Methodological Tool

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

(Version 02.2.1)

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 that generates electric power. Several power units at one site comprise one power plant, where~~by~~as a power unit is characterized by the fact that it can operate independently ~~of the~~ from 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.

Grid power plant/unit. A ~~P~~power plant/unit that supplies electricity to an electricity grid and, if applicable, to specific consumers. This means that power plants supplying electricity to the grid and specific captive consumers at the project are considered as a grid power plant/unit, while power plants that serve only captive consumers and do not supply electricity to the grid are not considered as a grid power plant/unit.

Off-grid power plant/unit. A ~~P~~power plant/unit that supplies electricity to specific consumers through a dedicated **distribution** network which is not used by any other power plants. For a power plant to be categorized as off-grid, the following conditions need be fulfilled:

(i) A grid (or grids) capable of supplying power to the specific consumer(s) to which the off-grid facility is connected, must exist;

(ii) The off-grid facility is not connected to the grid(s) and cannot supply power to the grid(s), but only to the consumer(s) to which it is connected;

(iii) Under normal conditions, the consumer(s) are supplied their power requirements from the grid only, i.e. the off-grid plant(s) which ~~are~~ is connected to the consumer(s) ~~are~~ is a standby on-site facility(ies) that ~~are~~ is only used when power supply from the grid fails (or in many cases, when the quality of power supply to the end-user is below acceptable quality);

(iv) To ensure a ~~sound~~ proper shift from the grid supply to the off-grid supply, the consumer has~~ve~~ in place a change-over-switch system (which may be manual or automatic).

Net electricity generation refers to the difference between the total quantity of electricity generated by the power plant/unit and the auxiliary electricity consumption (also known as parasitic load) of the power plant/unit (e.g. for pumps, fans, controlling etc).

A ~~G~~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.

Connected electricity system is an 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.

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 "combined margin" emission factor (CM) of the electricity system. The CM is the result of a weighted average of two emission factors pertaining to the electricity system: the "operating margin" (OM) and the "build margin" (BM). The operating margin is the emission factor that refers to the group of existing power plants whose current electricity generation would be affected by the proposed CDM project activity. The build margin is the emission factor that refers to the group of prospective power plants whose construction and future operation would be affected by the proposed CDM project activity.

This tool may be applied to estimate the OM, BM and/or CM when calculating baseline emissions for a project activity that substitutes grid electricity, 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).

Under this tool, the emission factor for the project electricity system can be calculated either for grid power plants only or, as an option, can include off-grid power plants. In the latter case, the conditions specified in "Annex 2 - Procedures related to off-grid power generation" should be met. Namely, the total capacity of off-grid power plants (in MW) should be at least 10% of the total capacity of grid power plants in the electricity system; or the total ~~power~~ electricity generation by off-grid power plants (in MWh) should be at least 10% of the total ~~power~~ electricity generation by grid power plants in the electricity system; and that factors which negatively affect the reliability and stability of the grid are primarily due to constraints in generation and not to other aspects such as transmission capacity.

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.

In case of CDM projects ~~T~~the tool is not applicable if the project electricity system is located partially or totally in an Annex I country.

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 the project electricity system in year *y*
$EF_{grid,BM,y}$	tCO_2/MWh	Build margin CO_2 emission factor for the project electricity system in year *y*
$EF_{grid,OM,y}$	tCO_2/MWh	Operating margin CO_2 emission factor for the project electricity system 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 electricity systems;
STEP 2. Choose whether to include off-grid power plants in the project electricity system (optional);
STEP 3. Select a method to determine the operating margin (OM);
STEP 4. Calculate the operating margin emission factor according to the selected method;
STEP 5. Calculate the build margin (BM) emission factor;
STEP 6. Calculate the combined margin (CM) emissions factor.

Step 1: Identify the relevant electricity systems

For determining the electricity emission factors, identify the relevant ~~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, identify any ~~a~~ **connected electricity systems**~~, e.g. national or international, is defined as an 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 a connected electricity system is located partially or totally in Annex-I countries, then the emission factor of that connected electricity system should be considered zero.

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 this information is not available, project participants should define the project electricity system and any connected electricity system, and justify

and document their assumptions in the CDM-PDD. The following criteria can be used to determine the existence of significant transmission constraints:[1]

- 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 larger) grid definition should be used by default. Document the geographical extent of the project electricity system transparently and identify all grid power plants/units connected to the system.

For the purpose of this tool, the reference system is the project electricity system. Hence e~~E~~lectricity transfers from a connected electricity systems to the project electricity system are defined as **electricity imports** while ~~and~~ electricity transfers from the project electricity system 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 the 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 from a connected electricity system:

0 tCO_2/MWh; or

(a) The weighted average operating margin (OM) emission rate of the exporting grid, determined as described in Step 4 (d) below; or

(b) The simple operating margin emission rate of the exporting grid, determined as described in Step 4 (a), if the conditions for this method, as described in Step 3 below, apply to the exporting grid; or

(c) The simple adjusted operating margin emission rate of the exporting grid, determined as described in Step 4 (b) below.

For imports from connected electricity systems located in Annex I country(ies), the emission factor is 0 tons CO_2 per MWh.

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

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

Step 2: Choose whether to include off-grid power plants in the project electricity system (optional)

Project participants may choose between the following two options to calculate the operating margin and build margin emission factor:

Option I: Only grid power plants are included in the calculation.

Option II: Both grid power plants and off-grid power plants are included in the calculation.

Option I corresponds to the procedure contained in earlier versions of this tool. Option II allows the inclusion of off-grid power generation in the grid emission factor. Option II aims to reflect that in some countries off-grid power generation is significant and can partially be displaced by CDM project activities, e.g. if off-grid power plants are operated due to an unreliable and unstable electricity grid. Option II requires collecting data on off-grid power generation as per Annex 2 and can only be used if the conditions outlined therein are met. Option II may be chosen only for the operating margin emission factor or for both the build margin and the operating margin emission factor but not only for the build margin emission factor.

