Puro.earth Certification Framework

Puro.earth CCS+ Program

Emissions from Electricity Consumption

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1. Emissions from Electricity Consumption

1.1. Summary Description

This Section sets out procedures for quantifying emissions from electricity consumption, whether those emissions arise as project emissions or as leakage emissions, for projects seeking certification under a Methodology of the Puro.earth CCS+ Program.

It currently applies to the **Carbon Capture and Storage Methodology**, and within it to:

- **Module A – Removals from CO_2 Capture from Air (Direct Air Capture)**
- **Module C – Project Emissions from CO_2 Transport for CCS Projects**
- **Module D – Project Emissions from CO_2 Storage in Saline Aquifers and Depleted Hydrocarbon Reservoirs**

The procedures cover four electricity supply scenarios: grid electricity systems (Scenario A), purpose-built wheeling arrangements (Scenario B), shared power plants, whether localized grid or hybrid (Scenario C), and dedicated power plants, whether off-grid or back-up (Scenario D).

1.2. Definitions

In addition to the definitions set out in the Puro.earth List of Definitions and Abbreviations, the following definitions apply to this Section.

Directly connected power plant

A power plant that supplies electricity consumed by the project, or associated with leakage, without supplying it through the national or regional grid. The electricity may be supplied through a direct connection or a localized grid. The power plant may be co-located with the project activities or located remotely.

Grid-connected project

An electricity consumer that is directly connected to the regional or national grid and may also have a supply of electricity wheeled through the regional or national grid using purpose-built wheeling arrangements (PBWAs), a connection to one or more shared power plants, or a connection to one or more dedicated power plants.

Localized grid

An electricity system that operates independently of the national or regional grid and supplies electricity from one or more power sources to one or more consumers. It may operate, for example, within an industrial complex or a defined geographic area. Localized grids include mini-grids, micro-grids, and isolated grids that have no connection to the national or regional grid.

Low-carbon power plant

A power plant that generates electricity with zero or low carbon emissions by avoiding fossil fuel combustion. Low-carbon power plants are classified as:

- Type 1: Zero-carbon emission sources for which emissions associated with electricity generation do not need to be accounted for. These include solar photovoltaic or solar thermal, with or without battery storage; wind, with or without battery storage; nuclear; and qualifying hydropower, including run-of-river, new plants on existing reservoirs with no change in reservoir volume, and new plants with a power density greater than 10 W/m².

- Type 2: Low-carbon sources for which emissions associated with electricity generation must be accounted for. These include geothermal; biomass combustion using renewable biomass, including residues derived through sustainable land management practices; hydropower with a power density greater than 4 W/m² and less than or equal to 10 W/m²; and biogas from organic waste, manure, or wastewater treatment. Mixed-waste incineration and other mixed fuels are excluded; pure streams of biomass residues are not considered mixed fuels.

Purpose-built wheeling arrangement (PBWA)

A legally binding arrangement between a power plant operator and a project proponent under which electricity generated by the power plant is supplied to the project through the national or regional grid.

Operating Margin (OM) emission factor

The emission factor representing existing power plants in the electricity system whose dispatch and generation would be affected by the project activity.

1.3. Applicability Conditions

The procedures set out in this Section cover the following four electricity supply scenarios:

1) **Scenario A Grid Electricity System:** The national or regional grid supplies electricity to the project.

2) **Scenario B Purpose-Built Wheeling Arrangements (PBWA):** A new, off-site, low-carbon power plant is constructed and connected to the national or regional grid to supply electricity to the project. All of the following conditions apply:

   a) the low-carbon power plant is in the same country as the project;

   b) the project and the power plant are connected through the national or regional grid such that electricity may be transmitted from the plant to the project, and the connection is metered;

   c) the low-carbon power plant capacity used in the PBWA is additional to jurisdictional renewable portfolio requirements, or is otherwise excluded from those requirements; and

   d) a power purchase agreement (PPA) is established that complies with all of the following conditions:

      i) the PPA is mutually executed by both the project proponent (or representative) and the power plant operator before the start of operation of the low-carbon power plant;

      ii) the PPA commits the power plant operator to supply a quantity of electrical energy to the national or regional grid, and the low-carbon beneficial claim related to consuming that quantity is afforded to the project proponent;

      iii) the term of the PPA, including any updates or modifications, corresponds to at least the first project Crediting Period; and

      iv) the PPA forbids the project proponent and the PPA counterparties from generating, transferring, or selling renewable energy credits (RECs) or other instruments representing the low-carbon benefits of the energy to others for the quantity of energy supplied to the project through the agreement.

3) **Scenario C Shared Power Plant(s):** One or more directly connected power plants supply part or all of their net electricity generation to the project, or to activities associated with leakage, and also supply other consumers. One of the following sub-scenarios applies:

   a) **Scenario C1 – Localized Grid:** the project is connected only to a localized grid supplied by one or more directly connected power plants. The localized grid may also supply other consumers and has no connection to the national or regional grid.

   b) **Scenario C2 – Hybrid:** the project is connected both to the national or regional grid (Scenario A or B) and to one or more directly connected power plants, whether by direct connection, via a localized grid, or via a mini-grid that is itself connected to the national or regional grid. The two connections are metered separately, and the project draws on both according to availability or operational needs during the Monitoring Period. The shared power plant may export electricity to the grid.

