Draft methodological tool

"Tool to calculate the emission factor for an electricity system"

I. DEFINITIONS, SCOPE, APPLICABILITY AND PARAMETERS

Definitions

For the purpose of this tool, the following definitions apply:

- **Power plant / unit**. A power plant / unit is a facility for the generation of electric power. Several power units at one site comprise one power plant, whereby a power unit characterizes that it can be operated independently of the other power units at the same site. Where several identical power units (i.e. with the same capacity, age and efficiency) are installed at one site, they may be considered as one single power unit.

- **Net electricity generation** refers to the difference between the total quantity of electricity generated by the power plant / unit and the auxiliary electricity consumption of the power plant / unit (e.g. for pumps, vans, controlling, etc).

- **Grid/project electricity system** is defined by the spatial extent of the power plants that are physically connected through transmission and distribution lines to the project activity (e.g. the renewable power plant location or the consumers where electricity is being saved) and that can be dispatched without significant transmission constraints.

Scope and applicability

This methodological tool determines the CO_2 emission factor for the displacement of electricity generated by power plants in an electricity system, by calculating the "operating margin" (OM) and "build margin" (BM) as well as the "combined margin" (CM). The operating margin refers to a cohort of power plants that reflect the existing power plants whose electricity generation would be affected by the proposed CDM project activity. The build margin refers to a cohort of power units that reflect the type of power units whose construction would be affected by the proposed CDM project activity.

This tool may be referred to in order to estimate the OM, BM and/or CM for the purpose of calculating baseline emissions for a project activity substitutes electricity from the grid, i.e. where a project activity supplies electricity to a grid or a project activity that results in savings of electricity that would have been provided by the grid (e.g. demand-side energy efficiency projects). Note that this tool is also referred to in the "Tool to calculate project emissions from electricity consumption" for the purpose of calculating project and leakage emissions in case where a project activity consumes electricity from the grid or results in increase of consumption of electricity from the grid outside the project boundary

Parameters

This tool provides procedures to determine the following parameters:

Parameter	SI Unit	Description
$EF_{grid,CM,y}$	tCO_2/MWh	Combined margin CO_2 emission factor for grid connected power generation in year y
$EF_{grid,BM,y}$	tCO_2/MWh	Build margin CO_2 emission factor for grid connected power generation in year y
$EF_{grid,OM,y}$	tCO_2/MWh	Operating margin CO_2 emission factor for grid connected power generation in year y

No methodology-specific parameters are required.

II. BASELINE METHODOLOGY PROCEDURE

Project participants shall apply the following six steps:

STEP 1. Identify the relevant electric power system.

STEP 2. Select an operating margin (OM) method.

STEP 3. Calculate the operating margin emission factor according to the selected method.

STEP 4. Identify the cohort of power units to be included in the build margin (BM).

STEP 5. Calculate the build margin emission factor.

STEP 6. Calculate the combined margin (CM) emissions factor.

STEP 1. Identify the relevant electric power system[1]

For the purpose of determining the electricity emission factors, a **project electricity system** is defined by the spatial extent of the power plants that are physically connected through transmission and distribution lines to the project activity (e.g. the renewable power plant location or the consumers where electricity is being saved) and that can be dispatched without significant transmission constraints.

Similarly, a **connected electricity system**, e.g. national or international, is defined as a electricity system that is connected by transmission lines to the project electricity system. Power plants within the connected electricity system can be dispatched without significant transmission constraints but transmission to the project electricity system has significant transmission constraint.

If the DNA of the host country has published a delineation of the project electricity system and connected electricity systems, these delineations should be used. If such delineations are not available, project participants should define the project electricity system and any connected electricity system and justify

[1] A proposed new methodology may choose to include a different procedure to identify the relevant electric power system. In that case, that procedure would replace this step. In the absence of an explicit procedure in the proposed methodology, the guidance in this step shall be followed.

and document their assumptions in the CDM-PDD. In doing, so the following criteria can be used to determine the existence of significant transmission constraints:[2]

- In case of electricity systems with spot markets for electricity: there are differences in electricity prices (without transmission and distribution costs) of more than 5 percent between the systems during 60 percent or more of the hours of the year.

- The transmission line is operated at 90% or more of its rated capacity during 90% percent or more of the hours of the year.

Where the application of these criteria does not result in a clear grid boundary, use a regional grid definition in the case of large countries with layered dispatch systems (e.g. provincial / regional / national). A provincial grid definition may indeed in many cases be too narrow given significant electricity trade among 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 emission factor, 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.

For the purpose of determining the operating margin emission factor, use one of the following options to determine the CO_2 emission factor(s) for net electricity imports ($EF_{grid,import,y}$) from a connected electricity system within the same host country(ies):

(a) 0 tCO_2/MWh, or

(b) The weighted average operating margin (OM) emission rate of the exporting grid, determined as described in step 3 (d) below; or

(c) The simple operating margin emission rate of the exporting grid, determined as described in step 3 (a), if the conditions for this method, as described in step 2 below, apply to the exporting grid; or

(d) The simple adjusted operating margin emission rate of the exporting grid, determined as described in step 3 (b) below.

