Revision to the approved baseline methodology AM0026

"Methodology for zero-emissions grid-connected electricity generation from renewable sources in Chile or in countries with merit order based dispatch grid"

Sources

This baseline methodology is based on elements from the NM0076-rev: "Methodology for zero-emissions grid-connected electricity generation from renewable sources in Chile", whose Baseline study, Monitoring and Verification Plan and Project Design Document were prepared by Prototype Carbon Fund (PCF), World Bank and Hidroelectrica Guardia Vieja, Chile.

For more information regarding the proposals and their consideration by the Executive Board please refer to <http://cdm.unfccc.int/methodologies/PAmethodologies/approved.html>. This methodology also refers to the latest approved versions of the "Tool to calculate the emission factor for an electricity system" and the "Tool for the demonstration and assessment of additionality"[1].

Selected approach from paragraph 48 of the CDM modalities and procedures

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

Applicability

The methodology is applicable to proposed electricity capacity additions that meet the following conditions:

1) Projects that are renewable electricity generation projects of the following types:
   (a) Run-of-river hydro power plants and hydro electric power projects with existing reservoirs where the volume of the reservoir is not increased;
   (b) New hydro electric power projects with reservoirs having power densities (installed power generation capacity divided by the surface area at the full reservoir level) greater than 4 W/m^2.[2]
   (c) Wind sources;
   (d) Solar sources;
   (e) Geothermal sources;
   (f) Wave and tidal sources.
2) Projects that are connected to the interconnected grids of the Republic of Chile and Projects that fulfils all the legal obligations under the Chilean Electricity Regulation; or

   Proposed projects implemented in countries other than Chile provided the country has a regulatory framework for electricity generation and dispatch that meets the following conditions:
   (a) An identifiable independent identity is responsible for optimal operation of the system based on the principle of lowest marginal costs.

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

[2] The adoption of this guidance does not prevent project participants from submiting new methodologies for hydroelectric projects, for consideration by the Meth Panel, in particular where reservoirs have no significant vegetative biomass in the catchments area.

(b) The data for merit order based on marginal costs is publicly made available by the authority responsible for operation of the system.
(c) The data on specific fuel consumption for each generation source in the system is publicly available.
(d) It is possible with the information available, to ensure that power plants dispatched for other considerations (e.g. safety conditions, grid stability, transmission constraints, and other electrical reasons) are not identified as marginal plants.

The methodology is not applicable to:
1) The proposed CDM project activities that involve switching from fossil fuels to renewable energy at the site of the project activity, and
2) if the baseline is the continued use of fossil fuels at the site.

This baseline methodology shall be used in conjunction with the approved monitoring methodology AM0026 (Monitoring methodology for zero-emissions grid-connected electricity generation from renewable sources in Chile or in countries with merit order based dispatch grid).

Baseline scenario

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:
1) 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 (EGy , in MWh/year), and no emission reductions are assumed to occur.

$$EG_{baseline} = EG_{historical} \text{ until } DATE_{BaselineRetrofit} \quad \textbf{(1)}$$
$$EG_{baseline} = EG_{y} \text{ on/after } DATE_{BaselineRetrofit}$$

2) 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 required[3]. 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

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

exceptional circumstances as described in footnote to the last sentence - a new methodology or methodology revision must be proposed.

3) 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.
4) In order to estimate the point in time when the existing equipment would need to be replaced in the absence of the project activity ($DATE_{BaselineRetrofit}$), 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.

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, available at the UNFCCC CDM web site*[4]*.*

Project participants who opt to use step 2 of the tool (investment analysis) can alternatively use the following approach for this step, provided that they use the optimization model used by the electricity regulatory authority to identify the capacity expansion plan:

To demonstrate the additionality of the proposed CDM project, the project proponents shall undertake the following steps:

(i) Run the optimization model where only the power plants identified in the expansion plan are included to estimate the net present cost of energy supply.
(ii) Run the optimization model where the proposed CDM project activity too is included in the expansion plan to estimate the net present cost of energy supply.
(iii) The proposed CDM project activity is additional only if the net present cost of the energy supply estimate in step (ii) above is greater than that estimated in step (i) above.

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.

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

- 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 CO_2 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 to which 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 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 emission factor, as described below, use one of the following options to determine the CO_2 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_2/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 baseline section 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_2 per MWh, or 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.