4) **Scenario D – Dedicated Power Plant(s):** One or more directly connected power plants supply all their net electricity generation to the project, or to activities associated with leakage, and supply no other consumers. One of the following sub-scenarios applies:

   a) **Scenario D1 – Off-grid:** the project is connected directly to the power plant and has no connection to the national or regional grid.

   b) **Scenario D2 – Back-up Generation:** the project is connected both to the national or regional grid (Scenario A or B) and to one or more directly connected power plants. The grid connection is metered, and the power plant supplies all its net electricity generation to the project as back-up to grid electricity.

Where Scenario C or Scenario D applies, the project description identifies the applicable sub-scenario, depicts the electricity system configuration and describes its operation.

This Section does not apply where the project activity is an upgrade or a fuel switch at a power plant (e.g., an efficiency improvement at a power plant). Capacity additions, and refurbishments extending the life of a power plant that is at end-of-life, are not upgrades for this purpose.

1.4. Procedures

The following equations must be applied to determine project and leakage emissions from electricity consumption.

$$\mathrm{PE_{Elec}} = \mathrm{PE_A} + \mathrm{PE_B} + \mathrm{PE_C} + \mathrm{PE_D} \quad (1)$$

$$\mathrm{LE_{Elec}} = \mathrm{LE_A} + \mathrm{LE_C} + \mathrm{LE_D} \quad (2)$$

Where:

- $\mathrm{PE_{Elec}}$ = Project emissions from electricity consumption (t CO_2e)
- $\mathrm{LE_{Elec}}$= Leakage emissions from electricity consumption (t CO_2e)
- $\mathrm{PE_{A,B,C,D}}$ = Project emissions under Scenarios A, B, C, and D respectively (t CO_2e)
- $\mathrm{LE_{A,C,D}}$ = Leakage emissions under Scenarios A, C, and D respectively (t CO_2e)

Scenario A: Grid Electricity System

Scenario A applies to electricity supplied to the project from the national or regional grid. Total grid electricity consumption must be quantified as metered at the project's grid connection point and allocated to one of the following categories:

1. **Project consumption:** electricity consumed within the project boundary to implement and operate the project activity.

2. **Leakage consumption:** electricity consumed outside the project boundary by activities that are affected by, or related to, the project activity.

Grid consumption may include electricity wheeled through the grid under a PBWA (Scenario B). It may also include grid electricity supplied to a project that is also connected to shared power plants (Scenario C2) or dedicated power plants (Scenario D2).

Where the project draws grid electricity at more than one connection point, and those points differ in emission factor or in transmission and distribution losses, each connection point must be quantified separately and the results summed.

The following equations must be applied to determine project emissions and leakage emissions from electricity consumption under Scenario A, respectively:

$$\mathrm{PE_A} = EC_{PE,A} \times EF_{PE,A} \times (1 + TDL_{PE,A}) \quad (3)$$

$$\mathrm{LE_A} = EC_{LE,A} \times EF_{LE,A} \times (1 + TDL_{LE,A}) \quad (4)$$

Where:

- $EC_{PE,A}$: Total project electricity consumption under Scenario A, determined using Equation (5) (MWh)
- $EC_{LE,A}$: Total leakage electricity consumption under Scenario A, including grid electricity supplied to a project that is also connected to one or more shared power plants (Scenario C2) or dedicated power plants (Scenario D2) (MWh)
- $EF_{PE,A}$, $EF_{LE,A}$: Emission factors applicable to project and leakage consumption under Scenario A, respectively (t CO_2e/MWh)
- $TDL_{PE,A}$, $TDL_{LE,A}$: Average transmission and distribution losses applicable to project and leakage consumption under Scenario A, respectively (dimensionless)

Electricity Consumed ($EC_{PE,A}$)

The project's electricity consumption from the national or regional grid must be calculated using Equation (5):

$$EC_{PE,A} = EC_{Grid} - EC_{PE,B} \quad (5)$$

Where:

- EC_{Grid}: Total metered grid electricity consumption of the project; includes electricity wheeled through the national or regional grid under a PBWA (Scenario B) and grid electricity supplied to a project that is also connected to one or more shared power plants (Scenario C2) or dedicated power plants (Scenario D2) (MWh)
- $EC_{PE,B}$: Electricity consumed under PBWAs, determined using Equation (7) (MWh)

Emission Factor ($EF_{PE,A}$ & $EF_{LE,A}$)

The emission factor for Scenario A is determined in accordance with 2. Electricity System Emission Factors.

Scenario B: Purpose-Built Wheeling Arrangements

Scenario A applies to electricity supplied through the national or regional grid under a PBWA. Project emissions from electricity consumption under Scenario B must be calculated using Equation (6):

$$\mathrm{PE_B} = EC_{PE,B} \times EF_{PE,B} \times (1 + TDL_{PE,B}) \quad (6)$$

Where:

- $EF_{PE,B}$: Emission factor of electricity supplied to the project under Scenario B (t CO_2e/MWh)

- $TDL_{PE,B}$: Average transmission and distribution losses applicable to electricity supplied to the project under Scenario B (dimensionless)

Electricity Consumed ($EC_{PE,B}$)

Scenario B applies to electricity generated by a low-carbon power plant and wheeled to the project through the national or regional grid under a PBWA that meets the applicability conditions set out in 1.3. Applicability Conditions.