For imports from connected electricity systems located in another host country(ies), the emission factor is 0 tons CO_2 per MWh. Electricity exports should <u>not</u> be subtracted from electricity generation data used for calculating and monitoring the electricity emission factors.

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[2] Project participants may propose other criteria or submit proposals for revision of these criteria for consideration by the CDM Executive Board.

STEP 2. Select an operating margin (OM) method

The calculation of the operating margin emission factor ($EF_{grid,OM,y}$) is based on one of the following methods:

(a) Simple OM, or

(b) Simple adjusted OM, or

(c) Dispatch data analysis OM, or

(d) Average OM.

Each method is described under Step 3. Any of the four methods can be used, however, the simple OM method (option a) can only be used if low-cost/must-run resources[3] constitute less than 50% of total grid generation in: 1) average of the five most recent years, or 2) based on long-term averages for hydroelectricity production.

For the simple OM, the simple adjusted OM and the average OM, the emissions factor can be calculated using either of the two following data vintages:

- Ex ante option: A 3-year generation-weighted average, based on the most recent data available at the time of submission of the CDM-PDD to the DOE for validation, without requirement to monitor and recalculate the emissions factor during the crediting period, or

- Ex post option: The year in which the project activity displaces grid electricity, requiring the emissions factor to be updated annually during monitoring. If the data required to calculate the emission factor for year *y* is usually only available later than six months after the end of year *y*, alternatively the emission factor of the previous year (y-1) may be used. If the data is usually only available 18 months after the end of year *y*, the emission factor of the year proceeding the previous year (y-2) may be used. The same data vintage (y, y-1 or y-2) should be used throughout all crediting periods.

For the dispatch data analysis OM, use the year in which the project activity displaces grid electricity and update the emission factor annually during monitoring.

The data vintage chosen should be documented in the CDM-PDD and not be changed during the crediting periods.

Power plants registered as CDM project activities should be included in the sample group that is used to calculate the operating margin if the criteria for including the power source in the sample group apply.

[3] Low-cost/must-run resources are defined as power plants with low marginal generation costs or power plants that are dispatched independently of the daily or seasonal load of the grid. They 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.

STEP 3. Calculate the operating margin emission factor according to the selected method

(a) Simple OM

The simple OM emission factor is calculated as the generation-weighted average CO_2 emissions per unit net electricity generation (tCO2/MWh) of all generating power plants serving the system, not including low-cost / must-run power plants / units. It may be calculated:

- Based on data on fuel consumption and net electricity generation of each power plant / unit[4] (Option A), or
- Based on data on net electricity generation, the average efficiency of each power unit and the fuel type(s) used in each power unit (Option B), or
- Based on data on the total net electricity generation of all power plants serving the system and the fuel types and total fuel consumption of the project electricity system (option C)

Option A should be preferred and must be used if fuel consumption data is available for each power plant / unit. In other cases, option B or option C can be used. For the purpose of calculating the simple OM, Option C should only be used if the necessary data for option A and option B is not available and can only be used if only nuclear and renewable power generation are considered as low-cost / must-run power sources and if the quantity of electricity supplied to the grid by these sources is known.

Where Option A is used, the simple OM emission factor is calculated as follows:

$$EF_{grid,OMsimple,y} = \frac{\sum_{i,m} FC_{i,m,y} \cdot NCV_{i,y} \cdot EF_{CO2,i,y}}{\sum_{m} EG_{m,y}} \quad \textbf{(1)}$$

Where:

$EF_{grid,OMsimple,y}$	=	Simple operating margin CO_2 emission factor in year *y* (tCO_2/MWh)
$FC_{i,m,y}$	=	Amount of fossil fuel type *i* consumed by power plant / unit *m* in year *y* (mass or volume unit)
$NCV_{i,y}$	=	Net calorific value (energy content) of fossil fuel type *i* in year *y* (GJ / mass or volume unit)
$EF_{CO2,i,y}$	=	CO_2 emission factor of fossil fuel type *i* in year *y* (tCO_2/GJ)
$EG_{m,y}$	=	Net electricity generated and delivered to the grid by power plant / unit *m* in year *y* (MWh)
m	=	All power plants / units serving the grid in year *y* except low-cost / must-run power plants / units

[4] Power *units* should be considered if some of the power units at the site of the power plant are low-cost / must-run units and some are not. Power *plants* can be considered if *all* power units at the site of the power plant belong to the group of low-cost / must-run units or if *all* power units at the site of the power plant do *not* belong to the group of low-cost / must-run units.

i = All fossil fuel types combusted in power plant / unit *m* in year *y*
y = Either the three most recent years for which data is available at the time of submission of the CDM-PDD to the DOE for validation (ex ante option) or the applicable year during monitoring (ex post option), following the guidance on data vintage in step 2

