T-VER-P-METH-08-01

Cement Production from Alternative Materials

Version 02

Scope: 04 - Manufacturing industries

Entry into force on July 23, 2026

Thailand Greenhouse Gas Management Organization (Public Organization) (TGO)

1. Methodology	**Cement production from alternative materials**
2. Project Type	The use of alternative materials to replace clinker
3. Scope	04 – Manufacturing industries
4. Project Outline	The project activities must aim to increase the proportion of alternative materials that reduce greenhouse gas emissions from the clinker production process, including the addition of supplementary cementitious materials in cement.
5. Applicability	The project involves activities for producing alternative materials derived from raw materials with no or low carbonate content for clinker production, including increasing the proportion of supplementary additives to reduce the clinker content in cement.
6. Project Conditions	1) The project activity does not include increase in clinker production capacity nor prolonging operational lifespan of existing equipment. 2) The choice of alternative raw materials must involve none or low carbonate content in clinker production. 3) The introduction of low carbonate materials and supplementary additives must not affect the quality of cement as specified under the Thai Industrial Standard TIS 2594. 4) The alternative raw materials must not be previously used by the project developer in clinker production prior to the implementation of project activities. 5) In the case where the project developer opts to implement fuel switching measures, such activity shall not be accounted for in the calculation of greenhouse gas emission reduction under this methodology. 6) This methodology shall not be applied to cement production intended for export.
7. Project Starting Date	The date on which the project owner (employer) and the contractor jointly signed the construction or installation agreement for the greenhouse gas reduction project to be developed as a T-VER project.
8. Definition	**Clinker** refers to the primary material used in cement production, obtained by calcination or clinker burning of raw materials such as clay and limestone at high temperatures.

	Supplementary additives refer to materials other than clinker, such as fly ash, gypsum, and slag, which are blended with clinker to produce various types of cement. **Alternative non carbonate raw materials for clinker production** refer to minerals, synthetic substances, or compounds that contain no carbonates in their chemical composition. These materials may be derived from mining, processing, or by-products from other industrial processes, and chemically interact with conventional raw materials used in clinker production. Such alternative materials may include bottom ash from thermal power plants, slag from iron furnaces, gypsum, anhydrite, fluoride, etc., which are not traditionally used in conventional production **Cement** refers to a material composed of clinker and supplementary additives. **Types of cement** refer to distinct products, varying based on the types and proportions of supplementary additives and clinker, and intended for different purposes. **Project activity cement product** refers to cement produced by blending clinker with supplementary additives under the scope of project activities. **Project activity clinker product** refers to clinker produced from alternative raw materials without carbonate content, under the scope of project activities **Raw materials** refer to the inputs that are processed in cement kilns to produce clinker. **Refuse Derived Fuel (RDF)** refers to municipal solid waste that has undergone physical processing such as sorting, screening, size reduction, and moisture removal to produce combustible materials with size and properties suitable for use as fuel in industrial or community settings, or as fuel in municipal solid waste incinerators or waste-to-energy power plants

Details of T-VER Methodology for Cement Production from Alternative Materials

1. Emission reductions activities used in the calculations

Table 1: Sources and Types of Greenhouse Gases

Greenhouse gas emission	Source	Greenhouse Gas	Details of activities that emit greenhouse gas emissions
Baseline Emission	Clinker kiln	CO_2	Raw material combustion in kiln
	Use of electricity	CO_2	Electricity consumption in the clinker kiln, including electricity use for raw material preparation and cement production
	Use of fossil fuels	CO_2	Fossil fuel consumption in the clinker kiln, including fuel use for raw material preparation
	Use of waste-derived fuel	CO_2	Utilization of refuse-derived fuel (RDF) in clinker kiln combustion
	Clinker transportation	CO_2	Fossil fuel consumption for transporting clinker to the cement production plant
Project Emission	Clinker kiln	CO_2	Raw material combustion in kiln
	Use of electricity	CO_2	Electricity consumption in the clinker kiln, including electricity use for raw material preparation and cement production
	Use of fossil fuels	CO_2	Fossil fuel consumption in the clinker kiln, including fuel use for raw material preparation
	Use of waste-derived fuel	CO_2	Utilization of refuse-derived fuel (RDF) in clinker kiln combustion
	Utilization of biomass and residual biomass	CO_2 and CH_4	● Cultivation of biomass in designated plantation areas ● Transportation of biomass ● Processing of biomass ● Transportation of residual biomass (if applicable)

Greenhouse gas emission	Source	Greenhouse Gas	Details of activities that emit greenhouse gas emissions
			● Processing of residual biomass (if applicable)
	Transportation and preparation of alternative materials	CO_2	The use of fossil fuels for transportation and preparation of alternative materials
	Clinker transportation	CO_2	Fossil fuel consumption for transporting clinker to the cement production plant
Leakage Emission	The transportation and acquisition of alternative raw materials and supplementary additives	CO_2	The use of fossil fuels for transporting alternative raw materials and supplementary additives
	The use of biomass and residual biomass	CO_2 and CH_4	● Cultivation of biomass in dedicated plantation areas ● Transportation of biomass ● Processing of biomass ● Transportation of residual biomass (if applicable) ● Processing of residual biomass (if applicable)

2. Scope of Project

Project activity is aimed to increase the proportion of alternative raw materials with low carbonate contents in clinker production including uses of additives in cement production.

The project scope encompasses all pertinent units within the cement manufacturing process, including raw material preparation, clinker production, and cement production. It further includes the receipt and handling of alternative raw materials, additives, and fossil fuels, as well as the dispatch and delivery of the finished cement product.

3. Additionality

The project must undergo further proof of operation from normal operations. (Additionality) using the “Proof of Operations Guidelines in addition to normal operations (Additionality) under the Thailand Voluntary Emission Reduction Program (T-VER)" standard equivalent to the international standards prescribed by the TGO.

4. Baseline Scenario

Baseline Determination Approach (Below BAU) considers the approach for determining baseline data below business-as-usual (BAU), cement production with lower greenhouse gas (GHG) emissions than Portland cement is treated as Below BAU. Hydraulic cement is chosen as BAU activity for this methodology, with reference emissions of 910 kgCO_2 per ton of cement as defined by the Thai Industrial Product Standard (TIS 15-2562: Portland Cement) and the Cement Industry Association of Thailand. Therefore, the below BAU baseline emission is defined as the production of hydraulic cement with a 10% reduction in clinker content, resulting in GHG emissions of 871 kgCO_2 per ton of cement.

5. Baseline Emission

Baseline emissions consider only carbon dioxide (CO_2) emissions associated with the volume of cement produced and sold domestically and emissions arising from the production of clinker and cement.

Case 1 If $\left(BE_{Clinker,BSL} \times B_{Blend,y}\right) + BE_{ele,ADD,BC} + BE_{FC,ADD,BC} < 871$ kgCO_2 per ton of cement

Calculation of $\left(BE_{Clinker,BSL} \times B_{Blend,y}\right) + BE_{ele,ADD,BC} + BE_{FC,ADD,BC}$ can be applied.

Case 2 If $\left(BE_{Clinker,BSL} \times B_{Blend,y}\right) + BE_{ele,ADD,BC} + BE_{FC,ADD,BC} \geq 871$ kgCO_2 per ton of cement

One shall assume $\left(BE_{Clinker,BSL} \times B_{Blend,y}\right) + BE_{ele,ADD,BC} + BE_{FC,ADD,BC} = 871$ kgCO_2 per ton of cement

Baseline emission can be calculated as follows:

$$BE_y = BC_y \times \left[\left(BE_{Clinker,BSL} \times B_{Blend,y}\right) + BE_{ele,ADD,BC} + BE_{FC,ADD,BC}\right] \qquad \text{Equation (1)}$$

Where

BE_y = Baseline emissions in year y (tCO_2/year)

BC_y = Cement produced and sold in the domestic market in year y (t cement)

$BE_{Clinker,BSL}$ = Baseline emissions per ton of clinker in base year (t CO_2/t clinker)

$B_{Blend,y}$ = Baseline benchmark share of clinker per ton of cement updated for year y (t clinker/t cement)

$BE_{ele,ADD,BC}$ = Baseline electricity emissions for cement grinding and preparation of additives (t CO_2/t cement)

$BE_{FC,ADD,BC}$ = Baseline fossil fuel emissions for cement grinding and preparation of additives (t CO_2/t cement)

5.1 Baseline emissions per ton of clinker in base year ($BE_{Clinker,BSL}$)

Baseline emissions per ton of clinker in base year can be calculated as follows

$$BE_{Clinker,BSL} = BE_{calcin} + BE_{FC} + BE_{ele,grid,CLNK} + BE_{ete,sg,CLNX} + BE_{Dust} + BE_{FC\_Dry} + BE_{TR} \qquad \text{Equation (2)}$$

Where

$BE_{Clinker,BSL}$ = Baseline emissions per ton of clinker in base year (t CO_2/t clinker)

BE_{calcin} = Baseline emissions per ton of clinker due to calcination of calcium carbonate and magnesium carbonate (t CO_2/t clinker)

BE_{FC} = Baseline emissions per ton of clinker due to combustion of fossil fuels for clinker production (t CO_2/t clinker)

$BE_{ele,grid,CLNK}$ = Baseline grid electricity emissions for clinker production per ton of clinker (t CO_2/t clinker)

$BE_{ete,sg,CLNk}$ = Baseline emissions from self-generated electricity for clinker production per ton of clinker (t CO_2/t clinker)

BE_{Dust} = Baseline emissions due to dust discarded through bypass and dedusting units (CKD) (t CO_2/t clinker)

BE_{FC_Dry} = Baseline emissions due to fuel consumption for preparation of raw materials or fuels (t CO_2/t clinker)

BE_{TR} = Baseline emissions from the transportation of clinker to the cement manufacturing plant (t CO_2/t clinker)

5.1.1 Baseline emissions per ton of clinker due to calcination of calcium carbonate and magnesium carbonate (BE_{calcin})

Baseline emissions per ton of clinker due to calcination of calcium carbonate and magnesium carbonate can be calculated as follows

$$BE_{calcin} = \frac{0.785 \times (OutCaO - InCaO) + 1.092 \times (OutMgO - InMgO)}{CLNK_{BSL}} \quad \text{Equation (3)}$$

Where

BE_{calcin}	=	Baseline emissions per ton of clinker due to calcinations of calcium carbonate and magnesium carbonate (t CO_2/t clinker)
0.785	=	Stoichiometric emission factor for CaO (t CO_2/t CaO)
1.092	=	Stoichiometric emission factor for MgO (t CO_2/t MgO)
InCaO	=	Baseline non-carbonated CaO content in the raw material (t CaO)
OutCaO	=	Baseline CaO content in the clinker produced (t CaO)
InMgO	=	Baseline non-carbonated MgO content in the raw material (t MgO)
OutMgO	=	Baseline MgO content in the clinker produced (t MgO)
$CLNK_{BSL}$	=	Annual production of clinker in the base year (t clinker)

