- a new methodology or methodology revision ~~has to~~ must be proposed.

#### EG<sub>y</sub>

All project electricity generation above baseline levels ( $EG_{\text{baseline}}$ ) would have otherwise been generated by the operation of grid-connected power plants and by the addition of new generation sources, as reflected in the combined margin (CM) calculations described below.

~~a baseline electricity output must should be obtained. The vintage of historical generation data should include all data from the most recent available year (or month) to the time at which the facility was constructed, retrofit, or modified in a manner that significantly affected output (i.e., by 5% or more). A from historical generation data minimum of 10 years (120 months) of historical generation data is required in the case of hydro facilities.~~

<sup>1</sup> "If a proposed CDM project activity seeks to retrofit or otherwise modify an existing facility, the baseline may refer to the characteristics (i.e. emissions) of the existing facility only to the extent that the project activity does not increase the output or lifetime of the existing facility. For any increase of output or lifetime of the facility which is due to the project activity, a different baseline shall apply." (EB08, Annex 1, <http://cdm.unfccc.int/EB/Meetings/>)

<sup>2</sup> Data for periods affected by unusual circumstances such as natural disasters, conflicts, transmission constraints shall be excluded.



Emission reductions are accounted until the plant or the respective equipment would need to be replaced or respectively retrofitted in the absence of the project activity. From that point of time, a different baseline shall apply. It is assumed that at that point of time the existing plant or equipment would be replaced by a technology with the same or similar performance as the technology installed as part of the project activity. For example, where the project activity involves the replacement of a low pressure boiler by a high pressure boiler, emission reductions are only accounted until the existing low pressure boiler would need to be replaced in the absence of the project activity. As a simplification, it is assumed that the low pressure boiler would at the end of its technical lifetime be replaced by a high pressure boiler with approximately the same efficiency as in the project plant.

In order to estimate the point in time when the existing equipment would need to be replaced in the absence of the project activity (**DATE<sub>BaselineRetrofit</sub>**), project participants may take the following approaches into account:

- (a) The typical average technical lifetime of the type equipment may be determined and documented, taking into account common practices in the sector and country, e.g. based on industry surveys, statistics, technical literature, etc.
- (b) The **common** practices of the responsible company regarding replacement schedules may be evaluated and documented, e.g. based on historical replacement records for similar equipment.

The point in time when the existing equipment would need to be replaced in the absence of the project activity should be chosen in a conservative manner, i.e. **if a range is identified, the earliest date point in time should be chosen in cases where only a time frame can be estimated.**

**A-The baseline** emission factor ( $EF_y$ ) is calculated as a combined margin (CM), consisting of the combination of operating margin (OM) and build margin (BM) factors according to the following three steps. Calculations for this combined margin must be based on data from an official source (where available)<sup>3</sup> and made publicly available.

<sup>3</sup> Plant emission factors used for the calculation of operating and build margin emission factors should be obtained in the following priority:

1. *acquired directly* from the dispatch center or power producers, if available; or
2. *calculated*, if data on fuel type, fuel emission factor, fuel input and power output can be obtained for each plant; if confidential data available from the relevant host Party authority are used the calculation carried out by the project participants shall be verified by the DOE and the CDM-PDD may only show the resultant carbon emission factor and the corresponding list of plants.
3. *calculated*, as above, but using estimates such as:  
default IPCC values from the *IPCC 1996 Revised Guidelines and the IPCC Good Practice Guidance* for net calorific values and carbon emission factors for fuels instead of plant-specific values (note that the *IPCC Good Practice Guidance* includes some updates from the IPCC 1996 Revised Guidelines);  
technology provider's name plate power plant efficiency or the anticipated energy efficiency documented in official sources (instead of calculating it from fuel consumption and power output). This is likely to be a conservative estimate, because under actual operating conditions plants usually have lower efficiencies and higher emissions than name plate performance would imply;  
conservative estimates of power plant efficiencies, based on expert judgments on the basis of the plant's technology, size and commissioning date; or



**STEP 1. Calculate the Operating Margin emission factor(s) ( $EF_{OM,y}$ )** based on one of the four following methods:

- (a) Simple OM, or
- (b) Simple adjusted OM, or
- (c) Dispatch Data Analysis OM, or
- (d) Average OM.

Each method is described below.

Dispatch data analysis should be the first methodological choice. Where this option is not selected project participants shall justify why and may use the simple OM, the simple adjusted OM or the average emission rate method taking into account the provisions outlined hereafter.