Where Option B is used, the simple OM emission factor is calculated based on the electricity generation of each power unit and an emission factor for each power unit, as follows:

$$EF_{grid,OMsimple,y} = \frac{\sum_{m} EG_{m,y} \cdot EF_{EL,m,y}}{\sum_{m} EG_{m,y}} \quad \textbf{(2)}$$

Where:
$EF_{grid,OMsimple,y}$ = Simple operating margin CO_2 emission factor in year *y* (tCO_2/MWh)
$EG_{m,y}$ = Net quantity of electricity generated and delivered to the grid by power unit *m* in year *y* (MWh)
$EF_{EL,m,y}$ = CO_2 emission factor of power unit *m* in year *y* (tCO_2/MWh)
m = All power units serving the grid in year *y* except low-cost / must-run power units
y = Either the three most recent years for which data is available at the time of submission of the CDM-PDD to the DOE for validation (ex ante option) or the applicable year during monitoring (ex post option), following the guidance on data vintage in step 2

The emission factor of each power unit *m* should be determined as follows:

- **Option B1.** If for a power unit *m* data on fuel consumption and electricity generation is available, the emission factor ($EF_{EL,m,y}$) should be determined as follows:

$$EF_{EL,m,y} = \frac{\sum_{i} FC_{i,m,y} \cdot NCV_{i,y} \cdot EF_{CO2,i,y}}{EG_{m,y}} \quad \textbf{(3)}$$

Where:[small "i"]
$EF_{EL,m,y}$ = CO_2 emission factor of power unit *m* in year *y* (tCO_2/MWh)
$FC_{i,m,y}$ = Amount of fossil fuel type *i* consumed by power unit *m* in year *y* (Mass or volume unit)
$NCV_{i,y}$ = Net calorific value (energy content) of fossil fuel type *i* in year *y* (GJ / mass or volume unit)
$EF_{CO2,I,y}$ = CO_2 emission factor of fossil fuel type *i* in year *y* (tCO_2/GJ)
$EG_{m,y}$ = Net quantity of electricity generated and delivered to the grid by power unit *m* in year *y* (MWh)
m = All power units serving the grid in year *y* except low-cost / must-run power units
I = All fossil fuel types combusted in power unit *m* in year *y*
y = Either the three most recent years for which data is available at the time of submission of the CDM-PDD to the DOE for validation (ex ante option) or the applicable year during monitoring (ex post option), following the guidance on data vintage in step 2

- **Option B2.** If for a power unit *m* only data on electricity generation and the fuel types used is available, the emission factor should be determined based on the CO_2 emission factor of the fuel type used and the efficiency of the power unit, as follows:

$$EF_{EL,m,y} = \frac{EF_{CO2,m,i,y} \cdot 3.6}{\eta_{m,y}} \quad \textbf{(4)}$$

Where:

$EF_{EL,m,y}$ = CO_2 emission factor of power unit *m* in year *y* (tCO_2/MWh)
$EF_{CO2,m,i,y}$ = Average CO_2 emission factor of fuel type *i* used in power unit *m* in year *y* (tCO_2/GJ)
$\eta_{m,y}$ = Average net energy conversion efficiency of power unit *m* in year *y* (%)
y = Either the three most recent years for which data is available at the time of submission of the CDM-PDD to the DOE for validation (ex ante option) or the applicable year during monitoring (ex post option), following the guidance on data vintage in step 2

Where several fuel types are used in the power unit, use the fuel type with the lowest CO_2 emission factor for $EF_{CO2,m,i,y}$.

- **Option B3.** If for a power unit *m* only data on electricity generation is available, an emission factor of 0 tCO_2/MWh can be assumed as a simple and conservative approach.

Where Option C is used, the simple OM emission factor is calculated based on the net electricity supplied to the grid by all power plants serving the system, not including low-cost / must-run power plants / units, and based on the fuel type(s) and total fuel consumption of the project electricity system, as follows:

$$EF_{grid,OMsimple,y} = \frac{\sum_i FC_{i,y} \times NCV_{i,y} \times EF_{CO2,i,y}}{EG_y} \quad \textbf{(5)}$$

Where:

$EF_{grid,OMsimple,y}$ = Simple operating margin CO_2 emission factor in year *y* (tCO_2/MWh)
$FC_{i,y}$ = Amount of fossil fuel type *i* consumed in the project electricity system in year *y* (mass or volume unit)
$NCV_{i,y}$ = Net calorific value (energy content) of fossil fuel type *i* in year *y* (GJ / mass or volume unit)
$EF_{CO2,i,y}$ = CO_2 emission factor of fossil fuel type *i* in year *y* (tCO_2/GJ)
EG_y = Net electricity generated and delivered to the grid by all power sources serving the system, not including low-cost / must-run power plants / units, in year *y* (MWh)
i = All fossil fuel types combusted in power sources in the project electricity system in year *y*
y = Either the three most recent years for which data is available at the time of submission of the CDM-PDD to the DOE for validation (ex ante option) or the applicable year during monitoring (ex post option), following the guidance on data vintage in step 2

For this approach (simple OM) to calculate the operating margin, the subscript *m* refers to the power plants / units delivering electricity to the grid, not including low-cost/must-run power plants / units, and including electricity imports[5] to the grid. Electricity imports should be treated as one power plant *m*.