5.1.2 Baseline emissions per ton of clinker due to combustion of fossil fuels for clinker production (BE_{FC})

Baseline emissions per ton of clinker due to combustion of fossil fuels for clinker production can be calculated as follows

$$BE_{FC} = BE_{FC,FF} + BE_{FC,RDF} \quad \text{Equation (4)}$$

Where

BE_{FC}	=	Baseline emissions per ton of clinker due to combustion of fossil fuels for clinker production (t CO_2/t clinker)
$BE_{FC,FF}$	=	Baseline emissions per ton of clinker due to combustion of fossil fuel in clinker kilns (t CO_2/t clinker)
$BE_{FC,RDF}$	=	Baseline emissions per ton of clinker due to combustion of waste-derived fuels in clinker kilns (t CO_2/t clinker)

5.1.2.1 Baseline emissions per ton of clinker due to combustion of fossil fuel in clinker kilns ($BE_{FC,FF}$)

Baseline emissions per ton of clinker due to combustion of fossil fuel in clinker kilns shall be calculated based on historical fuel consumption data for each type of fossil fuel used in the existing kiln. Project developers are required to provide fuel consumption records covering at least three years prior to the start of the project activity. These records shall be averaged, excluding any year with abnormal operating conditions. The emissions shall be calculated as follows:

$$BE_{FC,FF} = \frac{\sum_i FC_{i,BSL} \times NCV_i \times EF_{CO2,i} \times 10^{-6}}{CLNK_{BSL}} \qquad \text{Equation (5)}$$

Where

$BE_{FC,FF}$ = Baseline emissions per ton of clinker due to combustion of fossil fuel in clinker kilns (t CO_2/t clinker)

$FC_{i,BSL}$ = Quantity of fossil fuel of type i consumed for clinker production in the base year (unit)

NCV_i = Net calorific value of the fuel type i (GJ/unit)

$EF_{CO2,i}$ = CO_2 emissions from fossil fuel combustion type i ($kgCO_2$/TJ)

$CLNK_{BSL}$ = Annual production of clinker in the base year (t clinker)

i = Type of fossil fuel

5.1.2.2 Baseline emissions per ton of clinker due to combustion of waste-derived fuels in clinker kilns ($BE_{FC,RDF}$)

Baseline emissions per ton of clinker due to combustion of waste-derived fuels in clinker kilns: The baseline scenario provides two options for calculating the quantity of greenhouse gas emissions resulting from the combustion of RDF in clinker kilns, as outlined below:

Option 1: Pre-sorted waste

$$BE_{FC,RDF} = \frac{EFF_{COM} \times (44/12) \times \sum_j Q_j \times FCC_j \times FFC_j}{CLNK_{BSL}} \qquad \text{Equation (6)}$$

Where

$BE_{FC,RDF}$ = Baseline emissions per ton of clinker due to combustion of waste-derived fuels in clinker kilns (t CO_2/t clinker)

EFF_{COM} = Combustion efficiency of clinker kilns under the baseline scenario (%)

44/12 = Conversion factor (t CO_2 / t C)

Q_j = Quantity of waste type j used in clinker kilns under the baseline scenario (t)

FCC_j = Carbon content ratio of waste type j in baseline year y (t C/t)

FFC_j = Fossil carbon fraction in the total carbon content of waste type j under the baseline scenario (Weight-based ratio)

i = Type of clinker

j = Type of waste

1) Quantity of waste type j Used in clinker kilns under the baseline scenario (Q_j)

Quantity of waste type j used in clinker kilns under the baseline scenario can be calculated as follows

$$\mathbf{Q_j = Q_{waste} \times \frac{\sum_{n=1}^{z} P_{n,j}}{Z}}$$

Equation (7)

Where

Q_j = Quantity of waste type j used in clinker kilns (t)

Q_{waste} = Quantity of organic waste or refuse-derived fuel (RDF) used in clinker kilns (t)

$P_{n,j}$ = Weight-based fraction of waste Type j in sample n

Z = Number of Samples

n = Collected Sample

j = Type of waste

Option 2: Unsorted waste

$$\mathbf{BE_{FC,RDF}} = \frac{\sum_i (44/12) \times FF_{COM} \times Q_{waste} \times FFC_{waste}}{CLNK_{BSL}} \quad \text{Equation (8)}$$

Where

$BE_{FC,RDF}$ = Baseline emissions per ton of clinker due to combustion of waste-derived fuels in clinker kilns (t CO_2/t clinker)

Q_{waste} = Quantity of waste or refuse-derived fuel (RDF) used in clinker kilns in year y

FFC_{waste} = Fossil carbon fraction in waste or refuse-derived fuel (RDF) used in clinker kilns in year y (t C/t)

FF_{COM} = Combustion efficiency of the cement clinker kiln in year y (%)

44/12 = Conversion factor (t CO_2 / t C)

$CLNK_{BSL}$ = Annual production of clinker in the base year (t clinker)

i = Type of clinker

5.1.3 Baseline grid electricity emissions for clinker production per ton of clinker ($BE_{ele,grid,CLNK}$)

Baseline grid electricity emissions for clinker production per ton of clinker can be calculated as follows

$$\mathbf{BE_{ele,grid,CLNK}} = \frac{BELE_{grid,CLNK} \times EF_{EC,PJ,y}}{CLNK_{BSL}} \quad \text{Equation (9)}$$

Where

$BE_{ele,grid,CLNK}$ = Baseline grid electricity emissions for clinker production per ton of clinker (t CO_2/t clinker)

$BELE_{grid,CLNK}$ = Grid electricity consumed for clinker production in base year (MWh)

$EF_{EC,PJ,y}$ = Baseline grid emission factor (t CO_2/MWh)

$CLNK_{BSL}$ = Annual production of clinker in the base year (t clinker/year)

5.1.4 Baseline emissions from self-generated electricity for clinker production per ton of clinker ($BE_{ete,sg,CLNX}$)

Baseline emissions from self-generated electricity for clinker production per ton of clinker can be calculated as follows

$$BE_{ete,sg,CLNX} = \frac{\sum BELE_{sg,CLNK} \times EF_{sg,BSL}}{CLNK_{BSL}} \qquad \text{Equation (10)}$$

Where

$BE_{ete,sg,CLNX}$ = Baseline emissions from self-generated electricity for clinker production per ton of clinker (t CO_2/ t clinker)

$BELE_{sg,CLNK}$ = Self-generation of electricity for clinker production in the base year (MWh)

$EF_{sg,BSL}$ = Emission factor for self-generated electricity in the base year (t CO_2/MWh)

$CLNK_{BSL}$ = Annual production of clinker in the base year (t clinker)

5.1.5 Baseline emissions due to dust discarded through bypass and dedusting units (BE_{Dust})

Baseline emissions due to dust discarded through bypass and dedusting units can be calculated as follows

$$BE_{Dust} = \frac{\left\{ (C_{BSL} \times Bypass_{BSL}) + \left\{ \frac{C_{BSL} \times d_{BSL}}{(C_{BSL} \times (1- d_{BSL}) + 1)} \right\} \times CKD_{BSL} \right\}}{CLNK_{BSL}} \qquad \text{Equation (11)}$$

Where

BE_{Dust} = Baseline CO_2 emissions due to dust discarded through bypass and dedusting units (CKD) (t CO_2/t clinker)

C_{BSL} = Baseline calcination emissions factor due to both de-carbonization reaction and fuel consumption in clinker production (t CO_2/t clinker)

$Bypass_{BSL}$ = Annual production of bypass dust leaving kiln system (t)

CKD_{BSL} = Annual production of CKD dust leaving kiln system in the baseline (t)

d_{BSL} = CKD calcination rate (released CO_2 expressed as a fraction of the total carbonate CO_2 in the raw materials)

$CLNK_{BSL}$ = Annual production of clinker in the baseline (t)

1) Baseline calcination emissions factor due to both de-carbonization reaction and fuel consumption in clinker production (C_{BSL})

Baseline calcination emissions factor due to both de-carbonization reaction and fuel consumption in clinker production can be calculated as follows

$$C_{BSL} = BE_{calcin} + BE_{FC} \quad \text{Equation (12)}$$

Where

C_{BSL} = Baseline calcination factor due to both de-carbonization reaction and fuel consumption in clinker production (t CO_2/t clinker)

BE_{calcin} = Baseline CO_2 emissions from calcination of calcium carbonate and magnesium carbonate (t CO_2/t clinker)

BE_{FC} = Baseline CO_2 emissions from fuel consumption in clinker production (t CO_2/t clinker)

5.1.6 Baseline emissions from fuel consumption for preparation of raw materials or fuels (BE_{FC_Dry})

The amount of greenhouse gas emissions from fuel combustion during the preparation of alternative raw materials under the baseline scenario shall be calculated using the method described in Section 5.1.2: Calculation of greenhouse gas emissions from fuel combustion in the cement clinker kiln under the baseline scenario, assuming that BE_{FC_Dry} is equal to BE_{FC}.

5.1.7 Baseline emissions from fuel consumption for preparation of raw materials or fuels (BE_{FC_Dry})

Baseline emissions from fuel consumption for preparation of raw materials or fuels shall be calculated based on the amount of fossil fuel used for combustion in the preparation process. The project developer must provide data on the consumption of each type of fossil fuel used in raw material preparation for at least three years prior to the start of project activities, and the average shall be assessed (excluding years with abnormal usage). The calculation shall be carried out as follows

$$BE_{FC\_Dry} = \frac{\sum_i FC_{dry,i} \times NCV_i \times EF_{CO2,i} \times 10^{-6}}{CLNK_{BSL}} \quad \text{Equation (13)}$$

Where

BE_{FC_Dry} = Baseline emissions due to fuel consumption for preparation of raw materials or fuels (t CO_2)

$FC_{dry,i}$ = Quantity of fossil fuel i consumed for preparation of raw materials or fuels in the baseline (unit)

NCV_i = Net calorific value of the fuel type i (GJ/unit)

$EF_{CO2,i}$ = CO_2 emission factor for fuel type i (t CO_2/GJ)

$CLNK_{BSL}$ = Annual production of clinker in the baseline (t)

i = Type of fossil fuel

5.1.8 Baseline emissions from the transportation of clinker to the cement manufacturing plant (BE_{TR})

Baseline emissions from the transportation of clinker to the cement manufacturing plant shall consider only carbon dioxide (CO_2) emissions from fossil fuel combustion in vehicles powered by internal combustion engines. The calculation shall be carried out as follows

$$BE_{TR} = \frac{\sum_i FC_{TR,i} \times NCV_i \times EF_{CO2,i} \times 10^{-6}}{CLNK_{BSL}} \quad \text{Equation (14)}$$

Where

BE_{TR} = Baseline emissions from the transportation of clinkers to the cement manufacturing plant (tCO_2/year)

$FC_{TR,i}$ = Quantity of fossil fuel type i consumed by internal combustion engine vehicles for transporting clinkers to the cement manufacturing plant under baseline scenario (unit)

NCV_i = Net calorific value of fossil fuel type i (GJ/unit)

$EF_{CO2,i}$ = CO_2 emissions from the combustion of fossil fuel type i (kg CO_2/TJ)

$CLNK_{BSL}$ = Annual production of clinkers in the base year (t clinker/year)

i = Type of fossil fuel

5.2 Baseline benchmark share of clinker per ton of cement updated ($B_{Blend,y}$)

There are two options for determining the value of $B_{Blend,y}$ as detailed below:

Option 1: Use data on the clinker-to-cement ratio from the project developer for at least three years prior to the start of project activities, and assess the average value (excluding years with abnormal usage).