The Simple OM method (a) can only be used where low-cost/must run resources<sup>34</sup> constitute less than 50% of total grid generation in: 1) average of the five most recent years, or 2) based on long-term normals for hydroelectricity production.

The average emission rate method (d) can only be used where low-cost/must run resources constitute more than 50% of total grid generation and detailed data to apply option (b) is not available, and where detailed data to apply option (c) above is unavailable.

(a) *Simple OM*. The Simple OM emission factor ( $EF_{OM,simple,y}$ ) is calculated as the generation-weighted average emissions per electricity unit (tCO<sub>2</sub>/MWh) of all generating sources serving the system, not including low-operating cost and must-run power plants:

$$EF_{OM,y} = \frac{\sum_{i,j} F_{i,j,y} \cdot COEF_{i,j}}{\sum_j GEN_{j,y}} \quad (32)$$

where  $F_{i,j,y}$  is the amount of fuel  $i$  (in a mass or volume unit) consumed by relevant power sources  $j$  in year(s)  $y$ ,

$j$  refers to the power sources delivering electricity to the grid, not including low-operating cost and must-run power plants, and including imports<sup>5</sup> to the grid,

$COEF_{i,j,y}$  is the CO<sub>2</sub> emission coefficient of fuel  $i$  (tCO<sub>2</sub> / mass or volume unit of the fuel), taking into account the carbon content of the fuels used by relevant power sources  $j$  and the percent oxidation of the fuel in year(s)  $y$ , and

$GEN_{j,y}$  is the electricity (MWh) delivered to the grid by source  $j$ .

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4. *calculated*, for the simple OM and the average OM, using aggregated generation and fuel consumption data, in cases where more disaggregated data is not available.

<sup>4</sup> Low operating cost and must run resources typically include hydro, geothermal, wind, low-cost biomass, nuclear and solar generation. If coal is obviously used as must-run, it should also be included in this list, i.e. excluded from the set of plants.

<sup>5</sup> As described above, an import from a connected electricity system should be considered as one power source  $j$ .



The CO<sub>2</sub> emission coefficient  $COEF_i$  is obtained as

$$COEF_i = NCV_i \cdot EF_{CO_2,i} \cdot OXID_i \quad (43)$$

where:

$NCV_i$  is the net calorific value (energy content) per mass or volume unit of a fuel  $i$ ,

$OXID_i$  is the oxidation factor of the fuel (see page 1.29 in the 1996 Revised IPCC Guidelines for default values),

$EF_{CO_2,i}$  is the CO<sub>2</sub> emission factor per unit of energy of the fuel  $i$ .

Where available, local values of  $NCV_i$  and  $EF_{CO_2,i}$  should be used. If no such values are available, country-specific values (see e.g. IPCC Good Practice Guidance) are preferable to IPCC world-wide default values.

The Simple OM emission factor can be calculated using either of the two following data vintages for years(s)  $y$ :

A 3-year average, based on the most recent statistics available at the time of PDD submission, or

The year in which project generation occurs, if  $EF_{OM,y}$  is updated based on ex post monitoring.

(b) *Simple Adjusted OM*. This emission factor ( $EF_{OM,simple\ adjusted,y}$ ) is a variation on the previous method, where the power sources (including imports) are separated in low-cost/must-run power sources ( $k$ ) and other power sources ( $j$ ):

$$EF_{OM, simple \_ adjusted, y} = (1 - \lambda_y) \cdot \frac{\sum_{i,j} F_{i,j,y} \cdot COEF_{i,j}}{\sum_j GEN_{j,y}} + \lambda_y \cdot \frac{\sum_{i,k} F_{i,k,y} \cdot COEF_{i,k}}{\sum_k GEN_{k,y}} \quad (54)$$

where  $F_{i,k,y}$ ,  $COEF_{i,k}$  and  $GEN_k$  are analogous to the variables described for the simple OM method above for plants  $k$ ; the years(s)  $y$  can reflect either of the two vintages noted for simple OM above, and

$$\lambda_y = \frac{\text{number of hours per year for which low-cost / must-run sources are on margin}}{8760 \text{ hours per year}} \quad (65)$$

where lambda ( $\lambda_y$ ) should be calculated as follows (see figure below):

Step i) Plot a Load Duration Curve. Collect chronological load data (typically in MW) for each hour of a year, and sort load data from highest to lowest MW level. Plot MW against 8760 hours in the year, in descending order.