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

Any future amendments to "Project Boundary" definition in the "Tool to calculate the emission factor for an electricity system" should be considered as applicable to the present methodology, unless stated otherwise.

Emission Reduction

The project activity mainly reduces CO_2 emissions through substitution of power generation supplied by the existing generation sources connected to the grid and likely future additions to the grid. The emission reduction (ER_y) by the project activity during year y is the difference between the baseline emissions (BE_y), project emissions (PE_y) and emissions due to leakage (L_y), and can be expressed as follows:

$$ER_y = BE_y - PE_y - L_y \quad \textbf{(2)}$$

where:

ER_y	are the emissions reductions of the project activity during the year y in tons of CO_2,
BE_y	are the baseline emissions due to displacement of electricity during the year y in tons of CO_2,
PE_y	are the project emissions during the year y in tons of CO_2, and
L_y	are the leakage emissions during the year y in tons of CO_2.

In determining emission coefficients, emission factors or net calorific values in this methodology, guidance by the 2000 IPCC Good Practice Guidance should be followed where appropriate. Project participants may either conduct regular measurements or they may use accurate and reliable local or national data where available. Where such data is not available, IPCC default emission factors (country-specific, if available) may be used if they are deemed to reasonably represent local circumstances. All values should be chosen in a conservative manner and the choice should be justified.

Project Emissions

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

(I) Geothermal project activities, project participants shall account the following emission sources[5], where applicable:

(a) Fugitive emissions of carbon dioxide and methane due to release of non-condensable gases from produced steam; and
(b) 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:

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

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

$$PES_y = (w_{CO2} + w_{CH4} x GWP_{CH4}) x M_{S,y}$$ **(3)**

where:

PESy are the project emissions due to release of carbon dioxide and methane from the produced steam during the year y, expressed as tCO_2.

$w_{,CO2}$, $w_{,CH4}$ are the average mass fractions of carbon dioxide and methane in the produced steam, expressed as tCO_2/ton of steam.

GWP_{CH4} is the global warming potential of methane, and

$M_{S,y}$ is the quantity of steam produced during the year y, expressed in ton of steam.

b. Carbon dioxide emissions from fossil fuel combustion (PEFFy)

$$PEFF_y = \sum_i F_{i,y} * COEF_i$$ **(4)**

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, expressed as mass or volume untis, and

$COEF_i$ is the CO_2 emission factor coefficient of the fuel type i, expressed as tCO_2/mass or volume unit, and estimated as follows:

$$COEF_i = NCV_i * CEF_i * Oxid_i$$

where:

NCV_i Net Calorific Value of fuel i used in geothermal plant, expressed as TJ/ mass or volume unit.

$CEF_{i,}$ is the carbon emission factor of I, expressed tCO_2/TJ

$Oxid_i$ is the fraction of carbon in fuel i oxidized during combustion.

Thus for geothermal project activities,

$$PE_y = PES_y + PEFF_y$$ **(5)**

(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 $10W/m^2$:

$$PE_y = \frac{EF_{Res} * EG_y}{1000}$$

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 perEB23 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 $10W/m^2$

$PE_y = 0$.

Baseline

For project activities where the baseline scenario is that: electricity would be generated by the operation of the existing and likely future grid-connected power plants,the baseline emissions for year y are calculated as follows:

$$BE_y = EF_y * Generation_y \quad \textbf{(6)}$$

where:

EF_y Baseline emission factor, in tCO_2/MWh
$Generation_y$ Electricity generated by the proposed CDM Project in year y (in MWh).

A baseline emission factor (EFy) is calculated as a combined margin (CM) emission factor, consisting of the combination of operating margin (OM) and build margin (BM) emission factors according to the following steps.

$$EF_y = w_{OM} * EF_{OM,y} + w_{BM} * EF_{BM} \quad \textbf{(7)}$$

where:

$EF_{OM,y}$ Emission factor for operating margin power generation sources, in tCO_2/MWh
w_{OM} Weight for operating margin emission factor.
EF_{BM} Emission factor for build margin power generation sources, in tCO_2/MWh
w_{BM} Weight for build margin emission factor.

The methodology determines the w_{BM} by using the "Tool to calculate the emission factor for an electricity system" weighting method where the weights w_{OM} and w_{BM}, by default, are 50% (i.e., $w_{OM} = w_{BM} = 0.5$). 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. These default values will be amended as and when the "Tool to calculate the emission factor for an electricity system" weighting method is amended by the Executive Board.