Option 2: In cases where clinker-to-cement ratio data for the three years prior to the start of project activities is unavailable, the project developer shall use data with comparable operating conditions and statistical significance, or data obtained from relevant units. The priority of data sources shall be ranked as follows:

(1) Clinker-to-cement ratio from other companies with comparable operations conducted concurrently with the project;

(2) National statistics on clinker-to-cement ratios;

(3) International data on clinker-to-cement ratios.

5.3 Baseline electricity emissions for cement grinding and preparation of additives ($BE_{ele,ADD,BC}$)

Baseline electricity emissions for cement grinding and preparation of additives shall be calculated based on emissions from grid electricity and self-generated electricity used for cement grinding and additive preparation, as follows.

$$\mathbf{BE_{ele,ADD,BC} = BE_{ele,grid,BC} + BE_{ele,SG,BC} + BE_{ele,grid,ADD} + BE_{ele,SG,ADD}} \qquad \text{Equation (15)}$$

Where

$BE_{ele,ADD,BC}$ = Baseline electricity emissions for cement grinding and preparation of additives (t CO_2/t cement)

$BE_{ele,grid,BC}$ = Baseline grid electricity emissions for cement grinding (t CO_2/t cement)

$BE_{ele,SG,BC}$ = Baseline self-generated electricity emissions for cement grinding (t CO_2/t cement)

$BE_{ele,grid,ADD}$ = Baseline grid electricity emissions for additive preparation (t CO_2/t cement)

$BE_{ele,SG,ADD}$ = Baseline self-generated electricity emissions for additive preparation (t CO_2/t cement)

5.3.1 Baseline electricity emissions for cement grinding and preparation of additives ($BE_{ele,grid,BC}$)

Baseline electricity emissions for cement grinding and preparation of additives can be calculated as follows

$$BE_{ele,grid,BC} = \frac{BELE_{grid,BC} \times EF_{EC,PJ,y}}{BC_{BSL}}$$ Equation (16)

Where

$BE_{ele,grid,BC}$ = Baseline electricity emissions for cement grinding and preparation of additives (t CO_2/t cement)

$BELE_{grid,BC}$ = Baseline grid electricity for grinding cement (MWh)

$EF_{EC,PJ,y}$ = Baseline grid emission factor (t CO_2/MWh)

BC_{BSL} = Annual production of cement in the base year (t cement)

5.3.2 Baseline self-generated electricity emissions for cement grinding ($BE_{ele,SG,BC}$)

$$BE_{ele,SG,BC} = \frac{BELE_{SG,BC} \times EF_{SG,BSL}}{BC_{BSL}}$$ Equation (17)

Where

$BE_{ele,SG,BC}$ = Baseline self-generated electricity emissions for cement grinding (t CO_2/t cement)

$BELE_{SG,BC}$ = Baseline self-generation electricity for grinding cement (MWh)

$EF_{SG,BSL}$ = Emission factor for self-generated electricity in the base year (t CO_2/MWh)

BC_{BSL} = Annual production of cement in the base year (t cement)

5.3.3 Baseline grid electricity emissions for additive preparation ($BE_{ele,grid,ADD}$)

Baseline grid electricity emissions for additive preparation can be calculated as follows

$$BE_{ele,grid,ADD} = \frac{BELE_{grid,ADD} \times EF_{EC,PJ,y}}{BC_{BSL}}$$ Equation (18)

Where

$BE_{ele,grid,ADD}$ = Baseline grid electricity emissions for additive preparation (t CO_2/ t cement)

$BELE_{grid,ADD}$ = Baseline grid electricity for grinding additives (MWh)

$EF_{EC,PJ,y}$ = Baseline grid emission factor (t CO_2/MWh)

BC_{BSL} = Annual production of cement in the base year (t cement)

5.3.4 Baseline emissions from self-generated electricity for the preparation of additives ($BE_{ele,SG,ADD}$)

Baseline emissions from self-generated electricity for the preparation of additives can be calculated as follows

$$BE_{ele,SG,ADD} = \frac{BELE_{SG,ADD} \times EF_{SG,BSL}}{BC_{BSL}} \qquad \text{Equation (19)}$$

Where

$BE_{ele,SG,ADD}$ = Baseline self-generated electricity emissions for additive preparation ($t\ CO_2$/ t cement)

$BELE_{SG,ADD}$ = Baseline self-generation electricity for grinding additives (MWh)

$EF_{SG,BSL}$ = Emission factor for self-generated electricity in the base year ($t\ CO_2$/MWh)

BC_{BSL} = Annual production of cement in the base year (t cement)

5.3.4.1 Emission factor for self-generated electricity in the base year ($EF_{SG,BSL}$)

Emission factor for self-generated electricity in the base year can be calculated as follows

$$EF_{SG,BSL} = \frac{\sum_{m,n} FC_{m,n,BSL} \times COEF_m}{\sum_n GEN_{n,BSL}} \qquad \text{Equation (20)}$$

Where

$EF_{SG,BSL}$ = Emission factor for self-generated electricity in the base year ($t\ CO_2$/MWh)

$FC_{m,n,BSL}$ = Amount of fossil fuel m used for self-generated electricity from source n under the baseline scenario (unit)

n = Source of electricity for own use

$COEF_m$ = CO_2 emission coefficient of fuel m ($t\ CO_2$/ unit)

$GEN_{n,BSL}$ = Electricity generated by the source n in year y (MWh)

1) CO_2 emission coefficient of fuel m ($COEF_m$)

CO_2 emission coefficient of fuel m is calculated using the latest version of the calculation tool T-VER-P-TOOL-02-01: Tool to Calculate Project or Leakage CO_2 Emissions from Fossil Fuel Combustion.

5.4 Baseline fossil fuel emissions for cement grinding and preparation of additives ($BE_{FC,ADD,BC}$)

Baseline fossil fuel emissions for cement grinding and preparation of additives shall be calculated based on the amount of fossil fuel used for these activities. Project developers must provide fuel consumption data for each fuel type used in raw material preparation for at least three years prior to the start of project activities. The data should be averaged, excluding any years with abnormal usage. The emissions can be calculated as follows

$$BE_{FC,ADD,BC} = \frac{\sum_i FC_{add,bc,i} \times NCV_i \times EF_{CO2,i} \times 10^{-6}}{BC_{BSL}} \qquad \text{Equation (21)}$$

Where

$BE_{FC,ADD,BC}$ = Baseline fossil fuel emissions for cement grinding and preparation of additives (t CO_2 / t cement)

$FC_{add,bc,i}$ = Quantity of fossil fuel type i used in raw material preparation under the baseline scenario (unit)

NCV_i = Net calorific value of fossil fuel type i (GJ/unit)

$EF_{CO2,i}$ = CO_2 emissions from combustion of fossil fuel type i (kg CO_2/TJ)

BC_{BSL} = Annual production of cement in the base year (t cement)

i = Type of fossil fuel

6. Project Emission

Project Emissions consider only carbon dioxide (CO_2) emissions resulting from the amount of cement produced and sold domestically, as well as emissions from the production of clinkers and cement. The greenhouse gas emissions from project activities can be calculated as follows.

$$PE_y = BC_y \times (PE_{clinker,y} \times P_{Blend,y} + PE_{ele,ADD,BC,y} + PE_{FC,ADD,BC,y} + PE_{TR,ADD,BC,y}) \qquad \text{Equation (22)}$$

Where

PE_y = Project emissions in year y (t CO_2)

BC_y = Blended cement produced and sold in the domestic market in year y (t cement)

$PE_{clinker,y}$ = Project emissions per ton of clinker in the project activity plant in year y (t CO_2/t clinker)

$P_{Blend,y}$ = Share of clinker per ton of cement in year y (t clinker/t cement)

$PE_{ele,ADD,BC,y}$ = Electricity emissions for cement grinding and preparation of alternative raw material and additives in year y (t CO_2/ t cement)

$PE_{FC,ADD,BC,y}$ = Project emissions from fuel combustion for cement grinding, raw material/ alternative material production and preparation of additives (t CO_2/t cement)

$PE_{TR,ADD,BC,y}$ = Project emissions from transportation of raw material or alternative material to the cement manufacturing plant (t CO_2/t cement)

6.1 Project emissions per ton of clinker in the project activity plant ($PE_{clinker,y}$)

Project emissions per ton of clinker in the project activity plant can be calculated as follows

$$PE_{Clinker,y} = \sum\nolimits_i \left(PE_{calcin,i,y} + PE_{FC,i,y} + PE_{ele,CLNK,i,y} + PE_{Dust,i,y} + PE_{FC\_Dry,i,y} + PE_{TR,i,y}\right) \times P_{CLNK,i,y} \qquad \text{Equation (23)}$$

Where

$PE_{Clinker,y}$ = Project emissions per ton of clinker in the project activity plant in year y (t CO_2/t clinker)

$PE_{calcin,i,y}$ = Project emissions per ton of clinker i due to calcination of calcium carbonate and magnesium carbonate in year y (t CO_2/t clinker)

$PE_{FC,i,y}$ = Project emissions per ton of clinker i due to combustion of fossil fuels for clinker production in year y (t CO_2/t clinker)

$PE_{ele,grid,CLNK,i,y}$ = Project emissions from grid electricity for clinker production per ton of clinker i in year y (t CO_2/ t clinker)

$PE_{ete,sg,CLNX,i,y}$ = Emissions from self-generated electricity per ton of clinker i production in year y (t CO_2/t clinker)

$PE_{Dust,i,y}$ = Project emissions due to discarded dust from bypass and dedusting units (CKD) per ton of clinker i in year y (t CO_2/ t clinker)

$PE_{FC\_Dry,i,y}$ = Project emissions due to fuel consumption for preparation of raw materials or fuels per ton of clinker i in year y (t CO_2/ t clinker)

$PE_{TR,i,y}$ = Project emissions from the transportation of clinker to the cement manufacturing plant (t CO_2/t clinker)

$P_{CLNK,i,y}$ = Ratio of clinker i for total production of clinker in year y (t clinker /t clinker)

i = Type of clinker

6.1.1 Project emissions per ton of clinker i due to calcination of calcium carbonate and magnesium carbonate ($PE_{calcin,i,y}$)

Project emissions per ton of clinker i due to calcination of calcium carbonate and magnesium carbonate can be calculated as follows

$$PE_{calcin,i,y} = \frac{0.785 \times (OutCaO_{i,y} - InCaO_{i,y}) + 1.092 \times (OutMgO_{i,y} - InMgO_{i,y})}{CLNK_{i,y}}$$ Equation (24)

Where

$PE_{calcin,i,y}$ = Project emissions per ton of clinker i due to calcinations of calcium carbonate and magnesium carbonate in year y (t CO_2/t clinker)

0.785 = Stoichiometric emission factor for CaO (t CO_2/t CaO)

1.092 = Stoichiometric emission factor for MgO (t CO_2/t MgO)

$InCaO_{i,y}$ = Non-carbonated CaO content of clinker i in the raw material in year y (t CaO)

$OutCaO_{i,y}$ = CaO content in the clinker i produced in year y (t CaO)

$InMgO_{i,y}$ = Non-carbonated MgO content of clinker i in the raw material in year y (t MgO)