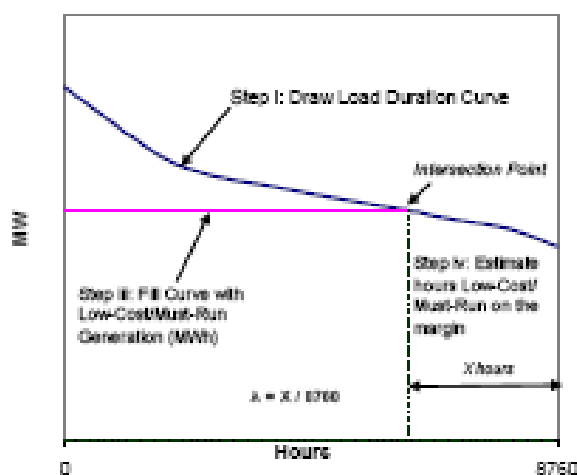
Step ii) Organize Data by Generating Sources. Collect data for, and calculate total annual generation (in MWh) from low-cost/must-run resources (i.e.  $\sum_k GEN_{k,y}$ ).

Step iii) Fill Load Duration Curve. Plot a horizontal line across load duration curve such that the area under the curve (MW times hours) equals the total generation (in MWh) from lowcost/must-run resources (i.e.  $\sum_k GEN_{k,y}$ ).

Step iv) Determine the "Number of hours per year for which low-cost/must-run sources are on the margin". First, locate the intersection of the horizontal line plotted in step (iii) and the load duration curve plotted in step (i). The number of hours (out of the total of 8760 hours) to the right

of the intersection is the number of hours for which low-cost/must-run sources are on the margin. If the lines do not intersect, then one may conclude that lowcost/must-run sources do not appear on the margin and  $\lambda_y$  is equal to zero. Lambda ( $\lambda_y$ ) is the calculated number of hours divided by 8760.

**Figure 1: Illustration of Lambda Calculation for Simple Adjusted OM Method**



Note: Step (ii) is not shown in the figure, it deals with organizing data by source.

(c) *Dispatch Data Analysis OM*. The Dispatch Data OM emission factor ( $EF_{OM,Dispatch Data,y}$ ) is summarized as follows:

$$EF_{OM,DispatchData,y} = \frac{E_{OM,y}}{EG_y} \quad (76)$$

where  $EG_y$  is the generation of the project (in MWh) in year  $y$ , and  $E_{OM,y}$  are the emissions (tCO<sub>2</sub>) associated with the operating margin calculated as

$$E_{OM,y} = \sum_h EG_h \cdot EF_{DD,h} \quad (87)$$

where  $EG_h$  is the generation of the project (in MWh) in each hour  $h$  and  $EF_{DD,h}$  is the hourly generation-weighted average emissions per electricity unit (tCO<sub>2</sub>/MWh) of the set of power plants ( $n$ ) in the top 10% of grid system dispatch order during hour  $h$ :

$$EF_{DD,h} = \frac{\sum_{i,n} F_{i,n,h} \cdot COEF_{i,n}}{\sum_n GEN_{n,h}} \quad (98)$$

where  $F$ ,  $COEF$  and  $GEN$  are analogous to the variables described for the simple OM method above, but calculated on an hourly basis for the set of plants ( $n$ ) falling within the top 10% of the system dispatch. To determine the set of plants ( $n$ ), obtain from a national dispatch center: a) the grid system dispatch order of operation for each power plant of the system; and b) the amount of power (MWh) that is



dispatched from all plants in the system during each hour that the project activity is operating ( $GEN_h$ ). At each hour  $h$ , stack each plant's generation ( $GEN_h$ ) using the merit order. The set of plants ( $n$ ) consists of those plants at the top of the stack (i.e., having the least merit), whose combined generation ( $\sum GEN_h$ ) comprises 10% of total generation from all plants during that hour (including imports to the extent they are dispatched).

(d) *Average OM*. The average Operating Margin (OM) emission factor ( $EF_{OM,average,y}$ ) is calculated as the average emission rate of all power plants, using equation (1) above, but including low-operating cost and must-run power plants. Either of the two data vintages described for the simple OM (a) may be used.