(A) Operating Margin Emission Factor ($EF_{OM,y}$)

Operating margin emission factor is calculated from the dispatch data obtained from the dispatch center, as follows:

$$EF_{OM,y} = \frac{\sum_{h=1}^{8760} EF_{j,h} x Generation_{j,h}}{\sum_{i=1}^{8760} Generation_{j,h}} \qquad (8)$$

where:

$EF_{j,h}$	Operating margin Emission factor for proposed CDM project actvity 'j' for hour 'h', in tCO_2/MWh
$Generation_{j,h}$	Generation of proposed CDM project 'j' during hour 'h', in MWh

The emission factor for the proposed CDM project 'j', in a system with N CDM project activities, for a hour 'h' is based on identification of the marginal plant(s) that would be operated to meet the electricity supplied by the proposed CDM project 'j'. The identification of marginal plant(s) displaced by proposed CDM project 'j' is based on "first-built first served" principle.[6] "Date of built" is defined as the date when the plant begins the dispatch of energy to the grid.

The emission factor for any hour 'h' for a CDM project 'j' in the system is estimated as the weighted average of the emission factor of the identified marginal plant(s) that would have supplied electricity to the grid in absence of the jth CDM plant. The emission factor is estimated as follows:

$$EF_{j,h} = \sum_{i=1}^{M} D(j,i) * d_i \ / \sum D(j,i) \qquad (9)$$

where:

D(j,i)	Energy displacement of the marginal plant 'i' due to the proposed CDM project 'j', in MWh
d_i	Emission factor of the marginal plant 'i', in tCO_2/MWh.
M	M is the total number of marginal plants that would be dispatched if the system is operated without the N CDM projects. M is such that:

$$\sum_{j=1}^{N} C_j \leq \sum_{i=1}^{M} (A_i - B_i) \qquad (10)$$

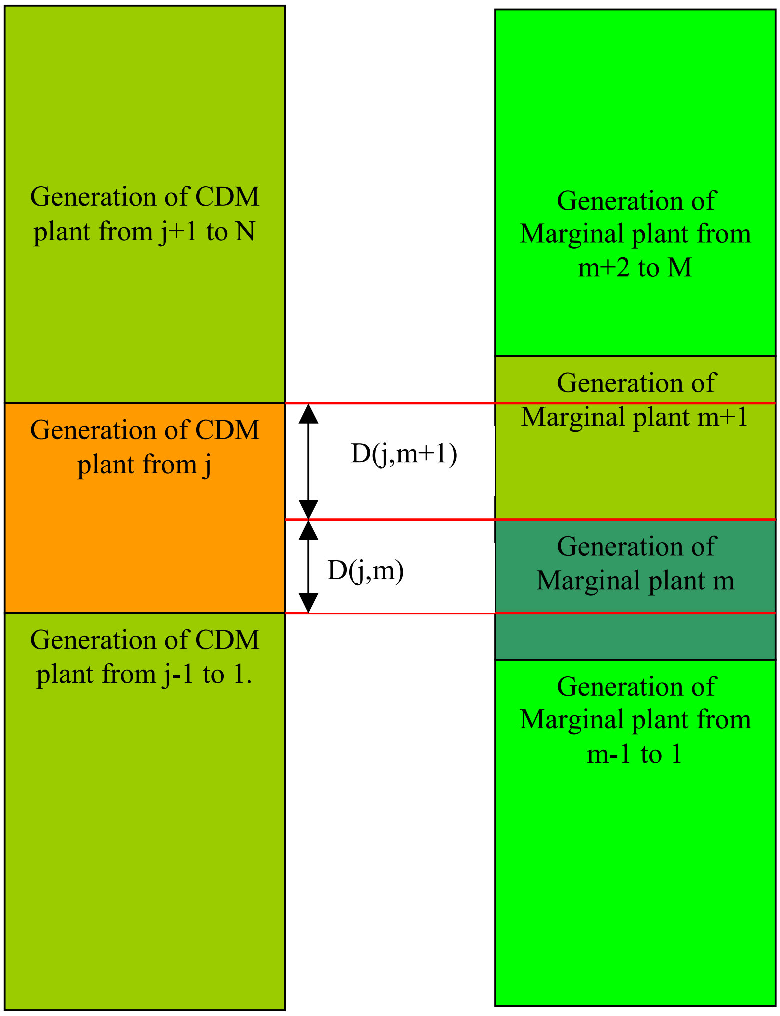
where:

[6] The "first-built first-served" principle implies that the "last" plant, existing in the grid, that would have been dispatched to meet the electricity requirement fulfilled by all the CDM projects in the grid is considered to be displaced due to introduction of the First CDM project built in the system. Similarly the first marginal plant is considered to be displaced by the CDM plant built last. Note that all CDM projects (even projects adopting other methodologies) must be considered.