$OutMgO_{i,y}$ = MgO content in the clinker i produced in year y (t MgO)

$CLNK_{i,y}$ = Production of clinker i in year y (t clinker)

6.1.2 Project emissions per ton of clinker i due to combustion of fossil fuels for clinker production ($PE_{FC,i,y}$)

Project emissions per ton of clinker i due to combustion of fossil fuels for clinker production can be calculated as follows

$$PE_{FC,i,y} = PE_{FC,FF,i,y} + PE_{FC,RDF,i,y} + PE_{biomass,i,y}$$ Equation (25)

Where

$PE_{FC,i,y}$ = Project emissions per ton of clinker due to combustion of fossil fuel in clinker kilns (t CO_2/t clinker)

$PE_{FC,FF,i,y}$ = Project emissions per ton of clinker due to combustion of waste-derived fuels in clinker kilns (t CO_2/t clinker)

$PE_{FC,RDF,i,y}$ = Project emissions per ton of clinker due to combustion of fossil fuel in clinker kilns (t CO_2/t clinker)

$PE_{FC,biomass,i,y}$ = Project emissions per ton of clinker due to combustion of biomass in clinker kilns (t CO_2/t clinker)

i = Type of fuel

Remark The project developer should compare the calculated project emissions from the use of fossil fuels and alternative fuels in the cement kiln (**$PE_{FC,i,y}$**) with the baseline emissions from the use of fossil fuels and alternative fuels (**BE_{FC}**), and consider the following values:

- If $\mathbf{PE_{FC,i,y} > BE_{FC}}$, use the value of $\mathbf{PE_{FC,i,y}}$
- If $\mathbf{PE_{FC,i,y} \leq BE_{FC}}$, use the value of $\mathbf{PE_{FC,i,y} = BE_{FC}}$

6.1.2.1 Project emissions per ton of clinker due to combustion of waste-derived fuels in clinker kilns ($PE_{FC,FF,i,y}$)

Project emissions per ton of clinker due to combustion of waste-derived fuels in clinker kilns can be calculated as follows

$$PE_{FC,FF,I,y} = \frac{\sum_i FC_{i,y} \times NCV_i \times EF_{CO2,i} \times 10^{-6}}{CLNK_{I,y}} \qquad \text{Equation (26)}$$

Where

$PE_{FC,FF,I,y}$ = Project emissions per ton of clinker due to combustion of waste-derived fuels in clinker kilns

$FC_{i,y}$ = Quantity of fossil fuel of type i consumed for clinker production in year y (unit)

NCV_i = Net calorific value of the fuel type i (GJ/unit)

$EF_{CO2,i}$ = CO_2 emissions from fossil fuel combustion type i ($kgCO_2$/TJ)

$CLNK_{i,y}$ = Production of clinker i in year y (t clinker)

6.1.2.2 Project emissions per ton of clinker due to combustion of fossil fuel in clinker kilns ($PE_{FC,RDF}$)

Project emissions per ton of clinker due to combustion of fossil fuel in clinker kilns is determined using two options, as outlined below

Option 1: Pre-sorted waste

$$PE_{FC,RDF,i,y} = \frac{EFF_{COM,y} \times (44/22) \times \sum_j Q_{j,y} \times FCC_{j,y} \times FFC_{j,y}}{CLNK_{i,y}} \qquad \text{Equation (27)}$$

Where

$PE_{FC,RDF,i,y}$ = Project emissions per ton of clinker due to combustion of fossil fuel in clinker kilns (t CO_2/t clinker)

$EFF_{COM,y}$ = Combustion Efficiency of clinker kilns under the project activity in year y (%)

44/22 = Conversion factor (t CO_2 / t C)

Q_j = Quantity of waste type j used in clinker kilns under the project activity (t)

$FCC_{j,y}$ = Carbon content ratio of waste type j in project year y (t C/t)

$FFC_{j,y}$ = Fossil carbon fraction in the total carbon content of waste type j under the project activity (Weight-based ratio)

i = Type of clinker

j = Type of waste

1) Quantity of waste type j used in clinker kilns under the project activity ($Q_{j,y}$)

Quantity of waste type j used in clinker kilns under the project activity is determined using the equation below.

$$Q_{j,y} = Q_{waste,y} \times \frac{\sum_{n=1}^{z} P_{n,j,y}}{Z} \qquad \text{Equation (28)}$$

Where

$Q_{j,y}$ = Quantity of waste type j used in clinker kilns in year y (t)

$Q_{waste,y}$ = Quantity of organic waste or refuse-derived fuel (RDF) used in clinker kilns in year y (t)

$P_{n,j,y}$ = Weight-based fraction of waste type j in sample n

Z = Number of samples

n = Collected sample

j = Type of waste

Option 2: Unsorted waste

$$PE_{FC,RDF,i,y} = \frac{\sum_i (44/22) \times FF_{COM,y} \times Q_{waste,y} \times FFC_{waste,y}}{CLNK_{i,y}} \qquad \text{Equation (29)}$$

Where

$PE_{FC,RDF,i,y}$ = Project emissions per ton of clinker due to combustion of fossil fuel in clinker kilns ($t\ CO_2/t$ clinker)

$Q_{waste,y}$ = Quantity of waste or refuse-derived fuel (RDF) used in clinker kilns in year y

$FFC_{waste,y}$ = Fossil carbon fraction in waste or refuse-derived fuel (RDF) used in clinker kilns in year y (t C/t)

$FF_{COM,y}$ = Combustion efficiency of the cement clinker kiln in year y (%)

44/22 = Conversion factor ($t\ CO_2$ / t C)

i = Annual production of clinker in the base year (t clinker)

6.1.2.3 Project emissions per ton of clinker due to combustion of biomass in clinker kilns ($PE_{biomass,i,y}$)

In cases where project activities utilize biomass or biomass residues as fuel, the project developer must calculate greenhouse gas emissions from project implementation using the latest version of the calculation tool T-VER-P-TOOL-02-02, Tool to Calculation for Project Emission and Leakage Emissions from Biomass" according to relevant activities

1) Cultivation of biomass in designated agricultural areas
2) Transportation of biomass
3) Processing of biomass
4) Transportation of biomass residues (if applicable)
5) Processing of biomass residues (if applicable)

Project emissions per ton of clinker due to combustion of biomass in clinker kilns can be calculated as follows

$$\mathbf{PE_{biomass,i,y}} = \frac{\mathbf{PE_{BC,y} + PE_{BT,y} + PE_{BRT,y} + PE_{BP,y} + PE_{BRP,y}}}{\mathbf{CLNK_{i,y}}} \qquad \text{Equation (30)}$$

Where

$PE_{biomass,i,y}$ = Project emissions per ton of clinker due to combustion of biomass in clinker kilns ($t\ CO_2/t$ clinker)

$PE_{BC,y}$ = Project emissions from biomass cultivation in designated agricultural areas in year y (t CO_2)

$PE_{BT,y}$ = Project emissions from biomass transportation in year y (t CO_2)

$PE_{BRT,y}$ = Project emissions from transportation of biomass residues in year y (t CO_2)

$PE_{BP,y}$ = Project emissions from biomass processing in year y (t CO_2)

$PE_{BRP,y}$ = Project emissions from processing of biomass residues in year y (t CO_2)

$CLNK_{i,y}$ = Production of clinker i in year y (t clinker)

6.1.3 Project emission from grid electricity for clinker production ($PE_{ele,grid,CLNK,i,y}$)

Project emission from grid electricity for clinker production can be calculated as follows

$$PE_{ele,grid,CLNK,i,y} = \frac{PELE_{grid,CLNK,i,y} \times EF_{EC,PJ,y}}{CLNK_{i,y}}$$

Equation (31)

Where

$PE_{ele,grid,CLNK,i,y}$ = Project emissions from grid electricity for clinker production per ton of clinker i in year y (t CO_2/ t clinker)

$PELE_{grid,CLNK,i,y}$ = Grid electricity for clinker i production in year y (MWh)

$EF_{EC,PJ,y}$ = Grid emission factor in year y for the production of clinker i (t CO_2/MWh)

$CLNK_{i,y}$ = Production of clinker i in year y (t clinker)

6.1.4 Project emissions from self-generated electricity per ton of clinker production ($PE_{ete,sg,CLNX,i,y}$)

Project emissions from self-generated electricity per ton of clinker production can be calculated as follows

$$PE_{ete,sg,CLNX,I,y} = \frac{PELE_{sg,CLNK,i,y} \times EF_{sg,i,y}}{CLNK_{i,y}}$$

Equation (32)

Where

$PE_{ete,sg,CLNX,I,y}$ = Project emissions from self-generated electricity per ton of clinker i production in year y (t CO_2/t clinker)

$PELE_{sg,CLNK,i,y}$ = Self-generation of electricity for clinker i production in year y (MWh)

$EF_{sg,i,y}$ = Emission factor for self-generated electricity in year y for the production of clinker i (t CO_2/MWh)

$CLNK_{i,y}$ = Production of clinker i in year y (t clinker)

6.1.5 Project emissions due to discarded dust from bypass and dedusting units per ton of clinker ($PE_{Dust,i,y}$)

$$PE_{Dust,i,y} = \frac{\left\{ (C_{i,y} \times Bypass_{i,y}) + \left\{ \frac{C_{i,y} \times d_{i,y}}{(C_{i,y} \times (1 - d_{i,y}) + 1)} \right\} \times CKD_{i,y} \right\}}{CLNK_{i,y}} \qquad \text{Equation (33)}$$

Where

$PE_{Dust,i,y}$ = Project emissions factor due to discarded dust from bypass and dedusting units (CKD) per ton of clinker i in year y (t CO_2)

$C_{i,y}$ = Project calcination factor due to both de-carbonization reaction and fuel consumption in clinker production (t CO_2/t clinker)

$Bypass_{i,y}$ = Annual production of bypass dust leaving kiln system (t)

$CKD_{i,y}$ = Annual production of CKD dust leaving kiln system (t)

$d_{i,y}$ = CKD calcination rate (released CO_2 expressed as a fraction of the total carbonate CO_2 in the raw materials)

$CLNK_{i,y}$ = Production of clinker i in year y (t clinker)

i = Type of clinker

6.1.5.1 Project calcination factor due to both de-carbonization reaction and fuel consumption in clinker production ($C_{i,y}$)

Project calcination factor due to both de-carbonization reaction and fuel consumption in clinker production can be calculated as follows

$$C_{i,y} = PE_{calcin,i,y} + PE_{FC,i,y} \qquad \text{Equation (34)}$$

Where

$C_{i,y}$ = Project calcination factor due to both de-carbonization reaction and fuel consumption in clinker production (t CO_2/t clinker)

$PE_{calcin,i,y}$ = Project emissions per ton of clinker i due to calcination of calcium carbonate and magnesium carbonate in year y (t CO_2/t clinker)

$PE_{FC,i,y}$ = Project emissions per ton of clinker i due to fuel consumption in clinker production in year y (t CO_2/t clinker)

6.1.6 Project emissions from fuel consumption for preparation of raw materials or fuels ($PE_{FC\_Dry,i,y}$)

Project emissions from fuel consumption for preparation of raw materials or fuels shall be calculated according to section 6.1.2, "Calculation of Greenhouse Gas Emissions from Fuel Combustion in Clinker Kilns under Project Activities," whereby $PE_{FC\_Dry,i,y}$ shall be set equal to $PE_{FC\_FF,i,y}$.