**STEP 2. Calculate the Build Margin emission factor ( $EF_{BM,y}$ )** as the generation-weighted average emission factor (tCO<sub>2</sub>/MWh) of a sample of power plants  $m$ , as follows:

$$EF_{BM,y} = \frac{\sum_{i,m} F_{i,m,y} \cdot COEF_{i,m}}{\sum_m GEN_{m,y}} \quad (49)$$

where  $F_{i,m,y}$ ,  $COEF_{i,m}$  and  $GEN_{m,y}$  are analogous to the variables described for the simple OM method above for plants  $m$ .

Project participants shall choose between one of the following two options:

*Option 1.* Calculate the Build Margin emission factor  $EF_{BM,y}$  *ex-ante* based on the most recent information available on plants already built for sample group  $m$  at the time of PDD submission. The sample group  $m$  consists of either

the five power plants that have been built most recently, or

the power plants capacity additions in the electricity system that comprise 20% of the system generation (in MWh) and that have been built most recently.

Project participants should use from these two options that sample group that comprises the larger annual generation.

*Option 2.* For the first crediting period, the Build Margin emission factor  $EF_{BM,y}$  must be updated annually *ex-post* for the year in which actual project generation and associated emissions reductions occur. For subsequent crediting periods,  $EF_{BM,y}$  should be calculated *ex-ante*, as described in option 1

above. The sample group  $m$  consists of either

the five power plants that have been built most recently, or

the power plants capacity additions in the electricity system that comprise 20% of the system generation (in MWh) and that have been built most recently.

Project participants should use from these two options that sample group that comprises the larger annual generation.

Power plant capacity additions registered as CDM project activities should be excluded from the sample group  $m$ .

**STEP 3. Calculate the baseline emission factor  $EF_y$**  as the weighted average of the Operating Margin emission factor ( $EF_{OM,y}$ ) and the Build Margin emission factor ( $EF_{BM,y}$ ):

$$EF_y = w_{OM} \cdot EF_{OM,y} + w_{BM} \cdot EF_{BM,y} \quad (4+10)$$



where the weights  $w_{OM}$  and  $w_{BM}$ , by default, are 50% (i.e.,  $w_{OM} = w_{BM} = 0.5$ ), and  $EF_{OM,y}$  and  $EF_{BM,y}$  are calculated as described in Steps 1 and 2 above and are expressed in tCO<sub>2</sub>/MWh. Alternative weights can be used, as long as  $w_{OM} + w_{BM} = 1$ , and appropriate evidence justifying the alternative weights is presented. These justifying elements are to be assessed by the Executive Board.<sup>6</sup>

The weighted average applied by project participants should be fixed for a crediting period and may be revised at the renewal of the crediting period.

### Leakage

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, fuel handling (extraction, processing, and transport), and land inundation (for hydroelectric projects – see applicability conditions above). Project participants do not need to consider these emission sources as leakage in applying this methodology. Project activities using this baseline methodology shall not claim any credit for the project on account of reducing these emissions below the level of the baseline scenario.

### Emission Reductions

The project activity mainly reduces carbon dioxide through substitution of grid electricity generation with fossil fuel fired power plants by renewable electricity. The emission reduction  $ER_y$  by the project activity during a given year  $y$  is the difference between baseline emissions ( $BE_y$ ), project emissions ( $PE_y$ ) and emissions due to leakage ( $L_y$ ), as follows:

$$ER_y = BE_y - PE_y - L_y \quad (1211)$$

where the baseline emissions ( $BE_y$  in tCO<sub>2</sub>) are the product of the baseline emissions factor ( $EF_y$  in tCO<sub>2</sub>/MWh) calculated in Step 3, times the electricity supplied by the project activity to the grid ( $EG_y$  in MWh) minus the baseline electricity ~~output~~ **output supplied to the grid in the case of modified or retrofit projects facilities ( $EG_{baseline}$  in MWh)**,<sup>7</sup> as follows:

$$BE_y = EG_y - EF_y$$

$$BE_y = (EG_y - EG_{baseline}) \cdot EF_y \quad (1212)$$

For most renewable energy project activities,  $PE_y = 0$ . However, for geothermal project activities, project participants shall account the following emission sources<sup>7</sup>, where applicable:

Fugitive emissions of carbon dioxide and methane due to release of non-condensable gases from produced steam; and

<sup>6</sup> More analysis on other possible weightings may be necessary and this methodology could be revised based on this analysis. There might be a need to propose different weightings for different situations.

<sup>7</sup> Fugitive carbon dioxide and methane emissions due to well testing and well bleeding are not considered as they are negligible.