C_j	Energy generation of CDM project j in MWh/h = $Generation_{j,h}$
N	Total number of CDM projects in the system, where N is the CDM project built first and 1 is the last CDM project built in the system
A_i	Maximum energy generation of the marginal plant 'i' in MWh/h (equivalent to the actual plant capacity in MW)
B_i	Actual energy generation of the marginal plant 'i' in MWh/h

The difference ($A_i - B_i$) represents the maximum possible additional electric energy that can be supplied by the ith marginal plant.

The first step in estimating the D is to identify the M marginal plants that will be required to meet the demand in the system in absence of all the N CDM projects as per Equation 9. The process of estimating D for jth CDM is explained in Figure below. Order the cumulative generation from the N CDM projects in the order of first CDM project (Nth) introduced into the system to the most recent CDM plant introduced in the system (1). Next order the cumulative net generation of marginal plants from the M marginal plant to the 1st on the list of marginal project. Identify the marginal plants that meet the requirement of the (j+1)th to N CDM plants. As per the Figure (m+2)th to M marginal plant plus some portion of (m+1) marginal plant meets the generation from (j+1)th to N CDM plants. Therefore, as shown in the Figure, the supply from the jth CDM plant displaces supply from (m-1)th marginal plant. If the surplus from the (m+1)th marginal plant, after meeting the supply from (j+1)th to N CDM plants, is not sufficient to meet the generation from the jth CDM project, check the generation available from the next in line marginal plant, i.e., mth marginal plant. As shown in Figure , the generation from jth CDM plant that can't be met by (m+1)th marginal plant is met by the mth marginal plant. The Figure shows the D(j,m+1) and D(j,m). Rest of the D( ) are zero for the jth CDM project.



As shown in Figure above not all the M marginal plants are affected by the jth CDM plant. The conditions below define the marginal plants that will not be displaced due to the jth CDM project.

(i) D(j,i) = 0 for all i < m, s.t $\sum_{i=1}^{m}(A_i - B_i) > \sum_{k=j+1}^{N} C_k$

(ii) D(j,i) = 0 for all i > m*, s.t $\sum_{i=1}^{m^*}(A_i - B_i) > \sum_{k=j+1}^{N} C_k + C_j$

Condition (i) states that cumulative maximum possible electricity supply from first (m-1) marginal plants will at the most meet the electricity supply to the system from CDM plants added prior to the jth CDM plant. 'k' in condition (i) represents group of CDM plants that were added to the system prior to the jth CDM plant. Condition (ii) states that marginal plants m^* to M are not affected by the jth CDM plant. Cumulative maximum possible electricity supply of the first m^* marginal plants is sufficient to meet the electricity supplied from j to N CDM plants in the system. CDM plant 'j' displaces electricity from one or more than one marginal plants depending on whether surplus of maximum possible electricity supply from a particular marginal plant 'i', after meeting the requirements of CDM plants added prior to the jth CDM plant, is sufficient to meet the generation from the jth CDM plant. The formulae below gives the quantity of electricity from ith marginal plant displaced by jth CDM plant.

$$D(j,i) = \mathrm{Min}\{C_j - \sum_{l=1}^{i-1} D(j,l); (A_i - B_i) - \sum_{k=j+1}^{N} D(k,i)\} \quad \textbf{(11)}$$

where:

'k' represents group of CDM plants that were built before the 'j' CDM plant.

D(j,0) = 0 & D(N+1, i) = 0. [NOTE: These two are redundant conditions as 'i' can not take a value of 0 and 'j' can't take value of N+1.]

and, "i" takes values between 'm' and 'm^*'.