If Option II is chosen, off-grid power plants should be classified as per the guidance in Annex 2 in different classes of off-grid power plants. Each off-grid power plant class should be considered as one power plant *j*, *k*, *m* or *n* in the following steps, as applicable.

Step 3: Select a method to determine the operating margin (OM)

The calculation of the operating margin emission factor ($EF_{grid,OM,y}$) is based on one of the following methods, which are described under Step 4:

(a) Simple OM; or

(b) Simple adjusted OM; or

(c) Dispatch data analysis OM; or

(d) Average OM.

~~Each method is described under Step 4.~~

The simple OM method (Option ~~A~~a) can only be used if low-cost/must-run resources[2] 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.

[2] 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.

The dispatch data analysis (Option ~~cd~~) cannot be used if off-grid power plants are included in the project electricity system as per Step 2 above.

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: If the *ex ante* option is chosen, the emission factor is determined once at the validation stage, thus no monitoring and recalculation of the emissions factor during the crediting period is required. For grid power plants, use 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. For off-grid power plants, use a single calendar year within the five ~~5~~ most recent calendar years prior to the time of submission of the CDM-PDD for validation.
- *Ex post* option: If the *ex post* option is chosen, the emission factor is determined for 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 should not be changed during the crediting period.

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.

Step 4: 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 (tCO_2/MWh) of all generating power plants serving the system, not including low-cost/must-run power plants/units.

The simple OM may be calculated by one of the following two options:

Option A: Based on the net electricity generation and a CO_2 emission factor of each power unit;[3] or

[3] 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.

Option B: Based 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 B can only be used if:

(a) The necessary data for Option A is not available; and

(b) Only nuclear and renewable power generation are considered as low-cost/must-run power sources and the quantity of electricity supplied to the grid by these sources is known; and

(c) Off-grid power plants are not included in the calculation (i.e. if Option I has been chosen in Step 2).

Option A - Calculation based on average efficiency and electricity generation of each plant

Under this option, the simple OM emission factor is calculated based on the net electricity generation of each power unit and an emission factor for each power unit, as follows:

$$EF_{grid,OMsimple,y} = \frac{\sum_{m} EG_{m,y} \times EF_{EL,m,y}}{\sum_{m} EG_{m,y}} \quad \textbf{(1)}$$

Where:

$EF_{grid,OMsimple,y}$ = Simple operating margin CO_2 emission factor in year *y* (tCO_2/MWh)
$EG_{m,y}$ = 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 = The relevant year as per the data vintage chosen in Step 3

Determination of $EF_{EL,m,y}$

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

- **Option A1.** 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:

$$EF_{EL,m,y} = \frac{\sum_{i} FC_{i,m,y} \times NCV_{i,y} \times EF_{CO2,i,y}}{EG_{m,y}} \quad \textbf{(2)}$$

Where:

$EF_{EL,m,y}$ = 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	=	The relevant year as per the data vintage chosen in Step 3

- **Option A2.** 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:

$$EF_{EL,m,y} = \frac{EF_{CO2,m,i,y} \times 3.6}{\eta_{m,y}} \quad \textbf{(3)}$$

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* (ratio)
m	=	All power units serving the grid in year *y* except low-cost/must-run power units
y	=	The relevant year as per the data vintage chosen in Step 3

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 A3.** 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.

Determination of $EG_{m,y}$

For grid power plants, $EG_{m,y}$ should be determined as per the provisions in the monitoring tables.

For off-grid power plants, $EG_{m,y}$ can be determined using one of the following options:[4]

- **Option 1.** $EG_{m,y}$ is determined based on (sampled) data on the electricity generation of off-grid power plants, as per the guidance in Annex 2.
- **Option 2.** $EG_{m,y}$ is determined based on (sampled) data on the quantity of fossil fuels combusted in the class of off-grid power plants *m*, as per the guidance in Annex 2, and the default efficiencies provided in Annex 1, as follows:

$$EG_{m,y} = \sum_i FC_{i,m,y} \times NCV_{i,y} \times \eta_{m,y} \quad \textbf{(4)}$$

[4] Note that different options can be applied to different classes of off-grid power plants; however, the same option should be applied to all (sampled) off-grid power plants within one class.

$$EG_{m,y} = \frac{\sum_i FC_{i,m,y} \times NCV_{i,y} \times \eta_{m,y}}{3.6} \quad \textbf{(4)}$$

Where:

$EG_{m,y}$	=	Net quantity of electricity generated and delivered to the grid by power unit *m* in year *y* (MWh)
$FC_{i,m,y}$	=	Amount of fossil fuel type *i* consumed by power plants included in off-grid power plant class *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)
$\eta_{m,y}$	=	Default net energy conversion efficiency of off-grid power plant class *m* in year *y* (ratio)
m	=	Off-grid power plant class considered as one power unit (as per the provisions in Annex 2 to this tool)
y	=	The relevant year as per the data vintage chosen in Step 3
i	=	Fossil fuel types used

- **Option 3.** $EG_{m,y}$ is estimated based on the capacity of off-grid electricity generation in that class and a default plant load factor, as follows:

$$EG_{m,y} = CAP_m \times PLF_{default,off-grid,y} \times 8760 \quad \textbf{(5)}$$

Where:

$EG_{m,y}$	=	Net quantity of electricity generated and delivered to the grid by power unit *m* in year *y* (MWh)
CAP_m	=	Total capacity of off-grid power plants in included in off-grid power plant class *m* (MW)
$PLF_{default,off-grid,y}$	=	Default plant load factor for off-grid generation in year *y* (ratio)
m	=	Off-grid power plant class considered as one power unit (as per the provisions in Annex 2 to this tool)
y	=	The relevant year as per the data vintage chosen in Step 3

The default plant load factor for off-grid generation ($PLF_{default,off-grid,y}$) should be determined using one of the following two options:

- Use a conservative default value of 300 hours per year, assuming that the off-grid power plants would at least operate for one hour per day at six days at full capacity (i.e. $PLF_{default,off-grid,y}$=300/8760); or
- Calculate the default plant load factor based on the average grid availability and a default factor of 0.5, assuming that off-grid power plants are operated at full load during approximately half of the time that the grid is not available, as follows:

~~$$PLF_{default,off-grid,y} = 8760 \times (1 - \frac{T_{grid,y}}{8760}) \times 0.5 \quad (6)$$~~

$$PLF_{default,off-grid,y} = (1 - \frac{T_{grid,y}}{8760}) \times 0.5 \quad (6)$$

Where:

$PLF_{default,off-grid,y}$ = Default plant load factor for off-grid generation in year *y* (ratio)
$T_{grid,y}$ = Average time the grid was available to final electricity consumers in year *y* (hours)

Option B - Calculation based on total fuel consumption and electricity generation of the system

Under this option, 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:

$$EF_{grid,OMsimple,y} = \frac{\sum_i \left(FC_{i,y} \times NCV_{i,y} \times EF_{CO2,i,y}\right)}{EG_y} \quad (7)$$

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 = The relevant year as per the data vintage chosen in Step 3

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 ($EF_{grid,OM-adj,y}$) 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 (*m*). As under Option A of the simple OM, it is calculated based on the net electricity generation of each power unit and an emission factor for each power unit, as follows:

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

$$EF_{grid,OM\text{-}adj,y} = (1-\lambda_y)\times \frac{\sum_m EG_{m,y}\times EF_{EL,m,y}}{\sum_m EG_{m,y}} + \lambda_y \times \frac{\sum_k EG_{k,y}\times EF_{EL,k,y}}{\sum_k EG_{k,y}} \quad \textbf{(8)}$$

Where:

$EF_{grid,OM\text{-}adj,y}$	=	Simple adjusted operating margin CO_2 emission factor in year *y* (tCO_2/MWh)
λ_y	=	Factor expressing the percentage of time when low-cost/must-run power units are on the margin in year *y*
$EG_{m,y}$	=	Net quantity of electricity generated and delivered to the grid by power unit *m* in year *y* (MWh)
$EG_{k,y}$	=	Net quantity of electricity generated and delivered to the grid by power unit *k* in year *y* (MWh)
$EF_{EL,m,y}$	=	CO_2 emission factor of power unit *m* in year *y* (tCO_2/MWh)
$EF_{EL,k,y}$	=	CO_2 emission factor of power unit *k* in year *y* (tCO_2/MWh)
m	=	All grid power units serving the grid in year *y* except low-cost/must-run power units
k	=	All low-cost/must run grid power units serving the grid in year *y*
y	=	The relevant year as per the data vintage chosen in Step 3

$EF_{EL,m,y}$, $EF_{EL,k,y}$, $EG_{m,y}$ and $EG_{k,y}$ should be determined using the same procedures as those for the parameters $EF_{EL,m,y}$ and $EG_{m,y}$ in Option A of the simple OM method above.

If off-grid power plants are included in the operating margin emission factor, off-grid power plants should be treated as other power units *m*.

Net electricity imports must be considered low-cost/must-run units *k*.

The parameter λ_y is defined as follows:

$$\lambda_y\,(\%) = \frac{\text{Number of hours low - cost / must - run sources are on the margin in year y}}{\text{8760 hours per year}} \quad \textbf{(9)}$$

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.

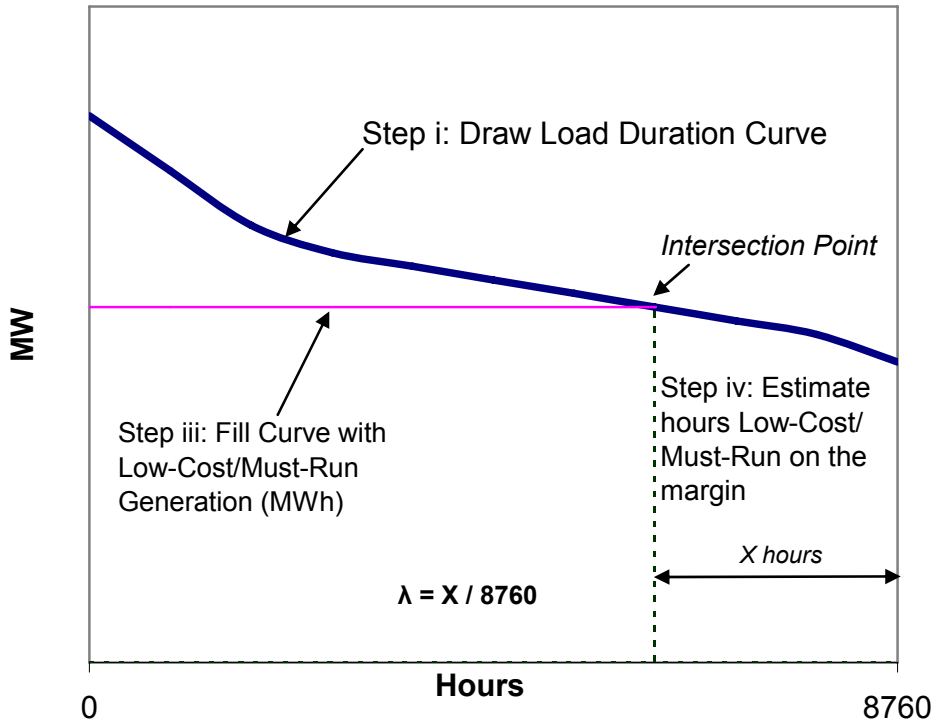
Step (ii) Collect ~~power~~ electricity generation data from each power plant/unit. Calculate the total annual generation (in MWh) from low-cost/must-run power plants/units (i.e. $\sum_k EG_{k,y}$).

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.

In determining λ_y only grid power units (and no off-grid power plants) should be considered.