6.1.7 Project emissions from the transportation of clinker to the cement manufacturing plant ($PE_{TR,i,y}$)

Project emissions from the transportation of clinker to the cement manufacturing plant by internal combustion engine vehicles can be calculated as follows

$$PE_{TR,i,y} = \frac{D_{i,y} \times Q_{CLNK,i,y} \times EF_{CO2,j} \times 10^{-6}}{CLNK_{i,y}} \qquad \text{Equation (35)}$$

Where

$PE_{TR,i,y}$ = Project emissions from the transportation of clinker to the cement manufacturing plant in year y (t CO_2/ t clinker)

$D_{i,y}$ = Two-way distance between clinker production plant of type i and cement production plant in year y (km)

$Q_{CLNK,i,y}$ = Quantity of clinker transported in year y (t clinker)

$EF_{CO2,j}$ = Emission factor from the use of fossil fuel type j for clinker transportation (g CO_2/t·km)

$CLNK_{i,y}$ = Production of clinker i in year y (t clinker)

i = Type of clinker

j = Type of fossil fuel

6.1.8 Ratio of clinker for total production of clinker in year y ($P_{CLNK,i,y}$)

Ratio of clinker for total production of clinker can be calculated as follows

$$P_{CLNK,i,y} = \frac{CLNK_{i,y}}{\sum_i CLNK_{i,y}} \qquad \text{Equation (36)}$$

Where

$P_{CLNK,i,y}$ = Ratio of clinker i for total production of clinker in year y (t clinker/t clinker)

$CLNK_{i,y}$ = Production of clinker i in year y (t clinker)

6.2 Electricity emissions for cement grinding and preparation of alternative raw material and additives ($PE_{ele,ADD,BC,y}$)

Electricity emissions for cement grinding and preparation of alternative raw material and additives can be calculated as follows

$$PE_{ele,ADD,BC,y} = PE_{ele,grid,BC,y} + PE_{ele,SG,BC,y} + PE_{ele,grid,ADD,y} + PE_{ele,SG,ADD,y} \qquad \text{Equation (37)}$$

Where

$PE_{ele,ADD,BC,y}$ = Electricity emissions for cement grinding and preparation of alternative raw material and additives (t CO_2/t cement)

$PE_{ele,grid,BC,y}$ = Project emissions from grid electricity for cement grinding (t CO_2/t cement)

$PE_{ele,SG,BC,y}$ = Project emissions from self-generated electricity for cement grinding (t CO_2/t cement)

$PE_{ele,grid,ADD,y}$ = Project emissions from grid electricity for alternative raw material and additive preparation (t CO_2/t cement)

$PE_{ele,SG,ADD,y}$ = Project emissions from self-generated electricity for alternative raw material and additive preparation (t CO_2/t cement)

6.2.1 Project emissions from grid electricity for cement grinding ($PE_{ele,grid,BC,y}$)

Project emissions from grid electricity for cement grinding can be calculated as follows

$$PE_{ele,grid,BC,y} = \frac{PELE_{grid,BC,y} \times EF_{EC,PJ,y}}{BC_y} \qquad \text{Equation (38)}$$

Where

$PE_{ele,grid,BC,y}$ = Project emissions from grid electricity for cement grinding (t CO_2/t cement)

$PELE_{grid,BC,y}$ = Grid electricity for grinding cement in year y (MWh)

$EF_{EC,PJ,y}$ = Grid emission factor in year y (t CO_2/MWh)

BC_y = Cement produced and sold in the domestic market in year y (t cement)

6.2.2 Project emissions from self-generated electricity for cement grinding ($PE_{ele,SG,BC,y}$)

Project emissions from self-generated electricity for cement grinding can be calculated as follows

$$PE_{ele,SG,BC,y} = \frac{PELE_{SG,BC,y} \times EF_{SG,y}}{BC_y} \qquad \text{Equation (39)}$$

Where

$PE_{ele,SG,BC,y}$ = Project emissions from self-generated electricity for cement grinding (t CO_2/t cement)

$PELE_{SG,BC,y}$ = Self-generated electricity for grinding cement in year y (MWh)

$EF_{SG,y}$ = Emission factor for self-generated electricity in year y (t CO_2/MWh)

BC_y = Blended cement produced and sold in the domestic market in year y (t cement)

6.2.3 Project emissions from grid electricity for alternative raw material and additive preparation ($PE_{ele,grid,ADD,y}$)

Project emissions from grid electricity for alternative raw material and additive preparation can be calculated as follows

$$PE_{ele,grid,ADD,y} = \frac{PELE_{grid,ADD,y} \times EF_{EC,PJ,y}}{BC_y} \qquad \text{Equation (40)}$$

Where

$PE_{ele,grid,ADD,y}$ = Project emissions from grid electricity for alternative raw material and additive preparation (t CO_2/t cement)

$PELE_{grid,ADD,y}$ = Grid electricity for alternative raw material and additive preparation in year y (MWh)

$EF_{EC,PJ,y}$ = Grid emission factor in year y (t CO_2/MWh)

BC_y = Blended cement produced and sold in the domestic market in year y (t cement)

6.2.4 Project emissions from self-generated electricity for alternative raw material and additive preparation ($PE_{ele,SG,ADD,y}$)

Project emissions from self-generated electricity for alternative raw material and additive preparation can be calculated as follows

$$PE_{ele,SG,ADD,y} = \frac{PELE_{SG,ADD,y} \times EF_{SG,y}}{BC_y} \qquad \text{Equation (41)}$$

Where

$PE_{ele,SG,ADD,y}$ = Project emissions from self-generated electricity for alternative raw material and additive preparation (t CO_2/t cement)

$PELE_{SG,ADD,y}$ = Self-generation electricity for alternative raw material and additive preparation additives in year y (MWh)

$EF_{SG,y}$ = Emission factor for self-generated electricity in year y (t CO_2/MWh)

BC_{BSL} = Blended cement produced and sold in the domestic market in year y (t cement)

6.2.4.1 Emission factor for self-generated electricity ($EF_{SG,y}$)

Emission factor for self-generated electricity can be calculated as follows

$$EF_{SG,y} = \frac{\sum_{k,j} FC_{k,j,y} \times COEF_k}{\sum_j GEN_{j,y}} \qquad \text{Equation (42)}$$

Where

$EF_{SG,y}$ = Emission factor for self-generated electricity in year y (t CO_2/MWh)

$FC_{k,j,y}$ = Quantity of fuel k consumed by relevant power sources j in year y (unit)

j = On-site power sources

$COEF_k$ = CO_2 emission coefficient of fuel k (t CO_2/ unit)

$GEN_{j,y}$ = Electricity generated by the source j in year y (MWh)

1) CO_2 emission coefficient of fuel ($COEF_k$)

For calculating CO_2 emission coefficient of fuel, the latest version of T-VER-P-TOOL-02-01: Tool to calculate project or leakage CO_2 emissions from fossil fuel combustion is applied.

6.3 Project emissions from fuel combustion for cement grinding, raw material/alternative material production and preparation of additives ($PE_{FC,ADD,BC,y}$)

Project emissions per ton of cement due to fuel combustion for cement grinding, raw material/alternative material production and preparation of additives can be calculated as follows:

$$PE_{FC,ADD,BC,y} = PE_{FC,ADD,FF,BC,y} + PE_{FC,ADD,RDF,BC,y} + PE_{FC,ADD,biomass,BC,y} \qquad \text{Equation (43)}$$

Where

$PE_{FC,ADD,BC,y}$ = Project emissions from fuel combustion for cement grinding, raw material/alternative material production and preparation of additives (t CO_2/t cement)

$PE_{FC,ADD,FF,BC,y}$ = Project emissions from fuel combustion of fossil fuel for cement grinding, raw material/alternative material production and preparation of additives (t CO_2/t cement)

$PE_{FC,ADD,RDF,BC,y}$ = Project emissions from fuel combustion of RDF for cement grinding, raw material/alternative material production and preparation of additives (t CO_2/t cement)

$PE_{FC,ADD,biomass,BC,y}$ = Project emissions from fuel combustion of biomass for cement grinding, raw material/alternative material production and preparation of additives (t CO_2/t cement)

i = Type of fuel

6.3.1 Project emissions from fuel combustion of fossil fuel for cement grinding, raw material/alternative material production and preparation of additives ($PE_{FC,ADD,FF,BC,y}$)

Project emissions per ton of cement due to fossil fuel combustion for cement grinding, raw material/alternative material production and preparation of additives can be calculated as follows:

$$PE_{FC,ADD,FF,BC,y} = \frac{\sum_i FC_{ADD,i,y} \times NCV_i \times EF_{CO2,i} \times 10^{-6}}{BC_y} \qquad \text{Equation (44)}$$

Where

$PE_{FC,ADD,FF,BC,y}$ = Project emissions from fuel combustion of fossil fuel for cement grinding, raw material/alternative material production and preparation of additives (t CO_2/t cement)

$FC_{ADD,i,y}$ = Quantity of fossil fuel of type i consumed for cement grinding, raw material/alternative material production and preparation of additives in year y (unit)

NCV_i = Net calorific value of the fossil fuel type i (GJ/unit)

$EF_{CO2,i}$ = CO_2 emissions from fossil fuel combustion type i (kgCO_2/TJ)

BC_y = Blended cement produced and sold in the domestic market in year y (t cement)

i = Type of fossil fuel

6.3.2 Project emissions from fuel combustion of RDF for cement grinding, raw material/alternative material production and preparation of additives ($PE_{FC,ADD,RDF,BC,y}$)

Project emission per ton of cement due to RDF combustion for cement grinding, raw material/alternative material production and preparation of additives is determined using two options, as outlined below

Option 1: Pre-sorted waste

$$PE_{FC,ADD,RDF,BC,y} = \frac{EFF_{COM,y} \times (44/22) \times \sum_{j} Q_{ADD,j,y} \times FCC_{j,y} \times FFC_{j,y}}{BC_y} \qquad \text{Equation (45)}$$

Where

$PE_{FC,ADD,RDF,BC,y}$ = Project emissions from fuel combustion of RDF for cement grinding, raw material/alternative material production and preparation of additives (t CO_2/t cement)

$EFF_{COM,y}$ = Combustion Efficiency of furnace under the project activity in year y (%)

44/22 = Conversion factor (t CO_2 / t C)

$Q_{ADD,j,y}$ = Quantity of waste type j used in furnace for cement grinding, raw material/alternative material production and preparation of additives in project year y (t)

$FCC_{j,y}$ = Carbon content ratio of waste type j in project year y (t C/t)

$FFC_{j,y}$ = Fossil carbon fraction in the total carbon content of waste type j under the project activity (Weight-based ratio)

BC_y = Blended cement produced and sold in the domestic market in year y

i = Type of clinker

j = Type of waste

1) Quantity of waste type j used in furnace under the project activity ($Q_{j,y}$)

Quantity of waste type j used in furnace under the project activity is determined using the equation below.

$$\mathbf{Q_{j,y} = Q_{waste,ADD,y} \times \frac{\sum_{n=1}^{z} P_{n,j,y}}{Z}} \qquad \text{Equation (46)}$$