The first term in Equation (10) represents electricity generation by the jth CDM plant over and above that could met by marginal plant on the dispatch list prior to the ith marginal plant, if any. The second term in Equation (10) is surplus electricity from ith marginal plant, after meeting the requirement of all the 'k' CDM plants added to the system prior to the jth CDM plant. If the first term is zero, it implies marginal plants upto (i-1)th marginal plant can supply the electricity generated by the jth CDM plant. If the second term is zero it implies that ith marginal plant has no surplus electricity to meet the generation from the jth CDM plant and, hence, all marginal plants from '1 to i' are not displaced by the jth CDM plant.

d_i, the emission factor for displaced marginal plant, is estimated as follows:

$$d_i = SFC_i * CEF_{OM,i} * Oxid_i \quad \textbf{(12)}$$

where:

SFC_i	Is the specific fuel consumption of ith marginal power plant, expressed as (ton of fuel or TJ)/MWh.
$CEF_{OM,i,}$	is the CO_2 emission factor of fuel used in ith marginal power plant, expressed as tCO_2/ (ton of fuel or TJ)
$Oxid_i$	Is fraction of carbon in fuel, used in ith marginal plant, oxidized during combustion.

The marginal plant(s) are those power plant listed in the top of the grid system dispatch order during hour 'h' needed to meet the electricity demand at the hour "h" without the generation of CDM project(s). If no thermal power plants are needed to meet the demand without the CDM projects, then the emission factor of the marginal plant is zero.

The data to identify the merit order of marginal plants and energy generation of marginal and CDM plants should be sourced from the information publicly made available by the dispatch center. Data for specific fuel consumption of plants included in marginal cohort should be sourced from published data of electricity regulatory authority (in case host country is Chile, it should be sourced from Node Price Reports published by CNE). In determining emission coefficients, emission factors or net calorific values in this methodology, guidance by the 2000 IPCC Good Practice Guidance should be followed where appropriate. Project participants may either conduct regular measurements or they may use accurate and reliable local or national data where available. Where such data is not available, IPCC default emission factors (country-specific, if available) may be used if they are deemed to reasonably represent local circumstances. All values should be chosen in a conservative manner and the choice should be justified.

Project proponents shall report ex-ante estimation of EF_{OM} in the CDM-PDD. For verifications purposes the project proponents shall estimate ex-post value of EF_{OM} for each year of credit period based on data for that year.

(B) Build Margin emission factor (EF_{BM})

Project proponents shall use either of the two options to estimate EF_{BM}

(i) Build margin emission factor estimation process described in "Tool to calculate the emission factor for an electricity system" (ex-post); or

(ii) The electricity generation options identified by the least cost expansion plan developed by the electricity regulatory authority.

For option (ii) above, EF_{BM} is calculated as follows:

$$EF_{BM} = \frac{\sum_{i=1}^{L} EF_{BM,i} * Gen_{BM,i}}{\sum_{i=1}^{L} Gen_{BM,i}} \quad \textbf{(13)}$$

L	Group of electricity generation plants included in the expansion plan for the next 10 years. All the power plants, included in the expansion plan, where construction has already been initiated are excluded from the build margin group.
$EF_{BM,i}$	Emission factor of i^{th} electricity generation plant in the build margin, expressed in tCO_2/MWh.
$Gen_{BM,i}$	Projected generation for the i^{th} electricity generation plant included in the build margin, expressed in MWh.

$$EF_{BM,i} = SFC_{BM,i} * CEF_{BM,i} * Oxid_i \quad \textbf{(14)}$$

where:

$SFC_{BM,i}$	Specific fuel consumption of the i^{th} electricity generation plant, expressed in ton of fuel /MWh or TJ of fuel /MWh. The data shall be taken from published data of electricity regulatory authority.
$CEF_{BM,i}$	CO_2 content of fuel used in i^{th} electricity generation plant, expressed as tCO_2/(ton of fuel or TJ of fuel).
$Oxid_i$	Fuel oxidation factor, expressed as fraction.

If option (ii) above is used, project proponents will check annually the EF_{BM} for accuracy and consistency. The project proponent shall compare EF_{BM}, estimated under option (ii) with the value obtained by using the procedure for estimating build margin emission factor described in "Tool to calculate the emission factor for an electricity system" method on an ex-post basis. If the value of EF_{BM} estimated using option (i) is lower by more than 20% than the value of EF_{BM} estimated using option (ii) method, then the value of EF_{BM} estimated using option (i) should be used for estimating the grid electricity emission factor.

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.