(b) Simple adjusted OM

The simple adjusted OM emission factor ($EF_{grid,OM\text{-}adj,y}$) is a variation of the simple OM, where the power plants / units (including imports) are separated in low-cost/must-run power sources (*k*) and other power sources (*j*). As with the simple OM, it can be calculated:

- Based on data on fuel consumption and net electricity generation of each power plant / unit[4] (Option A), as follows:

$$EF_{grid,OM\text{-}adj,y} = (1-\lambda_y) \times \frac{\sum_{i,j} FC_{i,j,y} \cdot NCV_{i,y} \cdot EF_{CO2,i,y}}{\sum_{j} EG_{j,y}} + \lambda_y \times \frac{\sum_{i,k} FC_{i,k,y} \cdot NCV_{i,y} \cdot EF_{CO2,i,y}}{\sum_{k} EG_{k,y}} \quad \textbf{(6)}$$

- Based on data on net electricity generation, the average efficiency of each power unit and the fuel type(s) used in each power unit (Option B), as follows:

$$EF_{grid,OM\text{-}adj,y} = (1-\lambda_y) \times \frac{\sum_{j} EG_{j,y} \times EF_{EL,j,y}}{\sum_{j} EG_{j,y}} + \lambda_y \times \frac{\sum_{k} EG_{k,y} \times EF_{EL,k,y}}{\sum_{k} EG_{k,y}} \quad \textbf{(7)}$$

Where $FC_{i,j,y}$, $FC_{i,k,y}$, $NCV_{i,y}$, $EF_{CO2,i,y}$, $EG_{j,y}$ and $EG_{k,y}$ are analogous to the variables described for the simple OM method above and where $EF_{EL,j,y}$ and $EF_{EL,k,y}$ should be determined as for the simple OM method above. The indices *j* and *k* are subsets of all power sources *m* supplying electricity to the grid in year *y*, where *k* refers to power plants / units which are either low-cost or are must-run and *j* refers to the remaining power plants / units. As with the simple OM, option A should be preferred and must be used if fuel consumption data is available for each power plant / unit. In other cases, option B can be used. Option C is not applicable to the simple adjusted OM.

Net electricity imports must be considered low-cost / must-run plants.

λ_y is defined as follows:

$$\lambda_y\,(\%) = \frac{\text{Number of hours low - cost / must - run sources are on the margin in year y}}{\text{8760 hours per year}} \quad \textbf{(8)}$$

[5] As described above, an import from a connected electricity system should be considered as one power source.

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

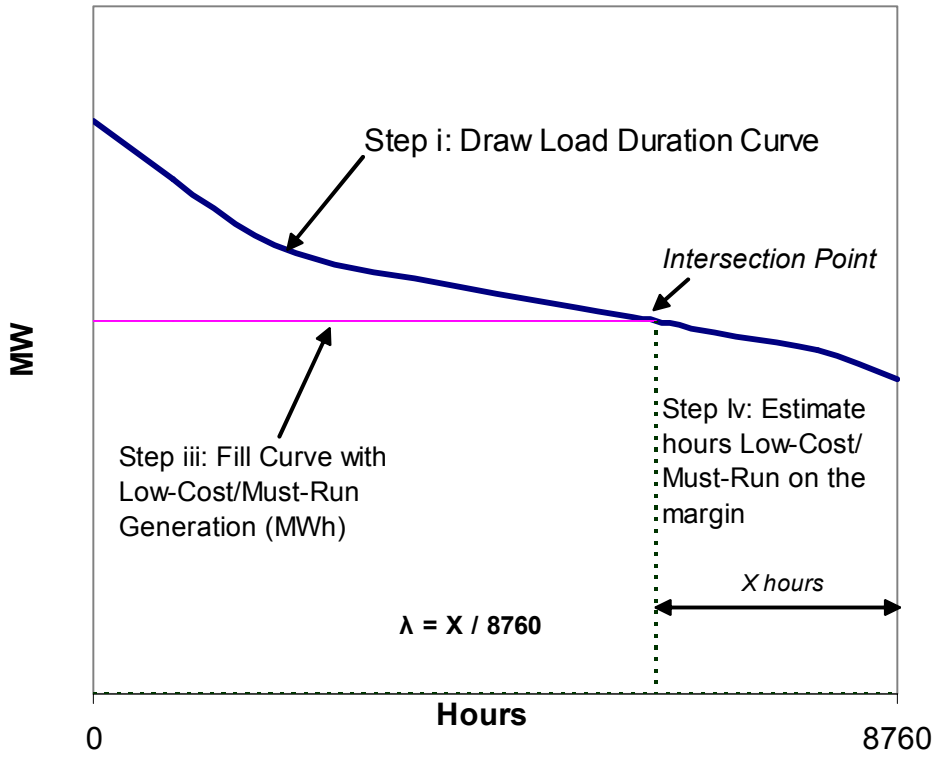
Step i) Plot a **load duration curve**. Collect chronological load data (typically in MW) for each hour of the year *y*, and sort the load data from the highest to the lowest MW level. Plot MW against 8760 hours in the year, in descending order.

