

**Draft revision to the 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: Jeparachi 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/PAmethodologies/approved.html>.

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.



- New hydro electric power projects with reservoirs having power densities (installed power generation capacity divided by the surface area at full reservoir level) greater than 4 W/m².¹
- 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

The additionality of the project activity shall be demonstrated and assessed using the latest version of the "Tool for the demonstration and assessment of additionality" agreed by the CDM Executive Board, which is available on the UNFCCC CDM web site².

Project Boundary

¹ The adoption of this guidance does not prevent project participants to submit new methodologies for hydroelectric projects, by the Meth Panel, in particular where reservoirs have no significant vegetative biomass in the catchments area.

² Please refer to: <<http://cdm.unfccc.int/methodologies/PAmethodologies/approved.html>>



- 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 new hydroelectric projects with reservoirs, the project boundary includes the physical site of the plant as well as the reservoir area.

For the baseline determination, project participants shall only account CO₂ 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.

Where the application of this methodology does not result in a clear grid boundary, given country-specific variations in grid management policies:

(a) Use the delineation of grid boundaries as provided by the DNA of the host country if available; or

(b) Use, Where DNA guidance is not available, the following definition of boundary:

- In large countries with layered dispatch systems (e.g. state/provincial/regional/national) the regional grid definition should be used. A state/provincial grid definition may indeed in many cases be too narrow given significant electricity trade among states/provinces that might be affected, directly or indirectly, by a CDM project activity;
- In other countries, the national (or other largest) grid definition should be used by default.

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 CO₂ emission factor(s) for net electricity imports ($COEF_{i,j,imports}$) from a connected electricity system within the same host country(ies):

- (a) 0 tCO₂/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 CO₂ 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, 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 baseline scenario is the following:

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

$$\begin{array}{ll}
 EG_{baseline} = EG_{historical} & \text{until } DATE_{BaselineRetrofit} \\
 EG_{baseline} = EG_y & \text{on/after } DATE_{BaselineRetrofit}
 \end{array}
 \tag{1}$$

Where $EG_{historical}$ is the 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 5 years (120 months) (excluding abnormal years) of historical generation data is required in the case of hydro facilities. For other facilities, a minimum of 3 years data is required³. In the case that 5 years of historical data (or three years in the case of non hydro project activities) are not available -- e.g., due to recent retrofits or exceptional circumstances as described in footnote 2 -- a new methodology or methodology revision must be proposed.

³ Data for periods affected by unusual circumstances such as natural disasters, conflicts, transmission constraints shall be excluded.



All project electricity generation above baseline levels (EG_{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.

In order to estimate the point in time when the existing equipment would need to be replaced in the absence of the project activity ($DATE_{\text{BaselineRetrofit}}$), 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 should be chosen.

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)⁴ and made publicly available.

Power plant capacity additions registered as CDM project activities should be excluded from all calculations below (subsets j , m , n below).

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

- (a) Simple OM, or

⁴ 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
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.

- (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 resources⁵ 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.

The Simple OM, simple-adjusted OM, and average OM emission factors can be calculated using either of the two following data vintages for years(s) y :

- (*ex-ante*) the full generation-weighted average for the most recent 3 years for which data are available at the time of PDD submission, if or,
- the year in which project generation occurs, if $EF_{OM,y}$ is updated based on *ex-post* monitoring.

The choice between *ex-ante* and *ex-post* vintage should be specified in the PDD, and cannot be changed during the crediting period.

(a) *Simple OM*. The Simple OM emission factor ($EF_{OM,simple,y}$) is calculated as the generation-weighted average emissions per electricity unit (tCO₂/MWh) of all generating sources serving the system, not including low-operating cost and must-run power plants:

$$EF_{OM,y} = \frac{\sum_{i,j} F_{i,j,y} \cdot COEF_{i,j}}{\sum_j GEN_{j,y}} \quad (2)$$

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 imports⁶ to the grid,

$COEF_{i,j,y}$ is the CO₂ emission coefficient of fuel i (tCO₂ / 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 .

The CO₂ emission coefficient $COEF_i$ is obtained as

⁵ 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.

⁶ As described above, an import from a connected electricity system should be considered as one power source j .

$$COEF_i = NCV_i \cdot EF_{CO_2,i} \cdot OXID_i \quad (3)$$

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 CO₂ 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.