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

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

(c) Dispatch data analysis OM

The dispatch data analysis OM emission factor ($EF_{grid,OM\text{-}DD,y}$) is determined based on the grid power units that are actually dispatched at the margin during each hour *h* where the project is displacing grid 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:

$$EF_{grid,OM-DD,y} = \frac{\sum_{h} EG_{PJ,h} \times EF_{EL,DD,h}}{EG_{PJ,y}} \quad \textbf{(10)}$$

Where:

$EF_{grid,OM-DD,y}$ = 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 grid 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:

$$EF_{EL,DD,h} = \frac{\sum_{i,n} FC_{i,n,h} \times NCV_{i,y} \times EF_{CO2,i,y}}{\sum_{n} EG_{n,h}} \quad \textbf{(11)}$$

Where:

$EF_{EL,DD,h}$ = CO_2 emission factor for grid 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 grid 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 grid power unit *n* in hour *h* (MWh)
n = Grid power units in the top of the dispatch (as defined below)
i = Fossil fuel types combusted in grid 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 emission factor is calculated based on the energy efficiency of the grid power unit and the fuel type used, as follows:

$$EF_{EL,DD,h} = \frac{\sum_{n} EG_{n,h} \times EF_{EL,n,y}}{\sum_{n} EG_{n,h}} \quad \textbf{(12)}$$

Where:

$EF_{EL,DD,h}$	=	CO_2 emission factor for grid 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 grid power unit *n* in hour *h* (MWh)
$EF_{EL,n,y}$	=	CO_2 emission factor of grid power unit *n* in year *y* (tCO_2/MWh)
n	=	Grid 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 grid power units *n* ($FE_{EL,n,y}$) should be determined as per the guidance for the simple OM, using the Options A1, A2 or A3.

To determine the set of grid 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 grid power unit of the system including power units from which electricity is imported; and
- The amount of power (MWh) that is dispatched from all grid power units in the system during each hour *h* that the project activity is displacing electricity.

At each hour *h*, stack each grid power unit's electricity generation using the merit order. The group of grid 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 by grid power plants 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 also including the low-cost/must-run power plants in all equations ~~also low-cost/must-run power plants~~.

Option B should only be used if the necessary data for Option A is not available.

Step 5: Calculate the build margin (BM) 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.

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

The sample group of power units *m* used to calculate the build margin should be determined as per the following procedure, consistent with the data vintage selected above:

(a) Identify the set of five power units, excluding power units registered as CDM project activities, that started to supply electricity to the grid most recently ($SET_{5\text{-units}}$) and determine their annual electricity generation ($AEG_{SET\text{-}5\text{-}units}$, in MWh);

(b) Determine the annual electricity generation of the project electricity system, excluding power units registered as CDM project activities (AEG_{total}, in MWh). Identify the set of power units, excluding power units registered as CDM project activities, that started to supply electricity to the grid most recently and that comprise 20% of AEG_{total} (if 20% falls on part of the generation of a unit, the generation of that unit is fully included in the calculation) ($SET_{\geq 20\%}$) and determine their annual electricity generation ($AEG_{SET\text{-}\geq 20\%}$, in MWh);

(c) From $SET_{5\text{-units}}$ and $SET_{\geq 20\%}$ select the set of power units that comprises the larger annual electricity generation (SET_{sample});

Identify the date when the power units in SET_{sample} started to supply electricity to the grid. If none of the power units in SET_{sample} started to supply electricity to the grid more than 10 years ago, then use SET_{sample} to calculate the build margin. In this case i~~I~~gnore steps (d), (e) and (f) ~~below~~.

Otherwise:

(d) Exclude from SET_{sample} the power units which started to supply electricity to the grid more than 10 years ago. Include in that set the power units registered as CDM project activit~~y~~ies, starting with power units that started to supply electricity to the grid most recently, until the electricity generation of the new set comprises 20% of the annual electricity generation of the project electricity system (if 20% falls on part of the generation of a unit, the generation of that unit is fully included in the calculation) to the extent is possible. Determine for the resulting set ($SET_{sample\text{-}CDM}$) the annual electricity generation ($AEG_{SET\text{-}sample\text{-}CDM}$, in MWh);

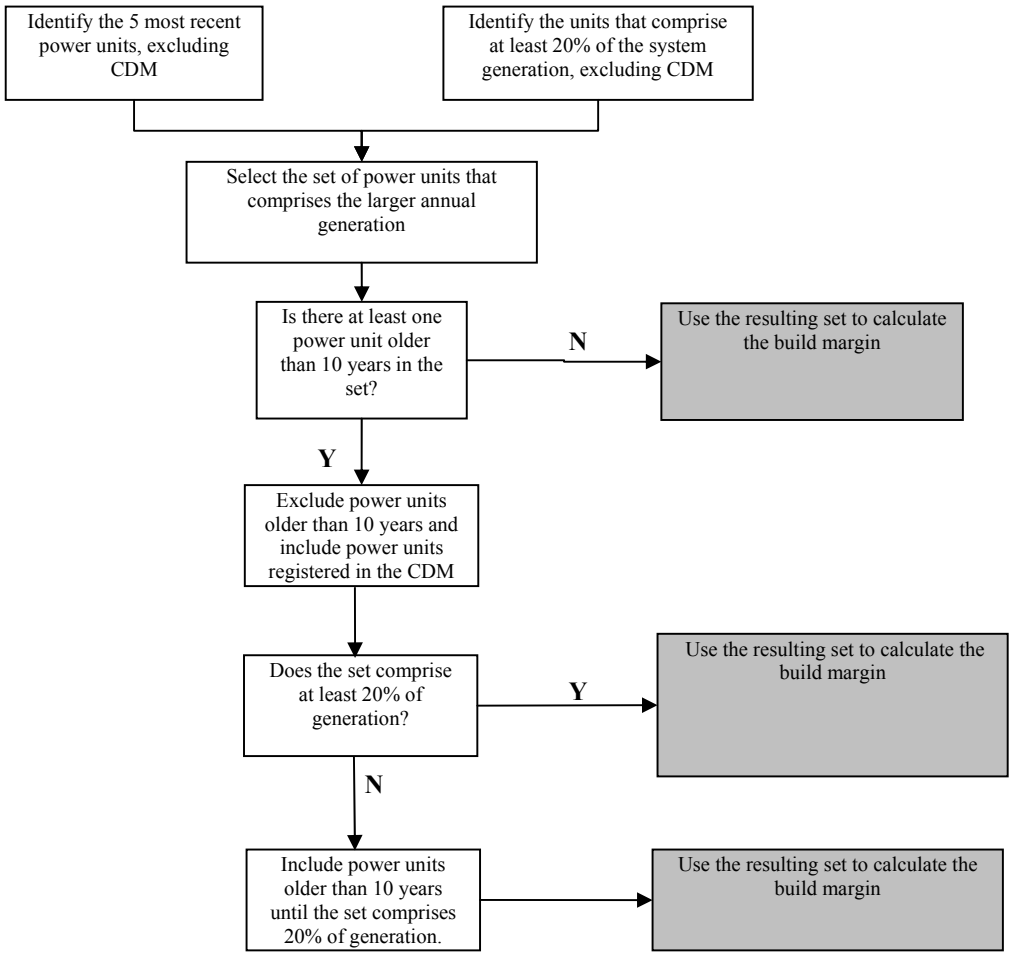
If the annual electricity generation of that set is comprises at least 20% of the annual electricity generation of the project electricity system (i.e. $AEG_{SET\text{-}sample\text{-}CDM} \geq 0.2 \times AEG_{total}$), then use the sample group $SET_{sample\text{-}CDM}$ to calculate the build margin. Ignore steps (e) and (f).