As a PBWA supplies the project activity only, all electricity attributed to it is project consumption. Scenario B therefore generates no leakage emissions.

The electricity attributed to the PBWA is the minimum of:

- the project's total grid electricity consumption EC_{Grid}; and
- the net electricity generation delivered under the arrangement,

as set out in Equation (7). Both quantities must be determined over the same reconciliation period: the Monitoring Period or the calendar year, whichever is shorter.

$$EC_{PE,B} = MIN\left(EC_{Grid}, \frac{EG_{PBWA}}{1+TDL_{PE,B}}\right) \quad (7)$$

Where:

- EG_{PBWA}: Electricity generated by low-carbon power plants for the PBWA, net of transmission and distribution losses (MWh)

Emission Factor for Low-Carbon Power Plants ($EF_{PE,B}$)

For Type 1 low-carbon power plants, the emission factor is 0 tCO_2e/MWh.

For Type 2 low-carbon power plants, the emission factor must be determined as follows. Unless stated otherwise, the emission factor equals the plant's emissions divided by its total net electricity generation (MWh) over the same period, and is expressed in t CO_2e/MWh.

1) Geothermal: direct emissions from geothermal electricity production, determined in accordance with CDM ACM0002.
2) Biomass: upstream emissions from the cultivation, processing and transport of biomass, determined in accordance with CDM TOOL16. Direct emissions from the combustion of renewable biomass, or of biomass residues obtained under sustainable land management practices, are considered zero.
3) Hydropower: a default emission factor of 0.1 t CO_2e/MWh applies. This option is available only to new plants with a power density greater than 4 W/m^2 and less than or equal to 10 W/m^2.
4) Biogas: upstream emissions from biogas production (e.g., manure management, digestion and transport), determined in accordance with CDM TOOL14.

Scenario C: Shared Power Plants

Scenario C applies to electricity supplied to the project by directly connected power plants that also supply other consumers. Project emissions and leakage emissions from electricity consumption under Scenario C must be calculated using Equations (8) and (9), respectively:

$$PE_C = \sum_n \left(EC_{PE,SPP,n} \times EF_{PE,SPP,n}\right) \quad (8)$$

$$LE_C = \sum_n \left(EC_{LE,SPP,n} \times EF_{LE,SPP,n}\right) \quad (9)$$

Where:

- $EC_{PE,SPP,n}$, $EC_{LE,SPP,n}$: Electricity supplied by shared power plant *n* for project consumption and leakage consumption, respectively (MWh); excludes electricity supplied by the national or regional grid (EC_{Grid}), which is quantified under Scenario A.
- $EF_{PE,SPP,n}$, $EF_{LE,SPP,n}$: Emission factor of shared power plant *n* applicable to project consumption and leakage consumption, respectively (t CO_2e/MWh)

Electricity Consumed ($EC_{PE,SPP,n}$ & $EC_{LE,SPP,n}$)

Electricity supplied by each shared power plant must be metered at the point of consumption, so that the metered quantity excludes any transmission and distribution losses. Under Scenario C2, consumption of electricity supplied by the national or regional grid and electricity supplied by the shared power plant(s) must be metered separately. Grid electricity consumption is quantified under Scenario A.

Emission Factor for Shared Power Plants ($EF_{PE,SPP,n}$ & $EF_{LE,SPP,n}$)

Scenario C1: Localized Grid

For a shared power plant that is a low-carbon power plant, the emission factor must be determined in accordance with Emission Factor for Low-Carbon Power Plants ($EF_{PE,B}$).

For any other shared power plant, the emission factor shall be determined for each plant *n* using Equation (10). Emissions attributable to heat production in cogeneration plants are excluded through the heat fraction.

$$EF_{PE,SPP,n}, EF_{LE,SPP,n} = \frac{\sum_f (Q_{n,f} \times NCV_f \times EF_{CO2,f})}{EG_n} \times (1 - H_n) \quad (10)$$

Where:

- $Q_{n,f}$: Quantity of fuel type f fired in power plant *n* during the Monitoring Period (mass or volume unit)
- NCV_f: Mean net calorific value of fuel type *f* (GJ/mass or volume unit)
- H_n: Fraction of the fuel energy input of power plant *n* attributable to heat production (dimensionless)
- $EF_{CO2,f}$: CO_2 emission factor of fuel type *f* (t CO_2e/GJ)
- EG_n: Net electricity generated by power plant *n* during the Monitoring Period (MWh)

For plants with no cogeneration system, $H_n = 0$. Otherwise, the heat fraction at the cogeneration system of each plant n is determined using the following equation:

$$H_n = \frac{HG_n}{\sum_f (Q_{n,f} \times NCV_f) \times \eta_{cogen,n}} \quad (11)$$

Where:

- HG_n: Quantity of heat cogenerated by power plant *n* during the Monitoring Period (GJ)
- $\eta_{cogen,n}$: Heat generation efficiency of cogeneration system *n* (dimensionless)

Where a plant fires more than one fuel type, the fuel mix applied shall be either the actual fuel mix during the Monitoring Period or a fuel mix that results in a conservative estimate of emissions.