(b) *Simple Adjusted OM*. This emission factor ($EF_{OM, simple \text{ adjusted}, y}$) 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):

$$EF_{OM, simple \text{ adjusted}, y} = (1 - \lambda_y) \cdot \frac{\sum_{i,j} F_{i,j,y} \cdot COEF_{i,j}}{\sum_j GEN_{j,y}} + \lambda_y \cdot \frac{\sum_{i,k} F_{i,k,y} \cdot COEF_{i,k}}{\sum_k GEN_{k,y}} \quad (4)$$

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

$$\lambda_y = \frac{\text{number of hours per year for which low - cost / must - run sources are on margin}}{8760 \text{ hours per year}} \quad (5)$$

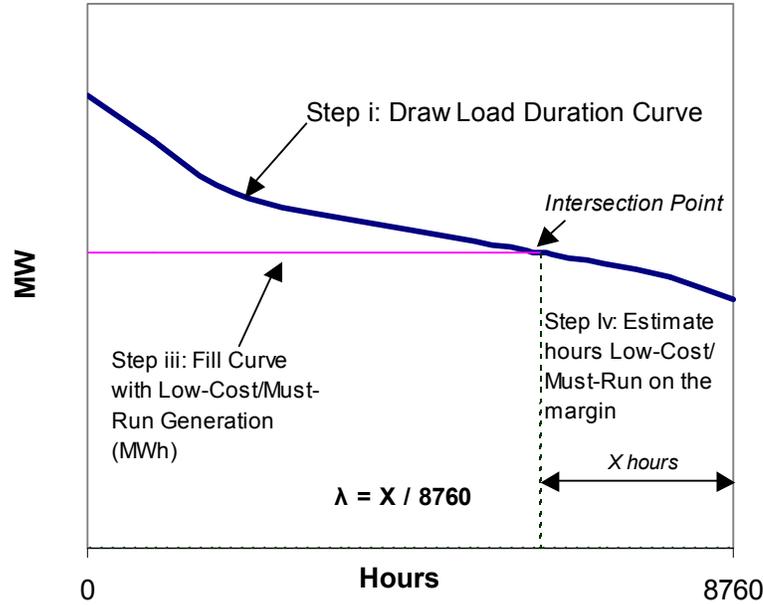
where lambda (λ_y) should be calculated as follows (see figure below):

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 λ_y is equal to zero. Lambda (λ_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:

$$EF_{OM,Dispatch\ Data,y} = \frac{E_{OM,y}}{EG_y} \quad (6)$$

where EG_y is the generation of the project (in MWh) in year y , and $E_{OM,y}$ are the emissions (tCO₂) associated with the operating margin calculated as

$$E_{OM,y} = \sum_h EG_h \cdot EF_{DD,h} \quad (7)$$

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 (tCO₂/MWh) of the set of power plants (n) in the top 10% of grid system dispatch order during hour h :

$$EF_{DD,h} = \frac{\sum_{i,n} F_{i,n,h} \cdot COEF_{i,n}}{\sum_n GEN_{n,h}} \quad (8)$$



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.

STEP 2. Calculate the Build Margin emission factor ($EF_{BM,y}$) as the generation-weighted average emission factor (tCO₂/MWh) of a sample of power plants m , as follows:

$$EF_{BM,y} = \frac{\sum_{i,m} F_{i,m,y} \cdot COEF_{i,m}}{\sum_m GEN_{m,y}} \quad (9)$$

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. **The choice among the two options should be specified in the PDD, and cannot be changed during the crediting period.**

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 plant capacity additions in the electricity system that comprise 20% of the system generation (in MWh) and that have been built most recently.⁷ 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 plant capacity additions in the electricity system that comprise 20% of the system generation (in MWh) and that have been built most recently.⁸ Project participants should use from these two options that sample group that comprises the larger annual generation.

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 ($EF_{BM,y}$):

⁷ If 20% falls on part capacity of a plant, that plant is fully included in the calculation.

⁸ If 20% falls on part capacity of a plant, that plant is fully included in the calculation.



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

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 tCO₂/MWh.

For wind and solar projects, the default weights are as follows: $w_{OM} = 0.75$ and $w_{BM} = 0.25$ (owing to their intermittent and non-dispatchable nature).

Alternative weights can be used, as long as $w_{OM} + w_{BM} = 1$, and the guidance provided below is followed. Justification should be provided to, and will be assessed by, the Executive Board.

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.

Guidance on selecting alternative weights

The following guidance provides a number of project-specific and context-specific factors for developing alternative operating and build margin weights to the above defaults. It does not, however, provide specific algorithms to translate these factors into quantified weights, nor does it address all factors that might conceivably affect these weights. In this case, project participants are suggested to propose specific quantification methods with justifications that are consistent with the guidance provided below. Given that it is unlikely that a project will impact either the OM or BM exclusively during the first crediting period, it is suggested that neither weight exceed 75% during the first crediting period.