Step ii) Collect power generation data from each power plant / unit. Calculate the total annual generation (in MWh) from low-cost/must-run power plants / units (i.e. $\sum_k EG_{k,y}$).

Step iii) Fill the load duration curve. Plot a horizontal line across the load duration curve such that the area under the curve (MW times hours) equals the total generation (in MWh) from low-cost/must-run power plants / units (i.e. $\sum_k EG_{k,y}$).

Step iv) Determine the "Number of hours for which low-cost/must-run sources are on the margin in year y". 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 low-cost/must-run sources do not appear on the margin and λ_y is equal to zero.

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 analysis OM emission factor ($EF_{grid,OM\text{-}DD,y}$) is determined based on the power units that are actually dispatched at the margin during each hour *h* where the project is displacing electricity. This approach is not applicable to historical data and, thus, requires annual monitoring of $EF_{grid,OM\text{-}DD,y}$.

The emission factor is calculated as follows:

$$EF_{grid,OM-DD,y} = \frac{\sum_{h} EG_{PJ,h} \cdot EF_{EL,DD,h}}{EG_{PJ,y}} \quad \textbf{(9)}$$

Where:

$EF_{grid,OM\text{-}DD,y}$ = Dispatch data analysis operating margin CO_2 emission factor in year *y* (tCO_2/MWh)
$EG_{PJ,h}$ = Electricity displaced by the project activity in hour *h* of year *y* (MWh)
$EF_{EL,DD,h}$ = CO_2 emission factor for power units in the top of the dispatch order in hour *h* in year *y* (tCO_2/MWh)

$EG_{PJ,y}$ = Total electricity displaced by the project activity in year *y* (MWh)
h = Hours in year *y* in which the project activity is displacing grid electricity
y = Year in which the project activity is displacing grid electricity

If hourly fuel consumption data is available, then the hourly emissions factor is determined as:

$$EF_{EL,DD,h} = \frac{\sum_{i,n} FC_{i,n,h} \cdot NCV_{i,y} \cdot EF_{CO2,i,y}}{\sum_{n} EG_{n,h}} \quad \textbf{(10)}$$

Where:
$EF_{EL,DD,h}$ = CO_2 emission factor for power units in the top of the dispatch order in hour *h* in year *y* (tCO_2/MWh)
$FC_{i,n,h}$ = Amount of fossil fuel type *i* consumed by power unit *n* in hour *h* (Mass or volume unit)
$NCV_{i,y}$ = Net calorific value (energy content) of fossil fuel type *i* in year *y* (GJ / mass or volume unit)
$EF_{CO2,i,y}$ = CO_2 emission factor of fossil fuel type *i* in year *y* (tCO_2/GJ)
$EG_{n,h}$ = Electricity generated and delivered to the grid by power unit *n* in hour *h* (MWh)
n = Power units in the top of the dispatch (as defined below)
i = Fossil fuel types combusted in power unit *n* in year *y*
h = Hours in year *y* in which the project activity is displacing grid electricity
y = Year in which the project activity is displacing grid electricity

Otherwise, the hourly emissions factor is calculated based on the energy efficiency of the power unit and the fuel type used, as follows:

$$EF_{EL,DD,h} = \frac{\sum_{n} EG_{n,h} \times EF_{EL,n,y}}{\sum_{n} EG_{n,h}} \quad \textbf{(11)}$$

Where:
$EF_{EL,DD,h}$ = CO_2 emission factor for power units in the top of the dispatch order in hour *h* in year *y* (tCO_2/MWh)
$EG_{n,h}$ = Net quantity of electricity generated and delivered to the grid by power unit *n* in hour *h* (MWh)
$EF_{EL,n,y}$ = CO_2 emission factor of power unit *n* in year *y* (tCO_2/MWh)
n = Power units in the top of the dispatch (as defined below)
h = Hours in year y in which the project activity is displacing grid electricity

The CO_2 emission factor of the power units *n* should be determined as per the guidance for the simple OM, using the options B1, B2 or B3.

To determine the set of power units *n* that are in the top of the dispatch, obtain from a national dispatch centre:

- The grid system dispatch order of operation for each power unit of the system including power units from which electricity is imported; and

- The amount of power (MWh) that is dispatched from all power units in the system during each hour *h* that the project activity is displacing electricity.

At each hour *h*, stack each power unit's generation using the merit order. The group of power units *n* in the dispatch margin includes the units in the top x% of total electricity dispatched in the hour *h*, where x% is equal to the greater of either:

(a) 10%; or

(b) The quantity of electricity displaced by the project activity during hour *h* divided by the total electricity generation in the grid during that hour *h*.

(d) Average OM

The average OM emission factor ($EF_{grid,OM\text{-}ave,y}$) is calculated as the average emission rate of all power plants serving the grid, using the methodological guidance as described under (a) above for the simple OM, but including in all equations also low-cost/must-run power plants.