Carbon dioxide emissions resulting from combustion of fossil fuels related to the operation of the geothermal power plant.

The data to be collected are listed in the associated monitoring methodology, AM00XX. Project emissions should be calculated as follows<sup>8</sup>:

- a) **Fugitive carbon dioxide and methane emissions due to release of non-condensable gases from the produced steam ( $PES_y$ ):**

$$PES_y = (w_{Main,CO_2} + w_{Main,CH_4} \cdot GWP_{CH_4}) \cdot M_{S,y} \quad (+13)$$

where  $PES_y$  are the project emissions due to release of carbon dioxide and methane from the produced steam during the year  $y$ ,  $w_{Main,CO_2}$  and  $w_{Main,CH_4}$  are the average mass fractions of carbon dioxide and methane in the produced steam,  $GWP_{CH_4}$  is the global warming potential of methane and  $M_{S,y}$  is the quantity of steam produced during the year  $y$ .

- b) **Carbon dioxide emissions from fossil fuel combustion ( $PEFF_y$ )**

$$PEFF_y = \sum F_{i,y} \cdot COEF_i \quad (+12)$$

where  $PEFF_y$  are the project emissions from combustion of fossil fuels related to the operation of the geothermal power plant in tons of  $CO_2$ ,  $F_{i,y}$  is the fuel consumption of fuel type  $i$  during the year  $y$  and  $COEF_i$  is the  $CO_2$  emission factor coefficient of the fuel type  $i$ .

Thus, for geothermal project activities,

$$PE_y = PES_y + PEFF_y \quad (+15)$$

### Estimation of Emissions Reductions Prior to Validation

Project participants should prepare as part of the PDD an estimate of likely project emission reductions for the proposed crediting period. This estimate should, in principle, employ the same methodology as selected above (i.e. OM option 1a, 1b, 1c or 1d). Where the emission factor ( $EF_y$ ) is determined *ex-post* during monitoring, project participants may use models or other tools to estimate the emission reductions prior to validation.

<sup>8</sup> In the case of retrofit projects at geothermal plants, this methodology does not currently subtract baseline emissions from steam components or fossil fuel combustion. Project proponents are welcome to propose new methodologies or methodology revisions to address these baseline emissions.

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### Monitoring Methodology

The methodology requires monitoring of the following:

- Electricity generation from the proposed project activity;
- Data needed to recalculate the operating margin emission factor, if needed, based on the choice of the method to determine the operating margin (OM), consistent with "Consolidated baseline methodology for grid-connected electricity generation from renewable sources" (ACM0002);
- Data needed to recalculate the build margin emission factor, if needed, consistent with "Consolidated baseline methodology for grid-connected electricity generation from renewable sources" (ACM0002);
- For geothermal power projects, data needed to calculate fugitive carbon dioxide and methane emissions and carbon dioxide emissions from combustion of fossil fuels required to operate the geothermal power plant.

### Project boundary

1) Consistent with the "Consolidated baseline methodology for grid-connected electricity generation from renewable sources" (ACM0002) the project boundary includes the following emissions sources:

- For geothermal project activities, fugitive emissions of methane and carbon dioxide from noncondensable gases contained in geothermal steam and carbon dioxide emissions from combustion of fossil fuels required to operate the geothermal power plant.

For the baseline determination, project participants shall only account CO<sub>2</sub> emissions from electricity generation in fossil fuel fired power that is displaced due to the project activity.

2) The **spatial extent** of the project boundary includes the project site and all power plants connected physically to the electricity system that the CDM project power plant is connected to.



**Baseline Emission Parameters**

The 6th column indicates which monitoring elements are required depending on which method is used to determine the operating margin (OM) in step 1 of the “Consolidated baseline methodology for grid-connected electricity generation from renewable sources” (ACM0002) “Simple OM” is defined in step 1a; “Simple Adjusted OM” in 1b; “Dispatch Data OM” in 1c; and “Average OM” in step 1d. Items required for “BM” are for the Build Margin defined in step 2. Note that for the “Simple OM”, “Simple Adjusted OM” and the “Average OM” as well as the “BM, where project participants choose, consistent with “Consolidated baseline methodology for grid-connected electricity generation from renewable sources” (ACM0002), a data vintage based on ex ante monitoring, at least E<sub>Gy</sub> shall be monitored, and all parameters will be required to recalculate the combined margin at any renewal of a crediting period, using steps 1-3 in the baseline methodology.