Scenario C2: Hybrid

The emission factor for each shared power plant *n* must be determined in accordance with Scenario C1 where at least one of the following conditions is met throughout the Monitoring Period:

a) the shared power plant operates to follow project and leakage electricity consumption (e.g., through demand matching or direct dispatch), and below its maximum available capacity, taking into account any capacity derating;
b) no electricity is consumed from the national or regional grid; or

c) electricity consumption from the national or regional grid is predetermined and outside the control of the project proponent (e.g., due to capacity constraints or dispatch instructions from the grid operator).

Condition (a) must be demonstrated using operational data or control system logs evidencing demand-matching or dispatch actions. Condition (c) must be demonstrated using agreements with the grid operator, or other documentation showing that the project proponent does not control grid electricity consumption.

Where none of these conditions is met, two emission factors shall be determined:

a) the shared power plant's, in accordance with Scenario C1,
b) and the grid's, in accordance with Emission Factor (EFPE,A & EFLE,A) (Scenario A).

The higher of the two shall be applied for that Monitoring Period.

Scenario D: Dedicated Power Plants

Scenario D applies to electricity supplied to the project by directly connected power plants that do not supply other consumers.

Because a dedicated power plant supplies all its net electricity generation to project and leakage activities, no allocation between consumers is required: the plant's emissions are accounted for in full as project or leakage emissions.

No transmission and distribution loss factor applies under Scenario D. Emissions are based on the electricity generated by the power plant, not the electricity consumed by the project, so any losses between the plant and the project are already included.

Scenario D1: Off-grid

Emissions in Scenario D (PE_D, LE_D) from fossil fuel-fired power plants must be determined in accordance with CDM TOOL03. Where a plant fires more than one fuel type, the fuel mix applied must be either the actual fuel mix during the Monitoring Period or a fuel mix that results in a conservative estimate of emissions from power and heat production.

Emissions from a low-carbon dedicated power plant are the product of its emission factor, determined in accordance with Emission Factor for Low-Carbon Power Plants ($EF_{PE,B}$) and its total net electricity generation during the Monitoring Period.

Scenario D2: Back-up Generation

The emissions of a dedicated power plant serving as back-up to the grid shall be determined in accordance with Scenario D1, and accounted for in full, including emissions from periods of excess generation. Where excess generation is exported to the grid, whether intentionally or not, the plant's generation shall not be reduced by the quantity exported, and no emission reduction shall be claimed for displaced grid generation.

1.5. Data And Parameters

Data and Parameters Available at Validation

Data/Parameter	$\eta_{cogen,n}$
Data unit	percent
Description	Efficiency of cogeneration system n in which heat is generated
Equations	(11)

Source of data	As per the procedures specified in CDM TOOL09
Value applied	Project-specific
Justification of choice of data or description of measurement methods and procedures applied	As per the procedures specified in CDM TOOL09
Purpose of data	Calculation of project emissions
Comments	Only applicable to project activities where CO_2 emissions from cogeneration are allocated to heat and power. The efficiency is expressed as a decimal equivalent (i.e., 20% is expressed as 0.20).

Data and Parameters Monitored

Data/Parameter	$EC_{PE,A}$, $EC_{LE,A}$, EC_{Grid}, $EC_{PE,B}$, $EC_{PE,SPP,n}$, $EC_{LE,SPP,n}$
Data unit	MWh
Description	Electricity consumption in the project and associated with leakage
Equations	(3), (4), (5), (8), (9)
Source of data	Direct measurement or estimation
Description of measurement methods and procedures to be applied	Direct measurement is required where any of the following applies: a) The electricity is supplied under a PBWA (Scenario B), or by a shared power plant (Scenario C2) or a dedicated power plant (Scenario D2) to a project that is also grid-connected, in which case each supply is metered separately. b) The maximum power consumption exceeds 100 kW. Where direct measurement is not required, the quantity of electricity consumed may be estimated. The estimate must be demonstrated to meet one of the following criteria: a) Conservative — the estimate takes into account whether the consumption is project or leakage consumption; physical limits such as maximum equipment capacity or continuous operation (24/7) are appropriate. b) Statistically significant — the estimate is derived from proxy measurements, correlations, models or another analytical technique; the uncertainty of the estimate is also quantified; the estimate is discounted using that uncertainty so as to be conservative (higher emissions in the project and

	in leakage), and the extent of conservativeness is justified in the project description.
Frequency of monitoring/recording	Continuous monitoring, with data aggregated at least monthly. Estimates are made at monthly intervals or more frequently.
QA/QC procedures to be applied	The meters are tested and calibrated regularly, in accordance with utility or national requirements and manufacturer specifications. The data is cross-checked against receipts or invoices from utilities or suppliers where applicable. Where invoices from utilities and suppliers disaggregate the grid electricity consumed ($EC_{PE,A}$) and the PBWA electricity consumed ($EC_{PE,B}$), that information may be used directly as a QA/QC check. Uncertainty is propagated according to the instructions specific to the Methodology used. For the uncertainty of direct measurement, the actual metering uncertainty is used, as specified by the error from the last calibration event or, where information from a previous calibration event is not available, by the meter manufacturer. For the uncertainty of estimates, zero is used for conservative estimates and a project-specific uncertainty is used for statistically significant estimates.
Purpose of data	Calculation of project and leakage emissions
Calculation method	For cumulative electricity meters, the difference between the initial and final readings is used, and the dates of each reading are recorded. Linear interpolation is applied where meter reading dates do not align with the Monitoring Period.
Comments	Where direct measurement is required but is temporarily not feasible because of technical or logistical constraints (e.g., lack of access to monitoring equipment, maintenance, or remote or hazardous project locations), estimation methods may be used. This must be accompanied by a justification and by a demonstration that the constraint is temporary and that the chosen estimation method is conservative.