Option A should be preferred and must be used if fuel consumption data is available for each power plant / unit. In other cases, option B or option C can be used. Option C should only be used if the necessary data for option A and option B is not available.

STEP 4. Identify the cohort of power units to be included in the build margin

The sample group of power units *m* used to calculate the build margin consists of either:[6]

(a) The set of five power units that have been built most recently, or

(b) The set of power 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 the set of power units that comprises the larger annual generation.

As a general guidance, a power unit is considered to have been built at the date when it started to supply electricity to the grid.

Options to be decided by the Board:

Option A:

Power plant registered as CDM project activities should be **included** in the sample group *m*.

[6] If this approach does not reasonably reflect the power plants that would likely be built in the absence of the project activity, project participants are encouraged to submit alternative proposals for consideration by the CDM Executive Board.

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

Option B:

Power plant registered as CDM project activities should be included in the build margin only if the set of power units in the build margin, without considering capacity additions registered as CDM project activities, would consist of power plants that have been built earlier than 10 (5) years before the submission of the CDM-PDD to the DOE.

Option C:

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

Capacity additions from retrofits of power plants should not be included in the calculation of the build margin emission factor.

In terms of vintage of data, project participants can choose between one of the following two options:

Option 1. For the first crediting period, calculate the build margin emission factor *ex-ante* based on the most recent information available on units already built for sample group *m* at the time of CDM-PDD submission to the DOE for validation. For the second crediting period, the build margin emission factor should be updated based on the most recent information available on units already built at the time of submission of the request for renewal of the crediting period to the DOE. For the third crediting period, the build margin emission factor calculated for the second crediting period should be used. This option does not require monitoring the emission factor during the crediting period.

Option 2. For the first crediting period, the build margin emission factor shall be updated annually, *ex-post*, including those units built up to the year of registration of the project activity or, if information up to the year of registration is not yet available, including those units built up to the latest year for which information is available. For the second crediting period, the build margin emissions factor shall be calculated *ex-ante*, as described in option 1 above. For the third crediting period, the build margin emission factor calculated for the second crediting period should be used.

The option chosen should be documented in the CDM-PDD.

STEP 5. Calculate the build margin emission factor

The build margin emissions factor is the generation-weighted average emission factor (tCO_2/MWh) of all power units *m* during the most recent year *y* for which power generation data is available, calculated as follows:

$$EF_{grid,BM,y} = \frac{\sum_{m} EG_{m,y} \times EF_{EL,m,y}}{\sum_{m} EG_{m,y}} \quad \textbf{(12)}$$

Where:

$EF_{grid,BM,y}$ = Build margin CO_2 emission factor in year *y* (tCO_2/MWh)
$EG_{m,y}$ = Net quantity of electricity generated and delivered to the grid by power unit *m* in year *y*

(MWh)
$EF_{EL,m,y}$ = CO_2 emission factor of power unit *m* in year *y* (tCO_2/MWh)
m = Power units included in the build margin
y = Most recent historical year for which power generation data is available

The CO_2 emission factor of each power unit *m* ($EF_{EL,m,y}$) should be determined as per the guidance in step 3 (a) for the simple OM, using options B1, B2 or B3, using for *y* the most recent historical year for which power generation data is available, and using for *m* the power *units* included in the build margin.

STEP 6. Calculate the combined margin emissions factor

The combined margin emissions factor is calculated as follows:

$$EF_{grid,CM,y} = EF_{grid,OM,y} \times w_{OM} + EF_{grid,BM,y} \times w_{BM} \quad \textbf{(13)}$$

Where:
$EF_{grid,BM,y}$ = Build margin CO_2 emission factor in year *y* (tCO_2/MWh)
$EF_{grid,OM,y}$ = Operating margin CO_2 emission factor in year *y* (tCO_2/MWh)
w_{OM} = Weighting of operating margin emissions factor (%)
w_{BM} = Weighting of build margin emissions factor (%)

The following default values should be used for w_{OM} and w_{BM}:

- Wind and solar power generation project activities: w_{OM} = 0.75 and w_{BM} = 0.25 (owing to their intermittent and non-dispatchable nature) for the first crediting period and for subsequent crediting periods.

- All other projects: w_{OM} = 0.5 and w_{BM} = 0.5 for the first crediting period , and w_{OM} = 0.25 and w_{BM} = 0.75 for the second and third crediting period,[8] unless otherwise specified in the approved methodology which refers to this tool.

Alternative weights can be proposed, as long as $w_{OM} + w_{BM} = 1$, for consideration by the Executive Board, taking into account the guidance as described below. The values for $w_{OM} + w_{BM}$ 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.

[8] Project participants can submit alternative proposal, for revision of tool or the methodology or deviation from its use, if the weightage does not reflect their situation with an explanation for the alternative weights.

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 *alone* do not appear to be justified.
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.[9]
Suppressed demand	Can increase BM weight for the 1st 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.[10]
For system management (nature of local electricity markets, planning, and actors) and other considerations no guidance is available at present.		