ID number	Data type	Data variable	Data unit	Measured (m) calculated (c) estimated (e)	For which baseline method(s) must this element be included	Recording frequency	Proportion of data monitored	How will data be archived? (electronic/ paper)	For how long is archived data kept?	Comment
1. E <sub>Gy</sub> (E <sub>Gh</sub> if dispatch data OM is used)	Electricity quantity	Electricity supplied to the grid by the project	MWh	Directly measured	Simple OM Simple Adjusted OM Dispatch Data OM Average OM BM	hourly measurement and monthly recording	100%	electronic	During the crediting period and two years after	Electricity supplied by the project activity to the grid. Double check by receipt of sales.
1b. E <sub>G</sub> <sup>historical</sup> (retrofit projects only)	Electricity quantity	Annual electricity supplied to grid prior to retrofit	GWh	c	Simple OM Simple Adjusted OM Dispatch Data OM Average OM BM	once	100%	Electronic/ paper	During the crediting period and two years after	As defined in the baseline methodology
2. E <sub>Fy</sub>	Emission factor	CO <sub>2</sub> emission factor of the grid	tCO <sub>2</sub> /MWh	c	Simple OM Simple Adjusted OM Dispatch Data OM Average OM BM	yearly	100%	electronic	During the crediting period and two years after	Calculated as a weighted sum of the OM and BM emission factors
3. E <sub>FOM,y</sub>	Emission	CO <sub>2</sub>	tCO <sub>2</sub> /	c	Simple OM	yearly	100%	electronic	During the	Calculated as



ID number	Data type	Data variable	Data unit	Measured (m) calculated (c) estimated (e)	For which baseline method(s) must this element be included	Recording frequency	Proportion of data monitored	How will data be archived? (electronic/ paper)	For how long is archived data kept?	Comment
	factor	Operating Margin emission factor of the grid	MWh		Simple Adjusted OM Dispatch Data OM Average OM				crediting period and two years after	indicated in the relevant OM baseline method above
4. $EF_{BM,y}$	Emission factor	CO <sub>2</sub> Build Margin emission factor of the grid	tCO <sub>2</sub> / MWh	c	BM	yearly	100%	electronic	During the crediting period and two years after	Calculated as $[\sum_i F_{i,y} * COEF_i] / [\sum_m GEN_{m,y}]$ over recently built power plants defined in the baseline methodology
5. $F_{i,y}$	Fuel quantity	Amount of each fossil fuel consumed by each power source / plant	Mass or volume	m	Simple OM Simple Adjusted OM Dispatch Data OM Average OM BM	yearly	100%	electronic	During the crediting period and two years after	Obtained from the power producers, dispatch centers or latest local statistics.
6. $COEF_i$	Emission factor coefficient	CO <sub>2</sub> emission coefficient of each fuel type i	tCO <sub>2</sub> / mass or volume unit	m	Simple OM Simple Adjusted OM Dispatch Data OM Average OM BM	yearly	100%	electronic	During the crediting period and two years after	Plant or country-specific values to calculate COEF are preferred to IPCC default values.
7. $GEN_{j/k/n,y}$	Electricity quantity	Electricity generation of each power source / plant	MWh/ha	m	Simple OM Simple Adjusted OM Dispatch Data OM Average OM	yearly	100%	electronic	During the crediting period and two years after	Obtained from the power producers, dispatch centers or latest local statistics.



ID number	Data type	Data variable	Data unit	Measured (m) calculated (c) estimated (e)	For which baseline method(s) must this element be included	Recording frequency	Proportion of data monitored	How will data be archived? (electronic/ paper)	For how long is archived data kept?	Comment
		j, k or n			BM				after	
8.	Plant name	Identification of power source / plant for the OM	Text	e	Simple OM Simple Adjusted OM Dispatch Data OM Average OM	yearly	100% of set of plants	electronic	During the crediting period and two years after	Identification of plants (j, k, or n) to calculate Operating Margin emission factors
9.	Plant name	Identification of power source / plant for the BM	Text	e	BM	yearly	100% of set of plants	electronic	During the crediting period and two years after	Identification of plants (m) to calculate Build Margin emission factors
10. $\lambda_y$	Parameter	Fraction of time during which low-cost/must-run sources are on the margin	Number	c	Simple Adjusted OM	yearly	100%	electronic	During the crediting period and two years after	Factor accounting for number of hours per year during which low-cost/must-run sources are on the margin
11.	Merit order	The merit order in which power plants are dispatched by documented evidence	Text	m	Dispatch Data OM	yearly	100%	paper for original documents, else electronic	During the crediting period and two years after	Required to stack the plants in the dispatch data analysis.