Data/Parameter	$EF_{PE,A}$, $EF_{LE,A}$
Data unit	t CO_2e/MWh
Description	Emission factor for electricity consumption in the project and associated with leakage

Equations	(3), (4)
Source of data	As per Electricity System Emission Factors
Description of measurement methods and procedures to be applied	As per Electricity System Emission Factors
Frequency of monitoring/recording	As per Electricity System Emission Factors
QA/QC procedures to be applied	For grids, the QA/QC procedures set out in Electricity System Emission Factors apply. Uncertainty is propagated according to the instructions specific to the Methodology used.
Purpose of data	Calculation of project and leakage emissions
Calculation method	As per Electricity System Emission Factors
Comments	N/A

Data/Parameter	$TDL_{PE,A}$, $TDL_{LE,A}$, $TDL_{PE,B}$
Data unit	percent
Description	Mean technical transmission and distribution losses for providing electricity consumed in the project boundary in the project and associated with leakage
Equations	(3), (4), (6), (7)
Source of data	Estimate
Description of measurement methods and procedures to be applied	TDL is estimated using one of the following: a) the most recent data available from the electricity grid to which the project is connected within the host country, region or equivalent; or b) 20% for high transmission and distribution losses in the project and leakage calculations, or where electricity consumption increases from the baseline to the project activities. TDL is estimated for the distribution and transmission networks of the electricity grid at the same voltage as the connection to the project. Other grid losses (e.g., commercial losses, theft) are not included in technical distribution losses. The distribution losses may be either calculated by the project proponent or based on references from utilities, network operators or other official documentation.

Frequency of monitoring/recording	Annually. Where data from the relevant year are not available, the most recent available values are used.
QA/QC procedures to be applied	Uncertainty is propagated according to the instructions specific to the Methodology used. An uncertainty of 5% is assumed for values published by national or regional governments, utilities, network operators or multinational institutions, and is propagated as per IPCC guidance.
Purpose of data	Calculation of project and leakage emissions
Calculation method	N/A
Comments	TDL is expressed as a decimal equivalent (i.e., 20% is expressed as 0.20).

Data/Parameter	EG_{PBWA}, EG_n
Data unit	MWh
Description	Total quantity of electricity generated by the power plant associated with the wheeling arrangement in the PPA during the Monitoring Period; total quantity of net electricity generated by shared power plant n during the Monitoring Period
Equations	(7), (10)
Source of data	Direct measurement
Description of measurement methods and procedures to be applied	Direct measurement using calibrated meters.
Frequency of monitoring/recording	Continuous monitoring, with data aggregated and recorded at least monthly.
QA/QC procedures to be applied	The meters are tested and calibrated regularly, in accordance with utility or national requirements and manufacturer specifications. Uncertainty is propagated according to the instructions specific to the Methodology used.
Purpose of data	Calculation of project and leakage emissions
Calculation method	For cumulative electricity meters, the difference between the initial and final readings is used, and the dates of each reading are recorded.

Comments	N/A

Data/Parameter	$Q_{n,f}$
Data unit	Mass or volume unit (at reference conditions)
Description	Quantity of fuel type f fired in power plant n
Equations	(10), (11)
Source of data	Direct measurement
Description of measurement methods and procedures to be applied	Direct measurement using mass or volume meters.
Frequency of monitoring/recording	Continuous monitoring, with data aggregated and recorded at least monthly.
QA/QC procedures to be applied	The meters are tested and calibrated regularly, in accordance with utility or national requirements and manufacturer specifications. Uncertainty is propagated according to the instructions specific to the Methodology used. The measured quantities are cross-checked against purchase invoices or delivery records where these are available.
Purpose of data	Calculation of project and leakage emissions
Calculation method	N/A
Comments	Quantities are expressed at the reference conditions to which the net calorific value NCV_f applies.

Data/Parameter	NCV_f
Data unit	GJ per mass or volume unit
Description	Mean net calorific value of fuel type f used in the reporting period
Equations	(10), (11)
Source of data	Data sources are used in the following order of priority: 1) Values provided by the fuel supplier in invoices or published by the fuel supplier. 2) Measurements by the project proponent in accredited laboratories.

	3) Regional or national default values (liquid fuels only, based on well-documented and reliable sources). 4) IPCC default values taken at the upper or lower limit, whichever is the more conservative, of the uncertainty at a 95 per cent confidence interval, as per Table 1.2, Chapter 1, Volume 2 of the 2006 IPCC Guidelines.
Description of measurement methods and procedures to be applied	For (1) and (2): Measurements must comply with national or international fuel standards (e.g., ASTM D5865-12, ISO 1928).
Frequency of monitoring/recording	For (1) and (2), obtain the NCV for each fuel delivery and calculate the weighted mean values for the monitoring period. For (3), review the appropriateness of the values annually. For (4), future revisions of the IPCC guidelines must be considered.
QA/QC procedures to be applied	Verify whether the values under (1), (2), and (3) are within the uncertainty range of the IPCC default values provided in Table 1.2, Chapter 1, Vol. 2 of the 2006 IPCC Guidelines. Where the values fall outside of this range, additional information from the testing laboratory should be collected to justify the outcome or to conduct additional measurements. The laboratories used as sources of data for Options (1), (2), and (3) should have ISO 17025 accreditation or justify that they are able to comply with similar quality standards.
Purpose of data	Calculation of project and leakage emissions
Calculation method	N/A
Comments	N/A