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Applicability

The methodology is applicable to proposed electricity capacity additions that meet the following conditions:

1) Projects that are renewable electricity generation projects of the following types:

   (a) Run-of-river hydro power plants and hydro power projects with existing reservoirs where the volume of the reservoir is not increased;
   (b) New hydro electric power projects with reservoirs having power densities (installed power generation capacity divided by the surface area at the full reservoir level) greater than 4 W/m^2.[8]
   (c) Wind sources;
   (d) Solar sources;
   (e) Geothermal sources;
   (f) Wave and tidal sources.

2) Projects that are connected to the interconnected grids of the Republic of Chile and Projects that fulfils all the legal obligations under the Chilean Electricity Regulation; or

   Proposed projects implemented in countries other than Chile provided the country has a comparable regulatory framework for electricity generation and dispatch to Chile and meets the following conditions:

   (a) An identifiable independent identity is responsible for optimal operation of the system based on the principle of lowest marginal costs.

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

[8] The adoption of this guidance does not prevent project participants from submiting new methodologies for hydroelectric projects, for consideration by the Meth Panel, in particular where reservoirs have no significant vegetative biomass in the catchments area.

(b) The data for merit order based on marginal costs is publicly made available by the authority responsible for operation of the system.
(c) The data on specific fuel consumption for each generation source in the system is publicly available.
(d) It is possible with the information available, to ensure that power plants dispatched for other considerations (e.g. safety conditions, grid stability, , transmission constraints, and other electrical reasons) are not identified as marginal plants.

The methodology is not applicable to:

1) The proposed CDM project activities that involve switching from fossil fuels to renewable energy at the site of the project activity, and
2) if the baseline is the continued use of fossil fuels at the site.

This monitoring methodology shall be used in conjunction with the approved baseline methodology AM0026 (Baseline methodology for zero-emissions grid-connected electricity generation from renewable sources in Chile or in countries with merit order based dispatch grid). The same applicability conditions as in baseline AM0026 apply.

Monitoring Methodology

The monitoring methodology involves the monitoring of the following:
- Electricity generated and fed into the grid by the proposed CDM project, and other CDM registered projects.
- Public data on dispatch of electricity and other relevant information from the dispatch center. This data is used to calculate the emission factor for the operating margin based on a dispatch increment analysis.
- Public data on official expansion planning for the system. This data will be used to calculate the emission factor for the build margin.
- Emission Factors for every thermal power plant that operates or is included in the expansion plan.

Data needed to calculate the build margin emission factor consistent with the “Tool to calculate the emission factor for an electricity system” .
- For new hydro electric power projects, the surface area of reservoir at the full reservoir level.

Project Boundary

1) Consistent with the “baseline methodology for zero-emissions grid-connected electricity generation from renewable sources in Chile (AM0026)”. The project boundary includes the following **emissions sources**:

(a) 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.
(b) 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 CO_2 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.

Project emissions parameters

Project participants should establish a system to monitor the amount of all types of fossil fuel combusted. On-site fossil fuel consumption for the operation of the geothermal power plant should be metered through flow or volume meters or respectively with an energy balance over the year, considering stocks at the beginning and at the end of each year. Where possible, project participants should cross-check these estimates with fuel purchase receipts. The following table lists the data to be collected or used in order to monitor emissions from the project activity.

ID number	Data Type	Data variable	Data unit	Measured (m) calculated (c) estimated (e)	Recording frequency	Proportion of data monitored	How will data be archived? (electronic/ paper)	For how long is archived data kept?	Comment
1) $Generation_y$	Electricity quantity	Electricity exported to the grid by proposed CDM project, in year y	MWh	M	Hourly measurement and daily recording	100%	Electronic	During the Crediting Period.	
2) Changes in the reservoir volume	Volume	The volume of the reservoir of hydro power plant	Volume units	E	Annually	100%	Electronic	During the Crediting Period.	The information is collected for proposed CDM projects proposed at an existing hydro power plant. The information is sourced from the records of the hydro power plant.