Otherwise:

(e) Include in the sample group $SET_{sample\text{-}CDM}$ the power units that started to supply electricity to the grid more than 10 years ago until the electricity generation of the new set comprises 20% of the annual electricity generation of the project electricity system (if 20% falls on part of the generation of a unit, the generation of that unit is fully included in the calculation);

(f) The sample group of power units m used to calculate the build margin is the resulting set ($SET_{sample\text{-}CDM\text{->}10yrs}$).

The following diagram summarizes the procedure above:



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~~electricity generation data is available, calculated as follows:

$$EF_{grid,BM,y} = \frac{\sum_{m} EG_{m,y} \times EF_{EL,m,y}}{\sum_{m} EG_{m,y}} \quad \textbf{(13)}$$

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~~electricity 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 4 (a) for the simple OM, using options A1, A2 or A3, using for *y* the most recent historical year for which ~~power~~electricity generation data is available, and using for *m* the power units included in the build margin.

If the power units included in the build margin *m* correspond to the sample group $SET_{sample\text{-}CDM\text{->}10yrs}$, then, as a conservative approach, only option A2 from guidance in Step 4 (a) can be used and the default values provided in Annex 1 shall be used to determine the parameter $\eta_{m,y}$.

For off-grid power plants, $EG_{m,y}$ should be determined as per the guidance in Step 4.

Step 6 : Calculate the combined margin emissions factor

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

(a) Weighted average CM; or

(b) Simplified CM.

The weighted average CM method (option A) should be used as the preferred option.

The simplified CM method (option b) can only be used if:

- The project activity is located in a Least Developed Country (LDC) or in a country with less than 10 registered CDM projects at the starting date of validation; and
- The data requirements for the application of step 5 above cannot be met.

(a) Weighted average CM

The combined margin emissions factor is calculated as follows:

$$EF_{grid,CM,y} = EF_{grid,OM,y} \times w_{OM} + EF_{grid,BM,y} \times w_{BM} \quad \textbf{(14)}$$

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,[6] 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.

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 output 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

[6] 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.

Factor	Summary – Impact on weights	Further Explanation
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[7]
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[8]
For system management (nature of local electricity markets, planning, and actors) and other considerations no guidance is available at present.		

(b) Simplified CM

The combined margin is calculated using equation 14 above with the following conditions:

- $w_{BM} = 0$;
- $w_{OM} = 1$;

Under the simplified CM, the operating margin emission factor ($EF_{grid,OM,y}$) must be calculated using the average OM (option (d) in step 3).

Data and parameters not monitored

Included in the monitoring methodology.

[7] 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.

[8] 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.

III. MONITORING METHODOLOGY

All data collected as part of monitoring should be archived electronically and be kept for at least two years ~~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:

- The following information f~~F~~or 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);[9]
  - If applicable: the fuel consumption of each fuel type in the relevant year(s);
  - In cases 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;
- 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;

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

- 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.

In case off-grid power plants are included, the guidance for monitoring data and parameters related to off-grid plants provided in Annex 2 should also be followed.

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:	$FC_{i,m,y}$, $FC_{i,y}$, $FC_{i,k,y}$, $FC_{i,n,y}$ and $FC_{i,n,h}$
Data unit:	Mass or volume unit
Description:	Amount of fossil fuel type *i* consumed by power plant/unit *m*, *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 3 above; • Dispatch data OM: If available, hourly (as per Step 3 above), otherwise annually for the year *y* in which the project activity is displacing grid electricity ~~or, if available, hourly~~. Further guidance can be found in Step 3 above; • BM: For the first crediting period, either once *ex ante* or annually *ex post*, following the guidance included in Step 5. For the second and third crediting period, only once *ex ante* at the start of the second crediting period.
QA/QC procedures:	-
Any comment:	-

<table>
<tr><td>Data / Parameter:</td><td>$NCV_{i,y}$</td></tr>
<tr><td>Data unit:</td><td>GJ/mass or volume unit</td></tr>
<tr><td>Description:</td><td>Net calorific value (energy content) of fossil fuel type i in year y</td></tr>
<tr><td>Source of data:</td><td>The following data sources may be used if the relevant conditions apply:
<table>
<tr><th>Data source</th><th>Conditions for using the data source</th></tr>
<tr><td>Values provided by the fuel supplier of the power plants in invoices</td><td>If data is collected from power plant operators (e.g. utilities)</td></tr>
<tr><td>Regional or national average default values</td><td>If values are reliable and documented in regional or national energy statistics/energy balances</td></tr>
<tr><td>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</td><td></td></tr>
</table></td></tr>
<tr><td>Measurement procedures (if any):</td><td>-</td></tr>
<tr><td>Monitoring frequency:</td><td>• 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 3 above;
• Dispatch data OM: Annually for the year y in which the project activity is displacing grid electricity or, if available, hourly. Further guidance can be found in Step 3 above;
• BM: For the first crediting period, either once ex ante or annually ex post, following the guidance included in Step 5. For the second and third crediting period, only once ex ante at the start of the second crediting period</td></tr>
<tr><td>QA/QC procedures:</td><td>-</td></tr>
<tr><td>Any comment:</td><td>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</td></tr>
</table>