Data/Parameter	$EF_{CO2,f}$
Data unit	t CO_2e/GJ
Description	CO_2 emission factor of fuel type f
Equations	(10)
Source of data	Data sources are used in the same order of priority as for NCV_f, with IPCC default values taken from Table 1.4, Chapter 1, Volume 2 of the 2006 IPCC Guidelines.
Description of measurement methods and procedures to be applied	For (1) and (2): Measurements should be undertaken in line with national or international fuel standards. For (1), where the fuel supplier provides the NCV value and CO_2 emission factor on the invoice, and these two values are based on

	measurements for this fuel, this CO_2 factor should be used. Where another source for the CO_2 emission factor is used or no CO_2 emission factor is provided, Options (2), (3), or (4) should be used.
Frequency of monitoring/recording	For (1) and (2): The CO_2 emission factor should be obtained for each fuel delivery, from which weighted mean values for the reporting period should be calculated. For (3): Review the appropriateness of the values annually. For (4): Any future revision of the IPCC guidelines must be considered.
QA/QC procedures to be applied	Verify whether the values under (1) and (2) are within the uncertainty range of the IPCC default values provided in Table 1.4 of Chapter 1, Vol. 2 of the 2006 IPCC Guidelines for National GHG Inventories. Where the values fall outside of this range, additional information from the testing laboratory should be collected to justify the outcome or to conduct additional measurements.
Purpose of data	Calculation of project and leakage emissions
Calculation method	N/A
Comments	N/A

Data/Parameter	HG_n
Data unit	GJ
Description	Quantity of heat cogenerated in power plant n
Equations	(11)
Source of data	Direct measurement
Description of measurement methods and procedures to be applied	Direct measurement of the flow and of the physical properties of the steam or other heat transfer medium, of the feedwater and of the condensate return.
Frequency of monitoring/recording	Continuous monitoring, with data aggregated and recorded at least monthly.
QA/QC procedures to be applied	The meters are tested and calibrated regularly, in accordance with utility or national requirements and manufacturer specifications. Uncertainty is propagated according to the instructions specific to the Methodology used.
Purpose of data	Calculation of project emissions

Calculation method	N/A
Comments	Only applicable to project activities where CO_2 emissions from cogeneration are allocated to heat and power.

2. Electricity System Emission Factors

2.1. Summary Description

This Section sets out procedures for quantifying the CO_2 emission factor of an existing grid electricity system (Scenario A) whose dispatch and generation is affected by projects seeking certification under a specific Methodology of the Puro.earth CCS+ Program. It applies to an electricity system for project activities that are net additional consumers of grid electricity and are supplied through a direct connection to the national or regional grid.

The procedure is derived from the CDM TOOL07 Tool to calculate the emission factor for an electricity system.

2.2. Applicability Conditions

This Section applies to an electricity system for project activities that are net additional consumers of grid electricity and are supplied through a direct connection to the national or regional grid. It is globally applicable.

2.3. Procedures

The following procedure must be applied to determine the operating margin (OM) emission factor of the project grid electricity system.

Step 1: Identify the relevant grid electricity system

Delineate the project's grid electricity systems

The project electricity system is the grid to which the project is connected, together with any electricity systems connected to it. It shall be delineated in line with the host country's Designated National Authority (DNA) where one has been published, and otherwise in accordance with CDM TOOL07.

Define the emission factor for net electricity import from connected electricity systems

The CO_2 emission factor of net electricity imports from a connected electricity system shall be one of the following:

a) a default value of 1.3 t CO_2/MWh;
b) the simple OM of the exporting electricity system, determined in accordance with Step 4a below, provided that the exporting system meets the applicability test in Step 3;
c) the simple adjusted OM of the exporting electricity system, determined in accordance with Section 6.4.2 of CDM TOOL07; or
d) the average OM of the exporting electricity system, determined in accordance with Section 6.4.4 of CDM TOOL07.

Electricity exports must not be subtracted from the electricity generation data used to calculate the emission factors.

Step 2: Exclude off-grid power plants

Off-grid power plants shall be excluded from the grid emission factor calculation (CDM TOOL07, Step 2, Option I). This includes plants connected to the grid only through the

project, such as back-up plants under Scenario D2, whose emissions are accounted for in full under that scenario.

Step 3: Select a method to determine the OM

The OM emission factor shall be calculated using one of the following methods. The choice depends on data availability and on the simple OM applicability test below.

1. **Simple OM:** the generation-weighted average CO_2 emissions per unit of net electricity generation (t CO_2/MWh) of all power plants serving the system, excluding low-cost/must-run power plants. This method requires annual data on electricity generation, fuel types and fuel consumption, either for each power unit (Option A) or for the system as a whole (Option B).
2. **Simple adjusted OM:** a variant of the simple OM in which low-cost/must-run power plants are included, weighted by the fraction of time they are at the margin. This method requires hourly grid load data.
3. **Dispatch data analysis OM:** based on the power units actually dispatched at the margin in each hour in which the project consumes grid electricity. This method can only be applied ex post.
4. **Average OM:** the average emission rate of all power plants serving the system, including low-cost/must-run power plants. This method requires only annual aggregated data for the grid.