Where

$Q_{ADD,j,y}$ = Quantity of waste type j used in furnace for cement grinding, raw material/alternative material production and preparation of additives in project year y (t)

$Q_{waste,ADD,y}$ = Quantity of organic waste or RDF used in furnace for cement grinding, raw material/alternative material production and preparation of additives in year y (t)

$P_{n,j,y}$ = Weight-based fraction of waste type j in sample n

Z = Number of samples

n = Collected sample

j = Type of waste

Option 2: Unsorted waste

$$PE_{FC,ADD,RDF,BC,y} = \frac{\sum_i (44/22) \times FF_{COM,y} \times Q_{waste,y} \times FFC_{waste,y}}{BC_y} \qquad \text{Equation (47)}$$

Where

$PE_{FC,ADD,RDF,BC,y}$ = Project emissions from fuel combustion of RDF for cement grinding, raw material/alternative material production and preparation of additives (t CO_2/t cement)

$Q_{waste,y}$ = Quantity of organic waste or RDF used in furnace in year y (t)

$FFC_{waste,y}$ = Fossil carbon fraction in waste or RDF used in furnace in year y (t C/t)

$FF_{COM,y}$ = Combustion Efficiency of furnace under the project activity in year y (%)

44/22 = Conversion factor (t CO_2 / t C)

i = Annual production of clinker in the base year (t clinker)

6.3.3 Project emissions from fuel combustion of biomass for cement grinding, raw material/alternative material production and preparation of additives ($PE_{FC,ADD,biomass,BC,y}$)

In cases where project activities utilize biomass or biomass residues as fuel, the project developer must calculate greenhouse gas emissions from project implementation using the latest version of the calculation tool T-VER-P-TOOL-02-02, Tool to Calculation for Project Emission and Leakage Emissions from Biomass” according to relevant activities

1) Cultivation of biomass in designated agricultural areas
2) Transportation of biomass
3) Processing of biomass
4) Transportation of biomass residues (if applicable)
5) Processing of biomass residues (if applicable)

Project emissions per ton of clinker due to combustion of biomass in clinker kilns can be calculated as follows:

$$PE_{FC,ADD,biomass,BC,y} = \frac{PE_{BC,y} + PE_{BT,y} + PE_{BRT,y} + PE_{BP,y} + PE_{BRP,y}}{BC_y} \qquad \text{Equation (48)}$$

Where

$PE_{FC,ADD,biomass,BC,y}$ = Project emissions from fuel combustion of biomass for cement grinding, raw material/alternative material production and preparation of additives (t CO_2/ t cement)

$PE_{BC,y}$ = Project emissions from biomass cultivation in designated agricultural areas in year y (t CO_2)

$PE_{BT,y}$ = Project emissions from biomass transportation in year y (t CO_2)

$PE_{BRT,y}$ = Project emissions from transportation of biomass residues in year y (t CO_2)

$PE_{BP,y}$ = Project emissions from biomass processing in year y (t CO_2)

$PE_{BRP,y}$ = Project emissions from processing of biomass residues in year y (t CO_2)

BC_y = Blended cement produced and sold in the domestic market in year y (t cement)

6.4 Project emissions from transportation of raw material or alternative material to the cement manufacturing plant ($PE_{TR,ADD,BC,y}$)

Project emissions from the transportation of raw material or alternative material to the cement manufacturing plant by internal combustion engine vehicles can be calculated as follows:

$$PE_{TR,ADD,BC,y} = \frac{\sum_i D_{ADD,i,y} \times Q_{ADD,TR,i,y} \times EF_{CO2,j}}{BC_y} \times 10^{-6} \qquad \text{Equation (49)}$$

Where

$PE_{TR,ADD,BC,y}$ = Project emissions from transportation of raw material or alternative material to the cement manufacturing plant (t CO_2/t cement)

$D_{ADD,i,y}$ = Two-way distance between raw material or alternative material production plant of type i and cement manufacturing plant in year y (km)

$Q_{ADD,TR,i,y}$ = Quantity of raw material or alternative material transported in year y (tons)

$EF_{CO2,j}$ = Emission factor from the use of fossil fuel type j for raw material or alternative material transportation (gCO_2/tkm)

BC_y = Blended cement produced and sold in the domestic market in year y (t cement)

i = Type of clinker

j = Type of fossil fuel

7. Leakage Emission

Leakage emissions are considered from the transportation of raw materials and alternative additives, the rerouting of existing raw materials and alternative additives, and emissions from the use of biomass and/or residual biomass, which can be calculated as follows

$$LE_y = LE_{TR,y} + LE_{ADD,y} + LE_{biomass,y} \qquad \text{Equation (50)}$$

Where

LE_y = Leakage emission in year y (tCO_2/year)

$LE_{TR,y}$ = Leakage emissions from the transportation of raw materials and alternative additives in year y (t CO_2/year)

$LE_{ADD,y}$ = Leakage emissions from the rerouting of existing raw materials and alternative additives in year y (t CO_2/year)

$LE_{biomass,y}$ = Leakage emissions from the use of biomass and/or residual biomass in year y (t CO_2/year)

7.1 Leakage emissions from the transportation of raw materials and alternative additives ($LE_{TR,y}$)

Leakage emissions from the transportation of raw materials and alternative additives can be calculated as follows:

$$LE_{TR,y} = \sum_f D_{f,y} \times Q_{ADD,y} \times EF_{CO2,f} \times 10^{-6} \qquad \text{Equation (51)}$$

Where

$LE_{TR,y}$ = Leakage emissions from the transportation of raw materials and alternative additives in year y (t CO_2/year)

$D_{f,y}$ = Round-trip distance between the origin and destination of transportation activities for raw materials and alternative additives of type f in year y (km)

$Q_{ADD,y}$ = Quantity of additional additives transported in year y (t additives)

$EF_{CO2,f}$ = Emission factor from fossil fuel use for transporting additional additives of type f (g CO_2/tkm)

f = Type of additives

7.1.1 Quantity of additional additives transported ($Q_{ADD,y}$)

Quantity of additional additives transported can be calculated as follows:

$$Q_{ADD,y} = (A_{pj,Blend,y} - A_{BSL,Blend,y}) \times BC_y$$ Equation (52)

Where

$Q_{ADD,y}$ = Quantity of additional additives transported in y (t additives)

$A_{pj,Blend,y}$ = Share of additives per ton of cement in year y (t additives/t cement)

$A_{BSL,Blend,y}$ = Baseline share of additives per ton of cement updated for year y (t additives/t cement)

BC_y = Blended cement produced and sold in the domestic market in year y (t cement)

7.2 Leakage emissions from the rerouting of existing raw materials and alternative additives ($LE_{ADD,y}$)

Leakage emissions from the rerouting of existing raw materials and alternative additives can be calculated as follows

$$LE_{ADD,y} = (BE_y - PE_y)\ \alpha_y$$ Equation (53)

Where

$LE_{ADD,y}$ = Leakage emissions from the rerouting of existing raw materials and alternative additives in year y (t CO_2/year)

BE_y = Baseline emissions in year y (t CO_2)

PE_y = Project emissions in year y (t CO_2)

α_y = Leakage penalty factor in year y (fraction)

7.2.1 Leakage penalty factor (α_y)

Leakage penalty factor can be calculated as follows:

$$\alpha_y = \frac{ADD_{NS,y}}{ADD_y}$$ Equation (54)

Where

α_y = Leakage penalty factor in year y (fraction)

$ADD_{NS,y}$ = Amount of alternative raw material and/or additives used for cement production in project plant for which the project participants could not substantiate that they are surplus in year y (t additives)

ADD_y = Amount of alternative raw material and additives used for cement production in project plant in year y (t additives)

7.3 Leakage emissions from the use of biomass and/or residual biomass ($LE_{biomass,y}$)

Project developers must assess leakage emissions from the use of biomass and/or residual biomass using the latest version of the calculation tool T-VER-P-TOOL-02-02, " Tool to Calculation for Project Emission and Leakage Emissions from Biomass" according to relevant activities," in the following areas

1) Change in pre-project activities to biomass cultivation in designated agricultural areas
2) Utilization of residual biomass from project activities for other uses beyond the project boundary
3) Processing of additional residual biomass resulting from project activities
4) Transportation of residual biomass

8. Emission Reduction

Emission reduction can be calculated as follows:

$$ER_y = BE_y - PE_y - LE_y \quad \text{Equation (55)}$$

Where

ER_y = Emission reductions in year y (tCO_2e/year)
BE_y = Baseline emissions in year y (tCO_2e/year)
PE_y = Project emissions in year y (tCO_2e/year)
LE_y = Leakage emissions in year y (tCO_2e/year)

9. Monitoring Plan

9.1 Monitoring approach

1) The project developer shall specify the process of the project activity data (Activity data) monitoring and verification procedures of all measurement results in the project document. The information shall include list of measuring instruments, responsible personnels, instruments calibration (if any) and quality control processes. If there exist multiple measurements options, project developers must specify the preferred measurements option. In addition, the installation, maintenance and calibration of measuring instruments

should be carried out in accordance with the instructions of the equipment manufacturer and in accordance with national standards. or international standards such as IEC, ISO, etc.

(2) All data collected as part of the greenhouse gas reduction monitoring shall be stored in electronic files format with the storage period aligned with the guidelines by the organization administrative or quality system in accordance with TGO guidelines. The list of monitoring parameters is presented in Table 9.2.

9.2 Data and parameters monitored

Parameter	BC_y
Unit	t cement
Description	Cement produced and sold in the domestic market in year y
Source of data	Project data records
Measurement procedures	Measured using the project's weighing scale
Monitoring frequency	Continuous monitoring is conducted, and data is recorded at least on a monthly basis

Parameter	$P_{blend,y}$
Unit	t clinker/t cement
Description	Share of clinker per ton of cement in year y
Source of data	Project data records
Measurement procedures	-
Monitoring frequency	Continuous monitoring is conducted, and data is recorded at least on a monthly basis

Parameter	$InCaO_{i,y}$
Unit	t CaO
Description	Non-carbonated CaO content of clinker i in the raw material in year y
Source of data	Project data records
Measurement procedures	-
Monitoring frequency	Continuous monitoring is conducted, and data is recorded at least on a monthly basis

Parameter	$OutCaO_{i,y}$
Unit	t CaO
Description	CaO content in the clinker i produced in year y
Source of data	Project data records
Measurement procedures	-
Monitoring frequency	Continuous monitoring is conducted, and data is recorded at least on a monthly basis

Parameter	$InMgO_{i,y}$
Unit	t MgO
Description	Non-carbonated MgO content of clinker i in the raw material in year y
Source of data	Project data records
Measurement procedures	-
Monitoring frequency	Continuous monitoring is conducted, and data is recorded at least on a monthly basis

Parameter	$OutMgO_{i,y}$
Unit	t MgO
Description	MgO content in the clinker i produced in year y
Source of data	Project data records
Measurement procedures	-
Monitoring frequency	Continuous monitoring is conducted, and data is recorded at least on a monthly basis

Parameter	$Q_{rm,y}$
Unit	ton
Description	Quantity of raw materials for clinker production in year y
Source of data	Project data records
Measurement procedures	Measured using the project’s weighing scale
Monitoring frequency	Continuous monitoring is conducted, and data is recorded at least on a monthly basis