<table>
<tr><td>Data / Parameter:</td><td>$EF_{CO2,i,y}$ and $EF_{CO2,m,i,y}$</td></tr>
<tr><td>Data unit:</td><td>tCO_2/GJ</td></tr>
<tr><td>Description:</td><td>CO_2 emission factor of fossil fuel type i used in power unit m in year y</td></tr>
<tr><td>Source of data:</td><td>The following data sources may be used if the relevant conditions apply:
<table>
<tr><th>Data source</th><th>Conditions for using the data source</th></tr>
<tr><td>Values provided by the fuel supplier of the power plants in invoices</td><td>If data is collected from power plant operators (e.g. utilities)</td></tr>
<tr><td>Regional or national average default values</td><td>If values are reliable and documented in regional or national energy statistics / energy balances</td></tr>
<tr><td>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</td><td></td></tr>
</table></td></tr>
<tr><td>Measurement procedures (if any):</td><td>-</td></tr>
<tr><td>Monitoring frequency:</td><td>• 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 3 above;
• Dispatch data OM: Annually for the year y in which the project activity is displacing grid electricity or, if available, hourly. Further guidance can be found in Step 3 above;
• BM: For the first crediting period, either once ex ante or annually ex post, following the guidance included in Step 5. For the second and third crediting period, only once ex ante at the start of the second crediting period</td></tr>
<tr><td>QA/QC procedures:</td><td>-</td></tr>
<tr><td>Any comment:</td><td>-</td></tr>
</table>

Data / Parameter:	$EG_{m,y}$, EG_y, $EG_{k,y}$ and $EG_{n,h}$
Data unit:	MWh
Description:	Net electricity generated by power plant/unit *m*, *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 3 above; • Dispatch data OM: Hourly. Further guidance can be found in Step 3 above; • BM: For the first crediting period, either once *ex ante* or annually *ex post*, following the guidance included in Step 5. 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:	$EG_{PJ,h}$ and $EG_{PJ,y}$
Data unit:	MWh
Description:	Electricity displaced by the project activity in hour *h* of year *y*, or in year *y*
Source of data:	As specified by the underlying methodology
Measurement procedures (if any):	As specified by the underlying methodology
Monitoring frequency:	Hourly or yearly, as applicable
QA/QC procedures:	As specified by the underlying methodology
Any comment:	-

Data / Parameter:	$\eta_{m,y}$ and $\eta_{k,y}$
Data unit:	-
Description:	Average net energy conversion efficiency of power unit *m* or *k* in year *y*
Source of data:	Use either: • Documented manufacturer's specifications (if the efficiency of the plant is not significantly increased through retrofits or rehabilitations); or • For grid power plants: 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 in Annex 1 (if available for the type of power plant)
Measurement procedures (if any):	-

Monitoring frequency:	Once for the crediting period
QA/QC procedures:	If the data obtained from the manufacturer, the utility, the dispatch center of official records is significantly lower than the default value provided in Annex 1 for the applicable technology, project proponents should assess the reliability of the values, and provide appropriate justification if deemed reliable. Otherwise, the default values provided in Annex 1 shall be used
Any comment:	-

Data / Parameter:	CAP_m
Data unit:	MW
Description:	Total capacity of off-grid power plants included in off-grid power plant class *m*
Source of data:	Survey on off grid-power plants, as per Annex 2
Measurement procedures (if any):	As per Annex 2
Monitoring frequency:	As per the provisions in Step 3 of this tool
QA/QC procedures:	-
Any comment:	Only applicable if Option II is chosen in Step 2 of this tool

Data / Parameter:	$PLF_{default,off-grid,y}$
Data unit:	dimensionless
Description:	Plant load factor for off-grid generation in year *y*
Source of data:	Default value of 300 hours per year, or calculate on the basis of equation 7
Measurement procedures (if any):	-
Monitoring frequency:	As per the provisions in Step 3 of this tool
QA/QC procedures:	-
Any comment:	Only applicable if Option II is chosen in Step 2 of this tool and if Option 3 is chosen to determine $EG_{m,y}$ in Step 4 of this tool

Data / Parameter:	$T_{grid,y}$
Data unit:	hours
Description:	Average time the grid was available to final electricity consumers in year *y*
Source of data:	Utility or government records or official publications
Measurement procedures (if any):	-
Monitoring frequency:	-
QA/QC procedures:	-
Any comment:	Only applicable if Option II is chosen in Step 2 of this tool and if Option 3 is chosen to determine $EG_{m,y}$ in Step 4 of this tool and if equation (7) is applied

Data / Parameter:	Other parameters related to off-grid power plants
Data unit:	As per Annex 2
Description:	As per Annex 2
Source of data:	As per Annex 2
Measurement procedures (if any):	As per Annex 2
Monitoring frequency:	As per Annex 2
QA/QC procedures:	As per Annex 2
Any comment:	-

Annex 1: Default efficiency factors for power plants

Grid power plants		
Generation Technology	**Old units (before and in 2000)**	**New units (after 2000)**
Coal	-	-
Subcritical	37%	39%
Supercritical	-	45%
Ultra-supercritical	-	50%
IGCC	-	50%
FBS	35.5%	-
CFBS	36.5%	40%
PFBS	-	41.5%
Oil	-	-
Steam turbine	37.5%	39%
Open cycle	30%	39.5%
Combined cycle	46%	46%
Naural gas	-	-
Steam turbine	37.5%	37.5%
Open cycle	30%	39.5%
Combined cycle	46%	60%

	Off-grid power plants						
	Nominal capacity of power plants (CAP, in kW)						
Generation Technology	**CAP≤10**	**10<CAP≤50**	**50<CAP≤100**	**100<CAP≤200**	**200<CAP≤400**	**400<CAP≤1000**	**CAP>1000**
Reciprocant engine system (e.g. diesel-, fuel oil-, gas-engines)	28%	33%	35%	37%	39%	42%	45%
Gas turbine systems	28%	32%	34%	35%	37%	40%	42%
Small boiler/steam/turbine system	7%	7%	7%	7%	7%	7%	N/A

Annex 2: Procedures related to off-grid power generation

The procedures in this annex serve to (a) identify those off-grid power plants that are eligible for inclusion in the grid emission factor and to (b) collect the necessary data to include them in the calculations of the operating and build margin emission factors of this tool.