Simple OM applicability test

The Simple OM may be used only if one of the following is satisfied:

- Low-cost/must-run resources constitute less than 50% of total grid generation (excluding off-grid generation), taken as the average of the five most recent years, or based on long-term averages for hydroelectricity over a minimum of 15 years; or
- The average load supplied by low-cost/must-run resources over the three most recent years is less than the average of the lowest annual system loads over the same three years.

Where the applicability test is not satisfied, one of the three other methods must be applied instead.

Data vintage

For the Simple OM, the simple adjusted OM and the average OM, one of two data vintages is selected and fixed for the Crediting Period:

- Ex ante – determined once at validation, with no recalculation during the Crediting Period. A three-year generation-weighted average based on the most recent data available at submission is used.
- Ex post – determined for the year in which the project operates and updated annually. Where data for year y is available only more than six months after the end of the year, year y-1 may be used; where it is available only after 18 months, year y-2 may be used. The same vintage is used throughout all Crediting Periods.

For the dispatch data analysis OM, the year in which the project activity displaces grid electricity must be used and the emission factor must be updated annually during monitoring.

Step 4: Calculate the operating margin emission factor

Where a purpose-built wheeling arrangement supplies electricity to the grid, that electricity is excluded from the grid emission factor calculation, provided the information is available.

Step 4a: Simple OM

Option A: Based on individual power units

Option A applies where data are available for individual power units. The emission factor is calculated from the net electricity generation and CO_2 emission factor of each unit, using Equation (12):

$$EF_{grid,OMsimple,y} = \frac{\sum_m (EG_{m,y} \times EF_{EL,m,y})}{\sum_m EG_{m,y}} \quad (12)$$

Where:

- $EG_{m,y}$: Net 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* (t CO_2/MWh)
- m: All power units serving the grid in year *y*, excluding low-cost/must-run power units
- y: The relevant year, according to the data vintage selected in Step 3 above

Determining $EF_{EL,m,y}$

$EF_{EL,m,y}$ must be determined using one of the following options, depending on the data available for unit *m*:

Option A1 – where data on both fuel consumption and electricity generation are available, $EF_{EL,m,y}$ must be calculated using Equation (13):

$$EF_{EL,m,y} = \frac{\sum_i (FC_{i,m,y} \times NCV_{i,y} \times EF_{CO2,i,y})}{EG_{m,y}} \quad (13)$$

Where:

- $FC_{i,m,y}$: Quantity of fuel type i consumed by unit *m* in year *y* (mass or volume unit)
- $NCV_{i,y}$: Net calorific value of fuel type *i* in year *y* (GJ/mass or volume unit), and
- $EF_{CO2,i,y}$: CO_2 emission factor of fuel type *i* in year *y* (t CO_2/GJ)

Option A2 – where only data on electricity generation and fuel types are available, $EF_{EL,m,y}$ shall be calculated using Equation (14):

$$EF_{EL,m,y} = \frac{EF_{CO2,m,i,y} \times 3.6}{\eta_{m,y}} \quad (14)$$

Where:

- $\eta_{m,y}$ is the average net energy conversion efficiency of unit *m* in year *y* (dimensionless).
- 3.6 Conversion factor (GJ/MWh)

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

Option A3 – where only data on electricity generation are available, a default value of 1.3 t CO_2/MWh shall be applied to $EF_{EL,m,y}$. The default applies only to the power unit(s) concerned. Those units are included in Equation (12) alongside units assessed under Options A1 and A2.

Determining $EG_{m,y}$

For grid power plants, $EG_{m,y}$ must be determined in accordance with 2.5. Data and Parameters Monitored.

Option B: Based on total system fuel consumption

Option B is based on the total net electricity generation of all power plants serving the system, and on the fuel types and total fuel consumption of the project electricity system. It may only be used where both of the following conditions are met:

a) the data required for Option A are not available; and

b) only nuclear and renewable power plants are treated as low-cost/must-run, and the electricity they supply to the grid is known.

The emission factor shall be calculated using Equation (15):

$$EF_{grid,OMsimple,y} = \frac{\sum_i (FC_{i,y} \times NCV_{i,y} \times EF_{CO2,i,y})}{EG_y} \quad (15)$$

Where:

- $FC_{i,y}$ = Quantity of fuel type i consumed in the project electricity system in year y (mass or volume unit)
- EG_y = Net electricity delivered to the grid by all sources serving the system, excluding low-cost/must-run units, in year y (MWh)

Step 4b: Simple adjusted OM

The simple adjusted OM is a variant of the simple OM in which power sources, including imports, are divided into low-cost/must-run sources (*k*) and other sources (*m*). It shall be calculated in accordance with Section 6.4.2 of CDM TOOL07.

Step 4c: Dispatch data analysis OM

The dispatch data analysis OM is based on the grid power units actually dispatched at the margin in each hour *h* in which the project consumes grid electricity. It can only be applied ex post, and shall be calculated in accordance with Section 6.4.3 of CDM TOOL07.