Parameter	$CLNK_{i,y}$
Unit	t clinker

Description	Production of clinker i in year y
Source of data	Project data records
Measurement procedures	Measured using the project's weighing scale
Monitoring frequency	Continuous monitoring is conducted, and data is recorded at least on a monthly basis

Parameter	$FC_{i,y}$
Unit	unit
Description	Quantity of fossil fuel of type i consumed for clinker production in year y
Source of data	Record of fossil fuel consumption measurements used in clinker production
Measurement procedures	-
Monitoring frequency	Continuous monitoring is conducted, and data is recorded at least on a monthly basis

Parameter	$FFC_{ADD,i,y}$
Unit	unit
Description	Quantity of fossil fuel of type i consumed for cement grinding, raw material/ alternative material production and preparation of additives in year y
Source of data	Record of fossil fuel consumption measurements used in cement grinding, raw material/alternative material production and preparation of additives
Measurement procedures	-
Monitoring frequency	Continuous monitoring is conducted, and data is recorded at least on a monthly basis

Parameter	$PELE_{grid,CLNK,i,y}$
Unit	MWh
Description	Grid electricity for clinker i production in year y
Source of data	Records from the project
Measurement procedures	Electricity Meter
Monitoring frequency	Continuous monitoring is conducted, and data is recorded at least on a monthly basis

Parameter	$PELE_{sg,CLNK,i,y}$
Unit	MWh

Description	Self-generation of electricity for clinker i production in year y
Source of data	Records from the project
Measurement procedures	Electricity Meter
Monitoring frequency	Continuous monitoring is conducted, and data is recorded at least on a monthly basis

Parameter	ADD_y
Unit	ton
Description	Amount of alternative raw material and additives used for cement production in project plant in year y
Source of data	Project data records
Measurement procedures	Weighing scale
Monitoring frequency	Continuous monitoring is conducted, and data is recorded at least on a monthly basis

Parameter	$ADD_{NS,y}$
Unit	ton
Description	Amount of alternative raw material and/or additives used for cement production in project plant for which the project participants could not substantiate that they are surplus in year y
Source of data	According to international sources or Project data records
Measurement procedures	Weighing scale
Monitoring frequency	Continuous monitoring is conducted, and data is recorded at least on a monthly basis

Parameter	$PELE_{grid,BC,y}$
Unit	MWh
Description	Grid electricity for grinding cement in year y
Source of data	Project data records
Measurement procedures	Electricity Meter
Monitoring frequency	Continuous monitoring is conducted, and data is recorded at least on a monthly basis

Parameter	$PELE_{sg,BC,y}$
Unit	MWh

Description	Self-generated electricity for cement grinding in year y
Source of data	Project data records
Measurement procedures	Electricity Meter
Monitoring frequency	Continuous monitoring is conducted, and data is recorded at least on a monthly basis

Parameter	$PELE_{grid,ADD,y}$
Unit	MWh
Description	Grid electricity for alternative raw material and additive preparation in year y
Source of data	Project data records
Measurement procedures	Electricity Meter
Monitoring frequency	Continuous monitoring is conducted, and data is recorded at least on a monthly basis

Parameter	$PELE_{sg,ADD,y}$
Unit	MWh
Description	Self-generation electricity for alternative raw material and additive preparation additives in year y
Source of data	Project data records
Measurement procedures	Electricity Meter
Monitoring frequency	Continuous monitoring is conducted, and data is recorded at least on a monthly basis

Parameter	$FC_{k,j,y}$
Unit	unit
Description	Quantity of fuel k consumed by relevant power sources j in year y
Source of data	Project data records
Measurement procedures	Weighing or volumetric scale
Monitoring frequency	Continuous monitoring is conducted, and data is recorded at least on a monthly basis

Parameter	$GEN_{j,y}$
Unit	MWh
Description	Electricity generated by the source j in year y

Source of data	Project data records
Measurement procedures	Electricity Meter
Monitoring frequency	Continuous monitoring is conducted, and data is recorded at least on a monthly basis

Parameter	$A_{PJ,blend,y}$
Unit	t additives/t cement
Description	Share of additives per ton of cement in year y
Source of data	Project data records
Measurement procedures	Report on the quantity of additives in cement
Monitoring frequency	Continuous monitoring is conducted, and data is recorded at least on a monthly basis

Parameter	$A_{BSL,blend,y}$
Unit	t additives/t cement
Description	Baseline share of additives per ton of cement updated for year y
Source of data	Project data records
Measurement procedures	-
Monitoring frequency	Continuous monitoring is conducted, and data is recorded at least on a monthly basis

Parameter	$TEMP_{CLNK,i}$
Unit	^{o}C
Description	Calcination temperature of the kiln for clinker production under the baseline scenario
Source of data	Project data records
Measurement procedures	-
Monitoring frequency	Continuous monitoring is conducted, and data is recorded at least on a monthly basis

Parameter	$ByPass_y$
Unit	ton
Description	Annual production of bypass dust leaving kiln system in year y
Source of data	Project data records

Measurement procedures	Measured using a weighing scale or a belt weigher
Monitoring frequency	Continuous monitoring is conducted, and data is recorded at least on a monthly basis

Parameter	CKDy
Unit	ton
Description	Output volume from bypass and dust removal units
Source of data	Project data records
Measurement procedures	Measured using a weighing scale or a belt weigher
Monitoring frequency	Continuous monitoring is conducted, and data is recorded at least on a monthly basis

Parameter	d_y
Unit	%
Description	CKD combustion rate (expressed as the proportion of CO_2 emissions relative to total carbonate-based CO_2 in the feedstock)
Source of data	Project data records
Measurement procedures	Sampling
Monitoring frequency	Continuous monitoring is conducted, and data is recorded at least on a monthly basis

Parameter	$EF_{EC,PJ,y}$
Unit	tCO_2/MWh
Description	Emission factor for electricity generation/consumption in year y
Source of data	Report on greenhouse gas emissions (Emission Factor) from electricity generation/consumption for projects and activities of greenhouse gas reduction published by TGO.
Measurement procedures	**For the preparation of project proposal documents** Use the latest $EF_{Elec,y}$ announced by TGO **For monitoring the results of reducing greenhouse gas emissions** Use the $EF_{Elec,y}$ values announced by TGO according to the year of the crediting period. However, in the case that the year of the crediting period does not have $EF_{Elec,y}$ values announced by TGO, use the latest $EF_{Elec,y}$ values announced by TGO in that year instead.
Monitoring frequency	-

Parameter	$EFF_{COM,y}$ and $FF_{COM,y}$
Unit	%
Description	Combustion Efficiency of Clinker Kilns under the project activity in year y
Source of data	Project specific data and parameters
Measurement procedures	Measuring by recognized standard in the cement industry
Monitoring frequency	Continuous monitoring is annually conducted.

Parameter	$p_{n,j,y}$
Unit	Weight fraction
Description	Weight-based fraction of waste Type j in sample n
Source of data	Monitoring report by the project developer
Measurement procedures	-
Monitoring frequency	A minimum of three samples shall be measured every three months, with results reported as annual averages

Parameter	$Q_{waste,y}$
Unit	tons
Description	Quantity of organic waste and RDF consumed by kiln in year y
Source of data	Monitoring report by the project developer
Measurement procedures	Measurement using a weighing scale
Monitoring frequency	Continuous monitoring is conducted, and data is recorded at least on a monthly basis

Parameter	$Q_{waste,ADD,y}$
Unit	tons
Description	Quantity of organic waste or RDF used in furnace for cement grinding, raw material/alternative material production and preparation of additives in year y
Source of data	Monitoring report by the project developer
Measurement procedures	Measurement using a weighing scale
Monitoring frequency	Continuous monitoring is conducted, and data is recorded at least on a monthly basis

Parameter	$Q_{ADD,TR,i,y}$
Unit	tons
Description	Quantity of raw material or alternative material transported in year y
Source of data	Monitoring report by the project developer
Measurement procedures	Measurement using a weighing scale
Monitoring frequency	Continuous monitoring is conducted, and data is recorded at least on a monthly basis

Parameter	$D_{i,y}$
Unit	km
Description	Two-way distance between clinker production plant of type i and cement production plant in year y
Source of data	Travel log and transportation route of the project developer
Measurement procedures	-
Monitoring frequency	At the commencement of carbon credit calculations

Parameter	$D_{ADD,y}$
Unit	km
Description	Two-way distance between raw material or alternative material production plant of type i and cement manufacturing plant in year y
Source of data	Travel log and transportation route of the project developer
Measurement procedures	-
Monitoring frequency	At the commencement of carbon credit calculations

9.3 Data and parameters not monitored

Parameter	$EF_{CO2,i}$
Unit	$kgCO_2/TJ$
Description	CO_2 emissions from fossil fuel combustion type i
Source of data	Table 1.4 2006 IPCC Guidelines for National GHG Inventories
Applicable value	-

Parameter	$EF_{CO2,j}$ and $EF_{CO2,f}$
Unit	gCO_2/tkm

Description	$EF_{CO2,j}$ Emission factor from the use of fossil fuel type j for raw material or alternative material transportation $EF_{CO2,f}$ Emission factor from the use of fossil fuel type f for the transportation of clinkers
Source of data	Option 1: Measured based on fossil fuel consumption Option 2: Use of constant values
Applicable value	In the case of selecting option 2, use the following values 1) For transportation by small vehicle, use a value of 245 gCO_2/tkm 2) For transportation by large vehicle, use a value of 129 gCO_2/tkm

Parameter	InCaO
Unit	t CaO
Description	Baseline non-carbonated CaO content in the raw material
Source of data	Project data records based on historical factory data from the year(s) prior to the start of the project activity. In cases where multiple years of data are available before the start of the project activity, use the average of no more than 3 years
Applicable value	In cases where the project participant can demonstrate that the raw materials used contain no carbonates such as gypsum, anhydrite, and fluorite the participant may apply a default value of 2% for the amount of non-carbonated CaO in the raw materials

Parameter	OutCaO
Unit	t CaO
Description	Baseline CaO content in the clinker produced
Source of data	Project data records based on historical factory data from the year(s) prior to the start of the project activity. In cases where multiple years of data are available before the start of the project activity, use the average of no more than 3 years
Applicable value	-

Parameter	InMgO
Unit	t MgO
Description	Baseline non-carbonated MgO content in the raw material
Source of data	Project data records based on historical factory data from the year(s) prior to the start of the project activity. In cases where multiple years of data are available before the start of the project activity, use the average of no more than 3 years
Applicable value	-

Parameter	OutMgO
Unit	t MgO

Description	Baseline CaO content in the clinker produced
Source of data	Project data records based on historical factory data from the year(s) prior to the start of the project activity. In cases where multiple years of data are available before the start of the project activity, use the average of no more than 3 years
Applicable value	-

Parameter	Q_{rm}
Unit	ton
Description	Quantity of raw materials for clinker production in year y
Source of data	Project data records shall be based on historical factory data from the years prior to the commencement of project activities. In cases where multiple years of data are available before the start of project activities, an average of up to three years shall be used
Applicable value	-

Parameter	$CLNK_{BSL}$
Unit	t clinker
Description	Annual production of clinker in the base year (t clinker/year)
Source of data	Project data records based on historical factory data from the year(s) prior to the start of the project activity. In cases where multiple years of data are available before the start of the project activity, use the average of no more than 3 years
Applicable value	-