Step 1: Obtain data on off-grid power generation

Data on off-grid power generation is usually not readily available and has to be collected in order to include off-grid power generation in the grid emission factor. The collection of data on off-grid power generation has two purposes: data is required to determine whether an identified power plant qualifies as "off-grid power plant", as defined in the definitions section; and data is required to calculate the emissions and electricity generation from off-grid power plants.

For this purpose, project proponents can conduct their ~~an~~ own survey, or use existing data (if such data provides the necessary information as outlined further below and if the existing data has the vintage as required per this tool).

The collected data can be used in the following two ways:

(a) **Direct use of data on a plant-by-plant basis:** Include in the emission factor only those off-grid power plants for which the necessary data is available or is collected. Ensure that the plants selected for inclusion in the grid emission factor are reasonably representative for the overall off-grid power generation in the electricity system;[10]

(b) **Statistical evaluation of the data based on sampling:** Collect the necessary data for a representative and appropriately stratified sample of off-grid power plants and infer the data to the entire electricity system.

Document in the CDM-PDD which approach is followed.

Step 1.1: Choose the data to be collected

Document which data is collected for each (sampled) off-grid power plant. Table 1 provides the minimum data that must be collected for each (sampled) off-grid power plant *p*.

[10] For example, information on off-grid power generation could only be available for some sectors of the economy. In this case, only the plants from these sectors may be included in the grid emission factor. However, in including selected plants, no systematic bias should be introduced (e.g. by including only coal fired plants).

Table 1: Minimum data/information to be collected on each off-grid power plant *p*

Data	Description
CAP_p:	Nominal electric capacity of the off-grid power plant *p* (MW)
$TECH_p$:	The type of technology of the off-grid power plant *p*. This should include, *inter alia*, the following types of technologies: (a) Reciprocating engines (b) Steam turbine (c) Gas turbine (d) Combined cycle power generation (e) Hydro, solar wind or geothermal power generation
$FUEL_p$:	The fuel type(s) used in the off-grid power plant *p*. This should include at least the following fuel types: (a) Diesel (b) Gasoline (c) Kerosene (d) Natural gas (e) Coal (f) Biomass/biofuels (g) Any relevant blends or other fuels
$GRID_p$:	Are the consumers supplied by the off-grid power plant also connected to an electricity grid which is capable of supplying their power demand entirely during time intervals where grid electricity is available, reliable and stable? (True/false)
$SWITCH_p$:	Can the consumers supplied by the off-grid power plant easily switch between electricity supply from the grid and off-grid power plants? This applies, for example, if the consumers have a manual or automatic change-over-switch system in place. (True/false)

In addition, other data may be collected, depending on how the requirements of this annex for inclusion of an off-grid power plant *p* in the grid emission factor are assessed and on which options are used in Step 3 of the tool to calculate the emission factor for a class of off-grid power plants m (Option A1, A2 or A3) and the electricity generation by a class of off-grid power plants m (Option 1, 2 or 3). This may include the following data:

Table 2: Additional data that may be collected on off-grid power generation

Data	Description	Explanation
$DATE_{start,p}$:	Year of first commissioning of the off-grid power plant *p* (year)	This data is required for inclusion of off-grid power in the BM emission factor
$EG_{p,y}$:	Electricity generation of off-grid power plant *p* in year *y* (MWh)	This data is required if Option 1 is used to determine $EG_{m,y}$ in Step 4 of the tool
$FC_{p,i,y}$:	Amount of fuel type *i* consumed by off-grid power plant *p* in year *y* (mass or energy unit)	This data is required if Option A1 in Step 4 of this tool is applied of if Option 2 is used to determine $EG_{m,y}$ in Step 4 of the tool
$NCV_{p,i,y}$:	Net calorific value of fuel type i consumed by off-grid power plant *p* in year *y* (GJ/mass or energy unit)	This data is required if Option A1 or Option 2 in Step 4 of this tool is applied and if the IPCC default values are not used

Data	Description	Explanation
$OMC_{p,y}$:	Variable operation and maintenance costs of off-grid power plant *p* in year *y* (currency/MWh)	This is data is required if in Step 2 the third condition is demonstrated by using Option (a)
$T_{EL,p,y}$:	Tariff of purchasing grid electricity for consumers supplied by off-grid power plant *p* in year *y*	This is data is required if in Step 2 the third condition is demonstrated by using Option (a)

Note that the same data collection approach should be applied to all off-grid plants in one sector (e.g. industrial, commercial and residential sector).

Step 1.2: Define the classification of off-grid power plants

To facilitate data collection and calculations, off-grid power plants should be classified in different classes of off-grid power plants. All off-grid power plants included in one class are considered as one single power unit for the calculations in this tool.

Off-grid power plants should be classified according to their capacity (CAP_p), fuel type ($FUEL_p$), and type of technology ($TECH_p$). If off-grid power plants are also included in the build margin, their vintage needs to be determined based on the start date of operation ($DATE_{start,p}$). In this case, the classes have to be differentiated into three data vintages: plants with up to five years of operation, plants with up to 10 years of operation and plants with more than 10 years of operation.

If default efficiencies, as provided in Annex 1 of this tool, are used to determine the emission factor for a power plant (see Option A2 in Step 4 of this tool), the power plant classification provided in Annex 1 should be used. If the Options A1 and/or A3 in Step 4 of this tool are applied to determine the emission factors for off-grid power plant classes, project participants may also use their own classification.