Step 4d: Average OM

The average OM is the average emission rate of all power plants serving the grid, including low-cost/must-run power plants. It shall be calculated using the procedure for the simple OM in Step 4a (Section 6.4.1 of CDM TOOL07), with low-cost/must-run power plants included in all equations, and in accordance with Section 6.4.4 of CDM TOOL07.

2.5 Data And Parameters

Data/Parameter	$\eta_{m,y}$
Data unit	Dimensionless
Description	Average net energy conversion efficiency of power unit *m* in year y.
Equations	(14)
Source of data	Manufacturer specifications, data from the utility or the dispatch centre, official records, or the default values for the applicable technology given in Table 2, Appendix of CDM TOOL09.
Frequency of monitoring/recording	Once for the Crediting Period

QA/QC procedures to be applied	Where the efficiency value obtained from the manufacturer, the utility, the dispatch centre or official records is significantly lower than the default value for the applicable technology in Table 2 of the Appendix to CDM TOOL09 ("Determining the baseline efficiency of thermal or electric energy generation systems")[14], the project proponent shall assess the reliability of the value. The value may be used only if it is justified as reliable. Otherwise, the default value from TOOL09 shall be used.
Comments	-

Data/Parameter	$EG_{m,y}$, EG_y
Data unit	MWh
Description	Net electricity generated and delivered to the grid by power unit *m* in year *y* and, in the case of EG_y, by all power sources serving the project electricity system, excluding low-cost/must-run power units, in year *y*.
Equations	(12), (13), (15)
Source of data	Utility or government records, or official publications.
Frequency of monitoring/recording	Once for the Crediting Period, as a three-year generation-weighted average, where the ex ante data vintage applies; annually where the ex post data vintage applies.
QA/QC procedures to be applied	-
Comments	-

Data/Parameter	$FC_{i,m,y}$, $FC_{i,y}$
Data unit	Mass or volume unit
Description	Quantity of fuel type *i* consumed by power plant/unit *m*, or *n* (or in the project electricity system in case of $FC_{i,y}$) in year *y*.
Equations	(13), (15)

Source of data	Utility or government records, or official publications.
Frequency of monitoring/recording	Once for the Crediting Period, as a three-year generation-weighted average, where the ex ante data vintage applies; annually where the ex post data vintage applies.
QA/QC procedures to be applied	-
Comments	-

Data/Parameter	$NCV_{i,y}$
Data unit	GJ per mass or volume unit
Description	Net calorific value of fossil fuel type i in year y
Equations	(13), (15)
Source of data	Data sources are used in the following order of priority: 1) Values provided by the fuel supplier in invoices or published by the fuel supplier. 2) Regional or national average default values. 3) IPCC default values taken at the upper or lower limit, whichever is the more conservative, of the uncertainty at a 95 per cent confidence interval, as per Table 1.2, Chapter 1, Volume 2 of the 2006 IPCC Guidelines.
Frequency of monitoring/recording	Once for the Crediting Period, as a three-year generation-weighted average, where the ex ante data vintage applies; annually where the ex post data vintage applies.
QA/QC procedures to be applied	-
Comments	Gross calorific values may be used in place of net calorific values, provided they are applied consistently to the fuel consumption data and to the emission factor.

Data/Parameter	$EF_{CO2,i,y}$, $EF_{CO2,m,i,y}$
Data unit	t CO_2/GJ

Description	CO_2 emission factor of fossil fuel type *i* in year y and, in the case of $EF_{CO2,m,i,y}$, of fossil fuel type *i* used in power unit *m* in year *y*.
Equations	(13), (14), (15)
Source of data	Data sources are used in the same order of priority as for $NCV_{i,y}$, with IPCC default values taken from Table 1.4, Chapter 1, Volume 2 of the 2006 IPCC Guidelines.
Frequency of monitoring/recording	Once for the Crediting Period, as a three-year generation-weighted average, where the ex ante data vintage applies; annually where the ex post data vintage applies.
QA/QC procedures to be applied	-
Comments	For biofuels the value applied to the CO_2 emission factor is zero

3.References

References to CDM methodologies and methodological tools are to the version in force at the time of validation.

CDM (ACM0002). Grid-connected electricity generation from renewable sources. Large-scale Consolidated Methodology. Clean Development Mechanism, UNFCCC.

CDM (TOOL03). Tool to calculate project or leakage CO_2 emissions from fossil fuel combustion. Methodological Tool. Clean Development Mechanism, UNFCCC.

CDM (TOOL07). Tool to calculate the emission factor for an electricity system. Methodological Tool. Clean Development Mechanism, UNFCCC.

CDM (TOOL09). Determining the baseline efficiency of thermal or electric energy generation systems. Methodological Tool. Clean Development Mechanism, UNFCCC.

CDM (TOOL14). Project and leakage emissions from anaerobic digesters. Methodological Tool. Clean Development Mechanism, UNFCCC.

CDM (TOOL16). Project and leakage emissions from biomass. Methodological Tool. Clean Development Mechanism, UNFCCC.

IPCC (2006). Chapter 1, Volume 2: Energy. In: 2006 IPCC Guidelines for National Greenhouse Gas Inventories. Institute for Global Environmental Strategies (IGES).

IPCC (2019). 2019 Refinement to the 2006 IPCC Guidelines for National Greenhouse Gas Inventories. IPCC.

Document History

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