[9] Capacity value refers to the impact of a capacity addition on the capacity requirements of a grid system, expressed as fraction of contribution to meeting peak demands relative to a conventional, dispatchable capacity addition or to a theoretical perfectly reliable one.

[10] 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.

Data and parameters not monitored

Included in the monitoring methodology.

III. MONITORING METHODOLOGY

All data collected as part of monitoring should be archived electronically and be kept at least for 2 years after the end of the last crediting period. 100% of the data should be monitored if not indicated otherwise in the tables below. All measurements should be conducted with calibrated measurement equipment according to relevant industry standards.

Some parameters listed below under "data and parameters" either need to be monitored continuously during the crediting period or need to be calculated only once for the crediting period, depending on the data vintage chosen, following the provisions in the baseline methodology procedure outlined above and the guidance on "monitoring frequency" for the parameter.

The calculation of the operating margin and build margin emission factors should be documented electronically in a spreadsheet that should be attached to the CDM-PDD. This should include all data used to calculate the emission factors, including:

- For each grid-connected power plant / unit the following information:
    - Information to clearly identify the plant;
    - The date of commissioning,
    - The capacity (MW);
    - The fuel type(s) used;
    - The quantity of net electricity generation in the relevant year(s)[11];
    - If applicable: the fuel consumption of each fuel type in the relevant year(s);
    - In case where the simple OM or the simple adjusted operating margin is used: information whether the plant / unit is a low-cost / must-run plant / unit;
- Net calorific values used;
- CO_2 emission factors used;
- Plant efficiencies used;

[11] In case of the simple adjusted OM, this includes the five most recent years or long-term averages for hydroelectricity production.

- Identification of the plants included in the build margin and the operating margin during the relevant time year(s);

- In case the simple adjusted operating margin is used: load data (typically in MW) for each hour of the year *y*;

- In case the dispatch data operating margin is used: for each hour *h* where the project plant is displacing grid electricity:

    - The dispatch order of all grid-connected power plants;

    - The total grid electricity demand;

    - The quantity of electricity displaced by the project activity;

    - Identification of the plants that are in the top of the dispatch and for each plant information on electricity generation and, where hourly fuel consumption data is available, data on the types and quantities of fuels consumed during that hour;

The data should be presented in a manner that enables reproducing of the calculation of the build margin and operating margin grid emission factor.

Data and parameters

Data / parameter:	**$FC_{i,m,y}$, $FC_{i,y}$, $FC_{i,j,y}$, $FC_{i,k,y}$, $FC_{i,n,y}$ and $FC_{i,n,h}$**
Data unit:	Mass or volume unit
Description:	Amount of fossil fuel type *i* consumed by power plant / unit *m*, *j*, *k* or *n* (or in the project electricity system in case of $FC_{i,y}$) in year *y* or hour *h*
Source of data:	Utility or government records or official publications
Measurement procedures (if any):	-
Monitoring frequency:	• Simple OM, simple adjusted OM, average OM: Either once for each crediting period using the most recent three historical years for which data is available at the time of submission of the CDM-PDD to the DOE for validation (ex-ante option) or annually during the crediting period for the relevant year, following the guidance in step 2 above. • Dispatch data OM: If available, hourly, otherwise annually for the year *y* in which the project activity is displacing grid electricity or, if available, hourly • BM: For the first crediting period, either once *ex-ante* or annually *ex-post*, following the guidance included in step 4. For the second and third crediting period, only once *ex-ante* at the start of the second crediting period.
QA/QC procedures:	

Any comment:	Applicable in the following cases: • Calculation of power *unit* emission factors ($EF_{EL,m,y}$, $EF_{EL,j,y}$, $EF_{EL,k,y}$ and $EF_{EL,n,y}$), as per equation (3), in cases where fuel consumption data for the power unit is available; • Calculation of the simple OM, the simple adjusted OM and the average OM in cases where fuel consumption data is available for all power plants / units, as per equations (1) and (5) • Calculation of the hourly emission factor of plants in the top of the dispatch where hourly fuel consumption data is available, as per equation (9)

Data / Parameter:	**$NCV_{i,y}$**
Data unit:	GJ / mass or volume unit
Description:	Net calorific value (energy content) of fossil fuel type *i* in year *y*
Source of data:	The following data sources may be used if the relevant conditions apply: **Data source** / **Conditions for using the data source** Values provided by the fuel supplier of the power plants in invoices / If data is collected from power plant operators (e.g. utilities) Regional or national average default values / If values are reliable and documented in regional or national energy statistics / energy balances IPCC default values at the lower limit of the uncertainty at a 95% confidence interval as provided in Table 1.2 of Chapter 1 of Vol. 2 (Energy) of the 2006 IPCC Guidelines on National GHG Inventories
Measurement procedures (if any):	-
Monitoring frequency:	• Simple OM, simple adjusted OM, average OM: Either once for each crediting period using the most recent three historical years for which data is available at the time of submission of the CDM-PDD to the DOE for validation (ex-ante option) or annually during the crediting period for the relevant year, following the guidance in step 2 above. • Dispatch data OM: Annually for the year *y* in which the project activity is displacing grid electricity or, if available, hourly • BM: For the first crediting period, either once *ex-ante* or annually *ex-post*, following the guidance included in step 4. For the second and third crediting period, only once *ex-ante* at the start of the second crediting period.
QA/QC procedures:	