Factor	Summary – Impact on weights	Further Explanation
Project size (absolute or relative to the grid size of the system or the size of other system capacity additions)	No change in weight on basis of absolute or relative size alone	Alternative weights on the basis of absolute or relative project size <i>alone</i> do not appear to be justified. See paper prepared by Mr. Bruce Biewald for further discussion and explanation. ⁹
Timing of project output	Can increase OM weight for highly off-peak projects; increase BM for highly on-peak projects.	Projects with output is mainly off-peak can have a greater OM weight (e.g. solar PV projects in evening peak regions, seasonal biomass generation during off-peak seasons), whereas projects with disproportionately high output during on-peak periods (e.g. air conditioning efficiency projects in some grids) can have greater BM weight.
Predictability of project output	Can increase OM for intermittent resources in some contexts.	Projects with output of an intermittent nature (e.g. wind or solar projects) may have limited capacity value, depending on the nature of the (wind/solar) resource and the grid in question, and to the extent that a project's capacity value is lower than that of a typical grid resource its BM weight can be reduced. Potential adjustments to the OM/BM margin should take into account available methods (in technical literature) for estimating capacity value. ⁱ
Suppressed demand	Can increase BM weight for the 1 st crediting period.	Under conditions of suppressed demand that are expected to persist through over half of the first crediting period across a significant number of hours per year, available power plants are likely to be operated fully regardless of the CDM project, and thus the OM weight can be reduced. ⁱⁱ
For system management (nature of local electricity markets, planning, and actors) and other considerations no guidance is available at present.		

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.

⁹ Please refer to <http://cdm.unfccc.int/Panels/meth/Meth17_repan12_BiewaldPaperOMBMMargins.pdf>.



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:

$$ER_y = BE_y - PE_y - L_y \quad (11)$$

where the baseline emissions (BE_y in tCO₂) are the product of the baseline emissions factor (EF_y in tCO₂/MWh) calculated in Step 3, times the electricity supplied by the project activity to the grid (EG_y in MWh) minus the baseline electricity supplied to the grid in the case of modified or retrofit facilities ($EG_{baseline}$ in MWh), as follows:

$$BE_y = (EG_y - EG_{baseline}) \cdot EF_y \quad (12)$$

For most renewable energy project activities, $PE_y = 0$. However, for following categories of projects, project emissions needs to be estimated:

(I) Geothermal project activities, project participants shall account the following emission sources¹⁰, where applicable:

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

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, ACM0002. Project emissions should be calculated as follows¹¹:

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 ($PEFF_y$)**

¹⁰ Fugitive carbon dioxide and methane emissions due to well testing and well bleeding are not considered as they are negligible.

¹¹ 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.



$$PEFF_y = \sum F_{i,y} \cdot COEF_i \quad (14)$$

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,

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

(II) New Hydro electric power projects with reservoirs, project proponents shall account for project emissions, estimated as follows:

- a) if the power density of project is greater than $4W/m^2$ and less than or equal to $10W/m^2$:

$$PE_y = \frac{EF_{Res} * EG_y}{1000} \quad (15b)$$

where,

PE_y	Emission from reservoir expressed as $tCO_2e/year$
ES_{Res}	is the default emission factor for emissions from reservoirs, and the default value as per EB23 is $90 Kg CO_2e /MWh$.
EG_y	Electricity produced by the hydro electric power project in year y , in MWh

- b) If power density of the project is greater than $10W/m^2$

$$PE_y = 0.$$

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.

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

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.
 - New hydro electric power projects with reservoirs having power densities (installed power generation capacity divided by the surface area at full reservoir level) greater than 4 W/m².¹²

¹² The adoption of this guidance does not prevent project participants to submit new methodologies for hydroelectric projects, by the Meth Panel, in particular where reservoirs have no significant vegetative biomass in the catchments area.



- 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).

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.
- For new hydro electric power projects, the surface area of reservoir at the full reservoir level.

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 new hydroelectric projects with reservoirs, the project boundary includes the physical site of the plant as well as the reservoir area.