Data monitored for estimating project emissions of Geothermal Projects proposed as CDM projects

ID number	Data Type	Data variable	Data unit	Measured (m) calculated (c) estimated (e)	Recording frequency	Pro-portion of data monitored	How will data be archived? (electronic/ paper)	For how long is archived data kept?	Comment
3)	Area	Surface area of reservoir	m^2	m	At start of project	100%	Electronic	During the Crediting Period.	
4) $M_{s,\ y}$	Mass quantity	Quantity of steam produced during year y	Ton (t)	M	Daily	100%	Electronic	During the Crediting Period.	See note 1 below.
5) w_{CO2}	Mass fraction	Fraction of CO_2 in steam produced	tCO_2/t steam	M	Quarterly	100%	Electronic	During the Crediting Period.	See note 2 below.
6) w_{CH4}	Mass fraction	Fraction of CH_4 in steam produced	tCH_4/ t of steam	M	Quarterly	100%	Electronic	During the Crediting Period.	See note 2 below.
7) $Mt_{s,y}$	Mass quantity	Quantity of steam produced during well testing	t	M	Daily	100%	Electronic	During the Crediting Period.	See note 1 below.
8) $wt_{,\ CO2}$	Mass fraction	Fraction of CO_2 in steam produced during well testing	tCO_2/t steam	M	Quarterly	100%	Electronic	During the Crediting Period.	See note 2 below.
9) wt_{CH4}	Mass fraction	Fraction of CH_4 in steam produced during well testing	tCH_4/ t of steam	M	Quarterly	100%	Electronic	During the Crediting Period.	See note 2 below.
10) $F_{i,\ y}$	Fuel quantity	Fossil fuel 'i' used for the operation of the	Mass or volume	M	Monthly	100%	Electronic	During the Crediting Period.	The quantity of fossil fuel combusted should be collected separately for

ID number	Data Type	Data variable	Data unit	Measured (m) calculated (c) estimated (e)	Recording frequency	Pro-portion of data monitored	How will data be archived? (electronic/ paper)	For how long is archived data kept?	Comment
		geothermal plant							each fuel.
11) $COEF_i$	Fuel Emission factor	CO_2 emission coefficient of fossil fuel 'i'.	tCO_2/mass or volume of fuel used	C	As required	100%	Electronic	During the Crediting Period.	Plant or country specific values should be used in preference to IPCC 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 CO_2 and H2S. They also contain a small quantity of hydrocarbons, including predominantly $\mathbf{CH_4}$. In geothermal power projects, NCGs flow with the steam into the power plant. A small proportion of the CO_2 is converted to carbonate / bicarbonate in the cooling water circuit. In addition, parts of the 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_2 and $\mathbf{CH_4}$ 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 (CO_2dissolve 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 $\mathbf{CH_4}$. 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.

Baseline emission parameters

ID number	Data Type	Data variable	Data unit	Measured (m) calculated (c) estimated (e)	Recording frequency	Pro-portion of data monitored	How will data be archived? (electronic/ paper)	For how long is archived data kept?	Comment
12) EF_y	Emission factor	Emission factor for displaced grid electricity	tCO_2/ MWh	C	Annually	100%	Electronic	During the Crediting Period.	Calculated as weighted sum of build margin (EF_{BM}) and operating margin (EF_{OM}) emission factors.
13) $EF_{OM,y}$	Emission factor	Operating margin emission factor	tCO_2/ MWh	C	Annually	100%	Electronic	During the Crediting Period.	Calculated as per Equation 7, described in the Baseline methodology section.
14) $EF_{j,h}$	Emission factor	Operating margin emission for hour h	tCO_2/ MWh	C	Hourly	100%	Electronic	During the Crediting Period.	Calculated as per Equation 8, described in the Baseline methodology section.
15) D(j,i)	Electricity quantity	Electricity displaced by j^{th} CDM project from i^{th} marginal plant in the system	MWh	C	Hourly	100%	Electronic	During the Crediting Period.	Calculated as per Equation 10, described in the Baseline methodology section.
16) d_i	Emission factor	Emission factor for electricity displaced D(j,i)	tCO_2/ MWh	C	Hourly	100%	Electronic	During the Crediting Period.	Estimated using Equation11, as described in the baseline methodology section.
17) SFC_i	Fuel intensity	Specific fuel consumption per unit of electricity produced in i^{th} marginal plant	(Ton or TJ)/MWh	E	Yearly	100%	Electronic	During the Crediting Period.	The information is sourced from the official information from dispatch center or electricity regulatory authority.