Step 1.3: Define the sectors for which data is collected

Define for which sectors (e.g. households, commercial sector) or industries data on off-grid electricity generation is collected or whether data is collected for the whole economy. The project participants may deliberately choose the sectors for which data is collected; however, the sectors should be clearly and unambiguously defined (e.g. which size of companies or households, the geographical area covered, etc) and the selection should include any systematic bias (e.g. by including only a sub-sector which uses only coal as fuel while less carbon intensive fuels are used in other sub-sectors).

Step 1.4: Establish the survey design and management scheme (applicable if a survey is used)

Document transparently the design and methodology of the survey, following best practices in survey design and statistics. In doing so, the following guidance shall be applied:

- The institution conducting the survey should have relevant experience with undertaking surveys;
- Ensure a proper stratification within the geographical area of the electricity system and within the different users of off-grid power generation (e.g. considering relevant differences between sectors, household income, etc). To this end, it may be necessary to conduct a pre-survey to collect information which sectors, companies or households typically use off-grid power plants;

- The results of the survey should be used to derive global estimates adjusted for their uncertainty at a 95% confidence level in a conservative manner (using the upper or lower uncertainty bound whatever is conservative);
- The methods used to collect data should strive to avoid any bias and should ensure random sampling in the various strata;
- Provide objective and transparent methods for data collection;
- Ensure that appropriate procedures for data verification are in place, including relevant quality assurance and quality control methods;

The DOE should carefully evaluate and confirm that the survey was conducted in accordance with these principles and best practices for conducting and evaluating surveys.

Step 1.5: Collect the data or use existing data sources

Collect the data or use relevant existing data sources. Exclude all plants for the sample for which not all necessary data (as identified in Step 1.1 of this annex) could be collected.

Step 2: Exclude plants that do not qualify as off-grid power plants

This step aims to exclude those power plants from the sample or other data source which cannot be considered as off-grid power plants according to the definition provided above. To this end, exclude those plants from the sample or other source of information for which one of the three following conditions is not met:

- $GRID_p$ = true;
- $SWITCH_p$ = true;
- Whenever the grid is reliable and stable, the consumers purchase electricity only from the grid and the off-grid power plant is not operating. This can be demonstrated in one of the following ways:
  - (a) $OMC_{p,y} > T_{EL,p,y}$; or
  - (b) Log book data on the hours of operation of the off-grid power plant *p* and the quality and availability of grid supply clearly shows that the plant only operated when the grid was not reliable and stable; or
  - (c) Demonstrate that $OMC > T_{EL}$ once for all off-grid power plants included in a class of off-grid power plants and a sector by showing that this condition generally applies to all plants in the class and sector, e.g. using the fuel costs (e.g. official statistics or projections on fuel prices), the efficiency of the plants in that class (e.g. using typical the default efficiencies provided in Annex 1) and relevant information on electricity purchase costs in the sector (e.g. statistics on electricity prices).

Step 3: Aggregate data according to classes of off-grid power plants

In the case of direct use of the data on a plant-by-plant basis (Option A in the introduction to Step 1), allocate the collected data to the classes of off-grid power plants.

In the case of a statistical evaluation of the data based on sampling (Option b in the introduction to Step 1), allocate the collected data to the applicable stratum. Use the results of the survey to derive global estimates for the total population, for each class of off-grid power plants m, adjusting conservatively for the uncertainty at a 95% confidence level.[11]

Step 4: Assess the extent of off-grid power

The effects of feeding additional electricity to the grid or saving electricity demand on off-grid power plants connected to the system are associated with significant uncertainty. For this reason, a significant amount of off-grid power should exist to include these plants in the grid emission factor.

The inclusion of off-grid power plants in the grid emission factor is only allowed if one of the following two conditions are met:

- The total capacity of off-grid power plants (in MW) is at least 10% of the total capacity of grid power plants in the electricity system; or
- The total ~~power~~electricity generation by off-grid power plants (in MWh) is at least 10% of the total ~~power~~electricity generation by grid power plants in the electricity system.

If one of these conditions are not met, then off-grid power plants cannot be included in the calculation of the grid emission factor of the electricity system. Otherwise, proceed to next step.

Step 5: Assess the reliability and stability of the grid and that this is primarily due to constraints in generation, and not to other aspects such as transmission capacity

It has to be demonstrated that the grid to which project participants have access is not reliable and not stable and that this is primarily due to constraints in generation and not due to other issues, such as limited transmission capacity. To this end, it needs to be demonstrated that

- Shortages, blinks, black-outs, load shedding and/or large variations in frequency and voltage ranges are common practice in the grid operation. Supporting evidence describing the number, duration and extent of events related to instability and unreliability of the grid has to be provided based on project participants or third parties statistics or surveys; and
- This situation is primarily due to constraints in generation, and not to other aspects such as transmission capacity.

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[11] Note that this should not include power plants which did not qualify as off-grid following the procedures in Step 2.

History of the document

Version	Date	Nature of revision(s)
02.2.1	EB 63, Annex 19 29 September 2011	Editorial amendment to: • Fix unit errors in equations (4) and (6); • Provide clarity throughout the text.
02.2.0	EB 61, Annex 12 3 June 2011	Amendment to: • Provide flexibility for LDCs and countries where less then ten CDM projects have been registered, when calculating the grid emission factor; and • Extend the procedure for the identification of sample groups of power units relevant to build margin calculation.
02.1.0	EB 60, Annex 8 15 April 2011	The tool was amended to allow the use of an operating margin emission factor different form zero in case of connected electricity systems located in countries other than the project host country.
02	EB 50, Annex 14 16 October 2009	• Inclusion of provisions to allow for the inclusion of off-grid power plants in the calculation of the electricity system emission factor; and • Deletion of the previous Option A in the operating margin emission factor calculation, as this option is covered by the previous Option B1 (A1 after revision)
01.1	29 July 2008	Editorial revision to: • Incorporate the "Tool to calculate baseline, project and/or leakage emissions from electricity consumption"; and • Provide additional clarification on the composition of a sample group for the calculation of the build margin.
01	EB 35, Annex 12 19 October 2007	Initial adoption.
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