For the baseline determination, project participants shall only account CO₂ 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_{Gy} 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 _{Gy} (E _{Gh} 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 _{Ghistorical} (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 _{Fy}	Emission factor	CO ₂ emission factor of the grid	tCO ₂ /MWh	c	Simple OM Simple Adjusted OM	Yearly	100%	Electronic	During the crediting period and	Calculated as a weighted sum of the OM and BM emission



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
					Dispatch Data OM Average OM BM				two years after	factors
3. EF _{OM,y}	Emission factor	CO ₂ Operating Margin emission factor of the grid	tCO ₂ /MWh	c	Simple OM Simple Adjusted OM Dispatch Data OM Average OM	Yearly	100%	Electronic	During the crediting period and two years after	Calculated as indicated in the relevant OM baseline method above
4. EF _{BM,y}	Emission factor	CO ₂ Build Margin emission factor of the grid	tCO ₂ /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	CO ₂ emission coefficient of	tCO ₂ /mass	m	Simple OM Simple Adjusted	Yearly	100%	Electronic	During the crediting	Plant or country-specific values to



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
	coefficient	each fuel type i	or volume unit		OM Dispatch Data OM Average OM BM				period and two years after	calculate COEF are preferred to IPCC default values.
7. GEN _{j/k/n,,y}	Electricity quantity	Electricity generation of each power source / plant j, k or n	MWh/a	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.
8.	Area	surface area at full reservoir level	m ²	m	For new hydro electric projects	At start of the project	100%	Electronic	During the Crediting Period.	
9.	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
10.	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



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
11. λ_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
12.	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.
12a. $GEN_{j/k/l/y}$ 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.



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
12b. COEF _{ijy} IMPORTS	<i>Emission factor coefficient</i>	CO ₂ emission coefficient of fuels used in connected electricity systems (if imports occur)	tCO ₂ /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
13. $M_{S,y}$	Mass quantity	Quantity of steam produced during the year y	t	m	daily	100%	Electronic	During the crediting period and two years after	See note 1
14. W_{Main,CO_2}	Mass fraction	Fraction of CO_2 in produced steam	t CO_2 / t steam	m	every 4 months	100%	Electronic	During the crediting period and two years after	See note 2
15. W_{Main,CH_4}	Mass fraction	Fraction of CH_4 in produced steam	t CH_4 / t steam	m	Every 4 months	100%	Electronic	During the crediting period and two years after	See note 2
16. $M_{t,y}$	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
17. w_{t,CO_2}	Mass fraction	Fraction of CO_2 in steam during well testing	t CO_2 / t steam	m	As required	100%	Electronic	During the crediting period and two years after	See note 2



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
18. w_{t,CH_4}	Mass fraction	Fraction of CO ₂ in steam during well testing	tCH ₄ / t steam	m	As required	100%	Electronic	During the crediting period and two years after	See note 2
19. $F_{i,y}$	Fuel quantities	Amount of fossil fuels used for the operation of the geothermal plant	Mass or volume	m	Monthly	100%	Electronic	During the crediting period and two years after	
20. COEF _i	Emission factors coefficient	CO ₂ emission coefficients of fossil fuels types i used for the operation of the geothermal plant	tCO ₂ / 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.

**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 CO₂ and H₂S. They also contain a small quantity of hydrocarbons, including predominantly CH₄. In geothermal power projects, NCGs flow with the steam into the power plant. A small proportion of the CO₂ 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 CO₂ and CH₄ 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 (H₂S) and carbon dioxide (CO₂) 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 CH₄. 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)

- CO₂ Emissions from Fuel Combustion
- Energy Statistics of Non-OECD Countries

ⁱ Capacity value refers to the impact of a capacity addition on the capacity requirements of a grid system, often expressed as fraction of contribution to meeting peak demands relative to a conventional, dispatchable capacity addition or to a theoretical perfectly reliable one. Capacity value is dependent on both the characteristics of the project and the characteristics (and other power plants) of the grid system in question. Capacity value is typically expressed in terms of relative MW, whereas, for estimating emissions, we are concerned solely with MWh; thus, capacity value cannot be used directly as a BM/OM weight. Analyses of capacity value for intermittent resources can be found in a number of reports and in journals such as *Energy Policy* and the *Electricity Journal*.

ⁱⁱ In other words, if, consistent with paragraph 46 of the CDM modalities and procedures, one assumes that electricity could otherwise be supplied to meet suppressed demand, this electricity would need to be provided by the construction and operation of new power plants, which is embodied in the build margin. In some cases, the reason for suppressed demand may be the inability to operate existing power plants, due, for example, to lack of spare parts or lack of availability or ability to pay for fuel. In such circumstances, the baseline scenario could represent the operation of these power plants, in which case the baseline emission factor should reflect their characteristics. This situation would likely require a new methodology.