ID number	Data Type	Data variable	Data unit	Measured (m) calculated (c) estimated (e)	Recording frequency	Pro-portion of data monitored	How will data be archived? (electronic/ paper)	For how long is archived data kept?	Comment
18) M	Number	Number of electricity generation plants on Margin that would supply to the system in absence of the CDM projects in the system	Number	E	Hourly	100%	Electronic	During the Crediting Period.	Estimated using Equation 9, described in the baseline methodology section. The list of marginal plant is sourced from merit order list prepared by the dispatch center.
19) N	List	List of CDM registered plants in the system			As required	100%	Electronic	During the Crediting Period.	
20) C_j	Electricity quantity	Electricity generated by j^{th} CDM plant in hour h	MWh	M/E	Hourly	100%	Electronic	During the Crediting Period.	The data for CDM plants other than using the methodology is sourced from dispatch center data.
21) A_i	Generation Capacity	Generation capacity of i^{th} plant on margin during hour h	MW	M	Hourly	100%	Electronic	During the Crediting Period.	
22) B_i	Electricity quantity	Electricity generated by i^{th} plant on the margin during hour h	MWh	M	Hourly	100%	Electronic	During the Crediting Period.	Data sourced from official information of dispatch center.

ID number	Data Type	Data variable	Data unit	Measured (m) calculated (c) estimated (e)	Recording frequency	Pro-portion of data monitored	How will data be archived? (electronic/ paper)	For how long is archived data kept?	Comment
23) EF_{BM}	Emission factor	Build margin emission factor	tCO_2/ MWh	C	Annually	100%	Electronic	During the Crediting Period.	Calculated as per option (ii) (Equation 11) described in the Baseline methodology section or as per method described in the "Tool to calculate the emission factor for an electricity system" (option (i))
24) EF_i	Emission factor	Emission factor for i^{th} plant in the Build margin cohort	tCO_2/ MWh	C	Annually	100%	Electronic	During the Crediting Period.	Calculated as per Equation 12, for option (ii).described in the Baseline methodology section
25) $Gen_{BM,i}$	Electricity quantity	Electricity generation of i^{th} plant in the Build margin cohort	MWh	E	Annually	100%	Electronic	During the Crediting Period.	The information is taken from official capacity expansion plan.
26) $F_{BM,i}$	Fuel quantity	Specific fuel consumption of i^{th} plant in the build margin cohort	Ton or TJ/MWh	E	Annually	100%	Electronic	During the Crediting Period.	The information is taken from official capacity expansion plan.
27) Fi,y	Fuel quantity	Amount of each fossil fuel consumed by each power source / plant	Mass or volume	M	Yearly	100%	Electronic	During the crediting period and two years after	Data for power plants included in the Build Margin Cohort as per the procedure described in "Tool to calculate the emission factor for an electricity system". 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)	Recording frequency	Pro-portion of data monitored	How will data be archived? (electronic/ paper)	For how long is archived data kept?	Comment
28) GENn,y	Electricity quantity	Electricity generation of each power source / plant n	MWh/a	M	Yearly	100%	Electronic	During the crediting period and two years after	Generation data for power plants included in the Build Margin Cohort as per the procedure described in "Tool to calculate the emission factor for an electricity system". Obtained from the power producers, dispatch centers or latest local statistics.
29)	Plant name	Identification of power source / plant for the BM	Text	E	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 as per the procedure defined in "Tool to calculate the emission factor for an electricity system"
30) CEF_i	Fuel emission factor	Carbon emission factor of fuel used in i[th] plant in build margin cohort	tCO_2/ton fuel or TJ	E		100%	Electronic	During the Crediting Period.	Local or national data should be used in preference to IPCC defaults.
31) $Oxid_i$	Fraction	Fraction of fuel oxidized on combustion.	Fraction.	E		100%	Electronic	During the Crediting Period.	IPCC default values can be used.
32) w_{BM}	fraction	Weight for build margin emission factor	Fraction	E	Annually	100%	Electronic	During the Crediting Period.	Calculates as per procedure described in baseline methodology section.
33) w_{OM}	fraction	Weight for operating margin emission factor	Fraction	E	Annually	100%	Electronic	During the Crediting Period.	Calculates as per procedure described in baseline methodology section.

Leakage

No data is required to monitored as Leakage are assumed negligible.

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

All measurements should use calibrated measurement equipment that is maintained regularly and checked for its functioning. QA/QC procedures for the parameters to be monitored are illustrated 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	The consistency of metered net electricity generation should be cross-checked with receipts from sales (if available) and the quantity of biomass fired (e.g. check whether the electricity generation divided by the quantity of biomass fired results in a reasonable efficiency that is comparable to previous years). Meters should be subject to regular maintenance and testing regime to ensure efficiency.

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