ID number	Data type	Data variable	Data unit	Measured (m) calculated (c) estimated (e)	For which baseline method(s) must this element be included	Recording frequency	Proportion of data monitored	How will data be archived? (electronic/ paper)	For how long is archived data kept?	Comment
11a. GEN <sub>i/k/1,y</sub> IMPORTS	Electricity quantity	Electricity imports to the project electricity system	kWh	c	Simple OM Simple Adjusted OM Dispatch Data OM Average OM BM	yearly	100%	electronic	During the crediting period and two years after	Obtained from the latest local statistics. If local statistics are not available, IEA statistics are used to determine imports.
11b. COEF <sub>i,i,y</sub> IMPORTS	Emission factor coefficient	CO <sub>2</sub> emission coefficient of fuels used in connected electricity systems (if imports occur)	tCO <sub>2</sub> / mass or volume unit	c	Simple OM Simple Adjusted OM Dispatch Data OM Average OM BM	yearly	100%	electronic	During the crediting period and two years after	Obtained from the latest local statistics. If local statistics are not available, IPCC default values are used to calculate.

*Project emissions (for geothermal projects)*

ID number	Data type	Data variable	Data unit	Measured (m), calculated (c) or estimated (e)	Recording frequency	Proportion of data to be monitored	How will the data be archived? (electronic/ paper)	For how long is archived data kept?	Comment
12. M <sub>S,y</sub>	Mass quantity	Quantity of steam produced during the year	t	m	daily	100%	electronic	During the crediting period and two years after	See note 1



ID number	Data type	Data variable	Data unit	Measured (m), calculated (c) or estimated (e)	Recording frequency	Proportion of data to be monitored	How will the data be archived? (electronic/paper)	For how long is archived data kept?	Comment
		y							
13. W <sub>Main,CO<sub>2</sub></sub> <sub>2</sub>	Mass fraction	Fraction of CO <sub>2</sub> in produced steam	tCO <sub>2</sub> / t steam	m	every 4 months	100%	electronic	During the crediting period and two years after	See note 2
14. W <sub>Main,CH<sub>4</sub></sub> <sub>4</sub>	Mass fraction	Fraction of CH <sub>4</sub> in produced steam	tCH <sub>4</sub> / t steam	m	every 4 months	100%	electronic	During the crediting period and two years after	See note 2
15. M <sub>ty</sub>	Mass quantity	Quantity of steam generated during well testing	t	m	daily	100%	electronic	During the crediting period and two years after	See note 1
16. W <sub>t,CO<sub>2</sub></sub>	Mass fraction	Fraction of CO <sub>2</sub> in steam during well testing	tCO <sub>2</sub> / t steam	m	as required	100%	electronic	During the crediting period and two years after	See note 2
17. W <sub>t,CH<sub>4</sub></sub>	Mass fraction	Fraction of CH <sub>4</sub> in steam during well testing	tCH <sub>4</sub> / t steam	m	as required	100%	electronic	During the crediting period and two years after	See note 2
18. F <sub>iy</sub>	Fuel quantities	Amount of fossil fuels used for the operation of the geothermal	Mass or volume	m	monthly	100%	electronic	During the crediting period and two years after	



ID number	Data type	Data variable	Data unit	Measured (m), calculated (c) or estimated (e)	Recording frequency	Proportion of data to be monitored	How will the data be archived? (electronic/paper)	For how long is archived data kept?	Comment
19. COEF <sub>i</sub>	Emission factors coefficient	CO <sub>2</sub> emission coefficients of fossil fuels types i used for the operation of the geothermal plant	tCO <sub>2</sub> / mass or volume unit	m	as required	100%	electronic	During the crediting period and two years after	Plant or country-specific values to calculate COEF are preferred to IPCC default values.