Parameter	$FC_{i,BSL}$
Unit	unit
Description	Quantity of fossil fuel type i used for clinker production under the baseline scenario
Source of data	Data recording from the weighing scale or relevant measuring instruments shall be based on historical records of the factory from the years prior to the commencement of project activities. If data from multiple years prior to the start of project activities is available, an average of up to three years shall be used
Applicable value	-

Parameter	$BELE_{grid,CLNK}$
Unit	MWh
Description	Grid electricity consumed for clinker production in base year
Source of data	Electricity meter data based on the historical records of the facility from the year (s) prior to the start of the project activity. In cases where multiple years of data are available prior to project implementation, the average of no more than three years shall be used

Applicable value	-

Parameter	$BELE_{SG,CLNK}$
Unit	MWh
Description	Self-generation of electricity for clinker production in the base year
Source of data	Electricity meter data based on the historical records of the facility from the year (s) prior to the start of the project activity. In cases where multiple years of data are available prior to project implementation, the average of no more than three years shall be used
Applicable value	-

Parameter	BC_{BSL}
Unit	t cement
Description	Annual production of cement in the base year
Source of data	Electricity meter data based on the historical records of the facility from the year (s) prior to the start of the project activity. In cases where multiple years of data are available prior to project implementation, the average of no more than three years shall be used
Applicable value	-

Parameter	$BELE_{SG,BC}$
Unit	MWh
Description	Baseline self-generation electricity for cement grinding
Source of data	Electricity meter data based on the historical records of the facility from the year (s) prior to the start of the project activity. In cases where multiple years of data are available prior to project implementation, the average of no more than three years shall be used
Applicable value	-

Parameter	$BELE_{glid,BC}$
Unit	MWh
Description	Baseline grid electricity for grinding cement
Source of data	Electricity meter data based on the historical records of the facility from the year (s) prior to the start of the project activity. In cases where multiple years of data are available prior to project implementation, the average of no more than three years shall be used
Applicable value	-

Parameter	$BELE_{glid,ADD}$
Unit	MWh
Description	Baseline self-generation electricity for grinding additives
Source of data	Electricity meter data based on the historical records of the facility from the year (s) prior to the start of the project activity. In cases where multiple years of data are available prior to project implementation, the average of no more than three years shall be used
Applicable value	-

Parameter	$BELE_{SG,ADD}$
Unit	MWh
Description	Baseline self-generation electricity for grinding additives
Source of data	Electricity meter data based on the historical records of the facility from the year (s) prior to the start of the project activity. In cases where multiple years of data are available prior to project implementation, the average of no more than three years shall be used
Applicable value	-

Parameter	$GEN_{n,BSL}$
Unit	MWh
Description	Electricity generated by the source n in year y
Source of data	Electricity meter data based on the historical records of the facility from the year (s) prior to the start of the project activity. In cases where multiple years of data are available prior to project implementation, the average of no more than three years shall be used
Applicable value	-

Parameter	$FC_{m,n,BSL}$
Unit	unit
Description	Amount of fossil fuel m used for self-generated electricity from source n under the baseline scenario
Source of data	Data recording from the weighing scale or relevant measuring instruments shall be based on historical records of the factory from the years prior to the commencement of project activities. If data from multiple years prior to the start of project activities is available, an average of up to three years shall be used
Applicable value	-

Parameter	$FC_{add,bc,i}$
Unit	unit

Description	Quantity of fossil fuel type i used in raw material preparation under the baseline scenario
Source of data	Data recording from the weighing scale or relevant measuring instruments shall be based on historical records of the factory from the years prior to the commencement of project activities. If data from multiple years prior to the start of project activities is available, an average of up to three years shall be used
Applicable value	-

Parameter	$FC_{TR,i}$
Unit	unit
Description	Quantity of fossil fuel type i consumed by internal combustion engine vehicles for transporting clinkers to the cement manufacturing plant under baseline scenario
Source of data	Data recording shall be based on the previous year d
Applicable value	-

Parameter	NCV_i
Unit	GJ/unit
Description	Net calorific value of the fuel type i
Source of data	Option 1: Net calorific value of the fossil fuel as specified in the invoice issued by the fuel supplier. Option 2: Net calorific value determined through measurement. Option 3: Value obtained from Thailand's national energy statistics published by the Department of Alternative Energy Development and Efficiency, Ministry of Energy. Option 4: Reference values from Table 1.2 of Chapter 1 in Volume 2 (Energy) of the 2006 IPCC Guidelines for National Greenhouse Gas Inventories.
Applicable value	-

Parameter	$TEMP_{CLNK}$
Unit	^{o}C
Description	Baseline calcination temperature of the kiln for clinker production
Source of data	Monitored data from the project
Applicable value	-

Parameter	$ByPass_{BSL}$
Unit	ton
Description	Annual production of bypass dust leaving kiln system
Source of data	Weight scale or weighbridge data from the past 3 years
Applicable value	-

Parameter	CKD_{BSL}
Unit	m/s^2
Description	Annual production of CKD dust leaving kiln system in the baseline
Source of data	Weight scale or weighbridge data from the past 3 years
Applicable value	-

Parameter	d_{BSL}
Unit	%
Description	CKD calcination rate (released CO_2 expressed as a fraction of the total carbonate CO_2 in the raw materials)
Source of data	Project data records covering at least 3 years prior to the commencement of project activities
Applicable value	-

Parameter	$d_{i,y}$
Unit	%
Description	CKD calcination rate (released CO_2 expressed as a fraction of the total carbonate CO_2 in the raw materials)
Source of data	Project data records
Applicable value	-

Parameter	$FC_{Dry,i}$
Unit	ton
Description	Quantity of fossil fuel type i used for raw material or fuel preparation under the baseline scenario
Source of data	Weight scale or weighbridge data, or inventory report from the previous year
Applicable value	-

Parameter	$D_{f,y}$
Unit	km
Description	Round-trip distance between the origin and destination of transportation activities for raw materials and alternative additives of type f in year y
Source of data	Project data records
Applicable value	-

Parameter	$Q_{ADD,y}$
Unit	t additives
Description	Quantity of additional additives transported in year y

Source of data	Project data records
Applicable value	-

Parameter	EFF_{COM}
Unit	%
Description	Combustion efficiency of clinker kilns under the baseline scenario
Source of data	Chapter 2, Volume 2 of the 2006 IPCC Guidelines
Applicable value	Use a default value equal to 1

<table>
<tr><td>Parameter</td><td>$FFC_{j,y}$</td></tr>
<tr><td>Unit</td><td>% by weight</td></tr>
<tr><td>Description</td><td>Fossil carbon fraction in the total carbon content of waste type j under the project activity</td></tr>
<tr><td>Source of data</td><td>Table 2.4, Chapter 2, Volume 5 of the 2006 IPCC Guidelines</td></tr>
<tr><td>Applicable value</td><td>
For Municipal solid waste (MSW), default values may be used for waste type j as follows

Table 1: Default values for $FFC_{j,y}$

<table>
<tr><th>Type of waste j</th><th>value</th></tr>
<tr><td>Paper/Cardboard</td><td>5</td></tr>
<tr><td>Textiles</td><td>50</td></tr>
<tr><td>Food Waste</td><td>-</td></tr>
<tr><td>Wood</td><td>-</td></tr>
<tr><td>Garden and Yard Waste</td><td>0</td></tr>
<tr><td>Diapers</td><td>10</td></tr>
<tr><td>Rubber and Leather</td><td>20</td></tr>
<tr><td>Plastic</td><td>100</td></tr>
<tr><td>Metals*</td><td>NA</td></tr>
<tr><td>Glass*</td><td>NA</td></tr>
<tr><td>Others, Inert Waste</td><td>100</td></tr>
</table>

1) Metals and glass contain carbon from fossil-based sources; large-scale combustion of glass or metals is uncommon
2) In cases where the waste type cannot be compared to the categories specified in Table 1, or cannot be clearly described as a combination of the categories listed in Table 1, or where the project developer chooses to directly measure FFC_j, the
</td></tr>
</table>

	project developer must determine $FFC_{j,y}$ using national or international standards, or the following specified standards 2.1) ASTM D6866: " Standard Test Methods for Determining the Biobased Content of Solid, Liquid, and Gaseous Samples Using Radiocarbon Analysis"; 2.2) ASTM D7459: " Standard Practice for Collection of Integrated Samples for the Speciation of Biomass (Biogenic) and Fossil Carbon Dioxide Emitted from Stationary Emissions Sources " 3) Measurements shall be conducted at least four times per year and used to calculate an annual average.

<table>
<tr><td>Parameter</td><td>$FCC_{j,y}$</td></tr>
<tr><td>Unit</td><td>t C/t</td></tr>
<tr><td>Description</td><td>Carbon content ratio of waste type j in project year y</td></tr>
<tr><td>Source of data</td><td>Table 2.4 in Chapter 2 of Volume 5 of the 2006 IPCC Guidelines for National Greenhouse Gas Inventories</td></tr>
<tr><td>Applicable value</td><td>For MSW, default values may be applied for waste type j as follows
Table 2: Default values for $FCC_{j,y}$
<table>
<tr><th>Type of waste j</th><th>value</th></tr>
<tr><td>Paper/Cardboard</td><td>50</td></tr>
<tr><td>Textiles</td><td>50</td></tr>
<tr><td>Food Waste</td><td>50</td></tr>
<tr><td>Wood</td><td>54</td></tr>
<tr><td>Garden and Yard Waste</td><td>55</td></tr>
<tr><td>Diapers</td><td>90</td></tr>
<tr><td>Rubber and Leather</td><td>67</td></tr>
<tr><td>Plastic</td><td>85</td></tr>
<tr><td>Metals*</td><td>NA</td></tr>
<tr><td>Glass*</td><td>NA</td></tr>
<tr><td>Others, Inert Waste</td><td>5</td></tr>
</table>
* Metals and glass contain partial carbon from fossil-based sources; large-scale combustion of glass or metals is uncommon</td></tr>
</table>

10. Reference

1) Clean Development Mechanism (CDM)
   - AM0121 Large-scale Methodology Emission reduction from partial switching of raw materials and increasing the share of additives in the production of blended cement
   - ACM0022: Alternative waste treatment processes Version 3.0
   - TOOL12 Project and leakage emissions from transportation of freight
2) Thai Cement Manufacturers Association www.thaicma.or.th

Document information T-VER-P-METH-08-01

Version	Amendment	Entry into force	Description
02	1	23 July 2026	■ Add a method for comparing project emissions from fuel combustion for cement clinker production ($\mathbf{PE_{FC,i,y}}$) with the result from baseline activity. ■ Add equations for calculating project emissions from fuel combustion for cement grinding, raw material/alternative material production, and additive preparation. ■ Add equation for calculating project emissions from transportation of raw material/alternative material to cement plant ■ Use default value for parameter of combustion efficiency at the clinker kiln from baseline activity ($\mathbf{EFF_{COM}}$). ■ Revise monitoring details for parameter of combustion efficiency at the clinker kiln from project activity ($\mathbf{EFF_{COM,y}}$ and $\mathbf{EFF_{COM,y}}$)
01	-	23 July 2025	Initial adoption