Any comment:	Applicable in the following cases: • Calculation of power *unit* emission factors ($EF_{EL,m,y}$, $EF_{EL,j,y}$, $EF_{EL,k,y}$ and $EF_{EL,n,y}$), as per equation (3), in cases where fuel consumption data for the power unit is available; • Calculation of the simple OM, the simple adjusted OM and the average OM in cases where fuel consumption data is available for all power plants / units, as per equations (1) and (5) • Calculation of the hourly emission factor of plants in the top of the dispatch where hourly fuel consumption data is available, as per equation (9) The gross calorific value (GCV) of the fuel can be used, if gross calorific values are provided by the data sources used. Make sure that in such cases also a gross calorific value basis is used for CO_2 emission factor.

Data / Parameter:	**$EF_{CO2,i,y}$ and $EF_{CO2,m,i,y}$**
Data unit:	tCO_2/GJ
Description:	CO_2 emission factor of fossil fuel type *i* in year *y*
Source of data:	The following data sources may be used if the relevant conditions apply:

Data source	**Conditions for using the data source**
Values provided by the fuel supplier of the power plants in invoices	If data is collected from power plant operators (e.g. utilities)
Regional or national average default values	If values are reliable and documented in regional or national energy statistics / energy balances
IPCC default values at the lower limit of the uncertainty at a 95% confidence interval as provided in table 1.4 of Chapter1 of Vol. 2 (Energy) of the 2006 IPCC Guidelines on National GHG Inventories	

Measurement procedures (if any):	-
Monitoring frequency:	• Simple OM, simple adjusted OM, average OM: Either once for each crediting period using the most recent three historical years for which data is available at the time of submission of the CDM-PDD to the DOE for validation (ex-ante option) or annually during the crediting period for the relevant year, following the guidance in step 2 above. • Dispatch data OM: Annually for the year *y* in which the project activity is displacing grid electricity or, if available, hourly • BM: For the first crediting period, either once *ex-ante* or annually *ex-post*, following the guidance included in step 4. For the second and third crediting period, only once *ex-ante* at the start of the second crediting period.
QA/QC procedures:	

Any comment:	-

Data / Parameter:	**$EG_{m,y}$, EG_y, $EG_{j,y}$, $EG_{k,y}$ and $EG_{n,h}$**
Data unit:	MWh
Description:	Net electricity generated and delivered to the grid by power plant / unit *m*, *j*, *k* or *n* (or in the project electricity system in case of EG_y) in year *y* or hour *h*
Source of data:	Utility or government records or official publications.
Measurement procedures (if any):	-
Monitoring frequency:	• Simple OM, simple adjusted OM, average OM: Either once for each crediting period using the most recent three historical years for which data is available at the time of submission of the CDM-PDD to the DOE for validation (ex-ante option) or annually during the crediting period for the relevant year, following the guidance in step 2 above. • Dispatch data OM: Hourly • BM: For the first crediting period, either once *ex-ante* or annually *ex-post*, following the guidance included in step 4. For the second and third crediting period, only once *ex-ante* at the start of the second crediting period.
QA/QC procedures:	
Any comment:	

Data / Parameter:	**$EG_{PJ,h}$**
Data unit:	MWh
Description:	Electricity displaced by the project activity in hour *h* of year *y*
Source of data:	As specified by the underlying methodology.
Measurement procedures (if any):	As specified by the underlying methodology.
Monitoring frequency:	Hourly
QA/QC procedures:	As specified by the underlying methodology.
Any comment:	Only applicable for the dispatch data OM

Data / parameter:	**$\eta_{m,y}$**
Data unit:	-
Description:	Average net energy conversion efficiency of power unit *m* in year *y*

<table>
<tr><td>Source of data:</td><td>Use either:
Documented manufacturer’s specifications (if the efficiency of the plant is not significantly increased through retrofits or rehabilitations); or
Data from the utility, the dispatch center or official records if it can be deemed reliable; or
The default values provided in the table below..
<table><tr><th>Power plant and technology type</th><th>Default net efficiency</th></tr><tr><td>###</td><td></td></tr><tr><td></td><td></td></tr><tr><td></td><td></td></tr><tr><td></td><td></td></tr></table></td></tr>
<tr><td>Measurement procedures (if any):</td><td>-</td></tr>
<tr><td>Monitoring frequency:</td><td>Once for the crediting period</td></tr>
<tr><td>QA/QC procedures:</td><td>If the data used is significantly lower than the default value of the applicable technology, project proponents should assess the reliability of the values, and provide appropriate justification if deemed reliable. Otherwise, the default values above shall be used.</td></tr>
<tr><td>Any comment:</td><td></td></tr>
</table>