*[The following variables are used only for the baseline, not monitoring—can we exclude them here?—Otherwise, we need to rename variable 20 and/or blend with 1.]*

ID-number	Data type	Data variable	Data-unit	Measured (m) calculated (c) estimated (e)	For which baseline method(s) must this element be included	Recording frequency	Proportion of data monitored	How will data be archived? (electronic/paper)	For how long is archived data kept?	Comment
20 EG, EG <sub>historical</sub>	Electricity quantity	Annual electricity supplied to grid prior to retrofit projects	GWh	m	Simple-OM Simple-Adjusted-OM Dispatch-Data-OM Average-OM BM	annual once	100%	Electronic paper	During the crediting period and two years after validation time-comprising	



									at least a 10-year period prior to project activities	
21. $EG_{baseline}$	Electricity quantity	Baseline annual energy	GWh	e	$\frac{e}{h}$	once		Electronic	At validation time	
22. PUF/UUF	Coefficient	Planned and Unplanned Unavailability factors:	%	m	Simple-OM Simple Adjusted OM Dispatch Data-OM Average OM—BM	annual	100%	Electronic	At validation time	Comprises unavailability factor due to planned outages (PUF), and due to all other reasons (UUF)

**Note 1: Flow rates****1a. Steam flow rate, power plant**

The steam quantity discharged from the geothermal wells should be measured with a venture flow meter (or other equipment with at least the same accuracy). Measurement of temperature and pressure upstream of the venture meter is required to define the steam properties. The calculation of steam quantities should be conducted on a continuous basis and should be based on international standards. The measurement results should be summarized transparently in regular production reports.

**Note 2: Non-condensable gases in geothermal steam**

Non-condensable gases (NCGs) in geothermal reservoirs usually consist mainly of CO<sub>2</sub> and H<sub>2</sub>S. They also contain a small quantity of hydrocarbons, including predominantly CH<sub>4</sub>. In geothermal power projects, NCGs flow with the steam into the power plant. A small proportion of the CO<sub>2</sub> is converted to carbonate / bicarbonate in the cooling water circuit. In addition, parts of the NCGs are reinjected into the geothermal reservoir. However, as a conservative approach, this methodology assumes that all NCGs entering the power plant are discharged to atmosphere via the cooling tower.

NCG sampling should be carried out in production wells and at the steam field-power plant interface using ASTM Standard Practice E1675 for Sampling 2-Phase Geothermal Fluid for Purposes of Chemical Analysis (as applicable to sampling single phase steam only). The CO<sub>2</sub> and CH<sub>4</sub> sampling and analysis procedure consists of collecting NCG samples from the main steam line with glass flasks, filled with sodium hydroxide solution and additional chemicals to prevent oxidation. Hydrogen sulphide (H<sub>2</sub>S) and carbon dioxide (CO<sub>2</sub>) dissolve in the solvent while the residual compounds remain in their gaseous phase. The gas portion is then analyzed using gas chromatography to determine the content of the residuals including CH<sub>4</sub>. All alkanes concentrations are reported in terms of methane. The NCG sampling and analysis should be performed at least every three months and more frequently, if necessary.

***Quality Control (QC) and Quality Assurance (QA) Procedures***

All variables, except one related to off-site transportation, used to calculate project and baseline emissions are directly measured or are publicly available official data. To ensure the quality of the data, in particular those that are measured, the data are double-checked against commercial data. The quality control and quality assurance measures planned for the Project are outlined in the following table.

Data	Uncertainty Level of Data (High/Medium/Low)	Are QA/QC procedures planned for these data?	Outline explanation how QA/QC procedures are planned
1.	Low	Yes	These data will be directly used for calculation of emission reductions. Sales record to the grid and other records are used to ensure the consistency.
Others	Low	Yes	Default data (for emission factors) and IEA statistics (for energy data) are used to check the local data.

**Baseline Data**

For default emission factors, IPCC 1996 Guidelines on GHG Inventory (The Revised 1996 IPCC Guidelines for National Greenhouse Gas Inventories, IPCC) and Good Practice Guidance Report (Good Practice Guidance and Uncertainty Management in National Greenhouse Gas Inventories, IPCC) are to be referred not only for their default values but also for their monitoring methodology as well as uncertainty management to ensure data credibility. These documents are downloadable from <http://www.ipccnggip.iges.or.jp/>. The latter document is a new supplementary document of the former.

## 1996 Guidelines:

- Vol. 2, Module 1 (Energy) for methodology,
- Vol. 3, Module 1 (Energy) for application (including default values)

## 2000 Good Practice Guidance on GHG Inventory and Uncertainty Management

- Chapter 2: Energy
- Chapter 6: Uncertainty

## IEA (Yearly Statistics)

- CO<sub>2</sub> Emissions from Fuel Combustion
- Energy Statistics of Non-OECD Countries