Draft revision to the approved baseline methodology ACM0003

"Emissions reduction through partial substitution of fossil fuels with alternative fuels in cement manufacture"

Source

This methodology is based on two cases "Replacement of Fossil Fuel by Palm Kernel Shell biomass in the production of Portland cement" NM0040, prepared by Lafarge Asia, and "Indocement's Sustainable cement Production Project" NM0048-rev, prepared by Indocement. For more information regarding the proposals and their consideration by the Executive Board please refer to cases NM0040 and NM0048-rev on http://cdm.unfccc.int/methodologies/PAmethodologies/approved.html.

Selected approach from paragraph 48 of the CDM modalities and procedures

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

Applicability

The methodology is applicable to the cement industry with the following conditions:

- Fossil fuel(s) used in cement manufacture are partially replaced by the following *alternative fuels*:
  (a) Wastes originating from fossil sources, such as tires, plastics, textiles from polymers, or rubber;
  (b) Biomass residues[1] where they are available in surplus and would in the absence of the project activity be dumped or left to decay or burned in an uncontrolled manner without utilizing them for energy purposes;
- CO_2 emissions reduction relates to CO_2 emissions generated from fuel burning requirements only and is unrelated to the CO_2 emissions from decarbonisation of raw materials (i.e. $CaCO_3$ and $MgCO_3$ bearing minerals);
- The methodology is applicable only for installed capacity (expressed in tonnes clinker/year) that exists by the time of validation of the project activity;
- The amount of alternative fuels available for the project is at least 1.5 times the amount required to meet the consumption of all users consuming the same alternative fuels, i.e. the project and other alternative fuel users.

This baseline methodology shall be used in conjunction with the approved monitoring methodology ACM0003 ("Monitoring methodology for emissions reduction through partial substitution of fossil fuels with alternative fuels in cement manufacture").

[1] In the context of this methodology, *biomass residues* means *biomass* by-products, residues and waste streams from agriculture, forestry and related industries and the non-fossilized and biodegradable organic fractions of industrial and municipal wastes. *Biomass* means non-fossilized and biodegradable organic material originating from plants, animals and micro-organisms. This shall also include products, by-products, residues and waste from agriculture, forestry and related industries as well as the non-fossilized and biodegradable organic fractions of industrial and municipal wastes. Biomass also includes gases and liquids recovered from the decomposition of non-fossilized and biodegradable organic material.

Project boundary

The physical project boundary covers all production processes related to clinker production. The specific production step associated with GHG emissions that will define the project boundary primarily includes pyro-processing. In terms of gases covered within the project boundary, only CO_2 emissions from the combustion of fuels are considered, because the cement manufacturing process involves high combustion temperatures and long residence times that would limit production of other GHG emissions.

Baseline scenario selection

1. Define alternative scenarios for the fuel mix

- Define a continuation of current practice scenario, i.e., a scenario in which the company continues cement production using the existing technology, materials and fuel mix. Quantify the amount of fossil fuel(s) that would be used for clinker production over the project period.
- Define scenario(s) reflecting the likely evolving fuel mix portfolios, and relative prices of fuels available. [2] The scenario(s) may be based on one fuel or a different mixes of fuels. Quantify the amount of fossil fuel(s) that is expected to be used for clinker production over the project period.
- Define a scenario in which traditional fuels are partially substituted with alternative fuels (i.e. the proposed project). If relevant, develop different scenarios with different mix of alternative fuels and varying degrees of fuel-switch from traditional to alternative fuels. These scenarios should reflect all relevant policies and regulations[3]. Quantify the amounts of fossil fuels and alternative fuels that would be used for clinker production over the project period.

2. Option 1: Select baseline scenario through financial analysis

The baseline scenario defines the most likely situation in the absence of the proposed project. A key assumption of this methodology is that the cement company is taking decisions to maximise its revenues. The baseline scenario for a fuel-switch project implemented in the cement sector, therefore, should be selected from among the alternative scenarios by conducting the following financial tests:

- Calculate the financial costs (e.g. capital and variable costs) of the different alternatives.
- For all relevant project scenarios, compare the scenarios on the basis of NPV, IRR, or an alternative indicator of financial attractiveness of investment. Compute the financial indicator using net incremental cash flow but excluding potential CER revenue.
- Based upon this comparison, select the most cost-effective scenario from the list of alternative scenarios. The scenario with the most attractive economics, as measured by the chosen financial indicator (e.g. highest IRR, highest NPV), should be selected as the baseline scenario.
- A sensitivity analysis should be performed to assess the robustness of the selection of the most likely future scenario to reasonable variations in critical assumptions and to establish that the project is not the baseline. The financial indicator is calculated conservatively if assumptions tend to make the CDM project's indicators more attractive and the alternatives' indicators less attractive.

The baseline scenario should take into account relevant national/local and sectoral policies and circumstances, and the proponent should demonstrate that the key factors, assumptions and parameters of the baseline scenario are conservative.

[2] If relevant, construction of a new cement kiln or plant using alternative fuels could be included as a possible scenario. Note that the clinker production capacity should remain constant.
[3] Please refer to Executive Board guidance on national policies
<http://cdm.unfccc.int/EB/Meetings/016/eb16repan3.pdf>

Option 2: Select baseline scenario through barriers analysis

The baseline scenario defines the most likely situation in the absence of the proposed project.

Each fuel selection scenario should be processed via the barriers analysis step of the latest version of the ***"Tool for demonstration assessment and of additionality"*** agreed by the CDM Executive Board, which is available on the UNFCCC CDM web site[4.]
The baseline scenario should take into account relevant national/local and sectoral policies and circumstances, and the proponent should demonstrate that the key factors, assumptions and parameters of the baseline scenario are conservative.

Additionality

The additionality of the project activity shall be demonstrated and assessed using the latest version of the ***"Tool for the demonstration and assessment of additionality"*** *agreed by the CDM Executive Board, which is available on the UNFCCC CDM web site*[5].

Baseline and project emissions calculations

The project reduces CO_2 emissions from burning fossil fuel in cement kilns.

CH_4 emissions from kilns are negligible and are ignored. The project activity also generates CO_2, CH_4, and N_2O emissions due to on-site transportation of the alternative fuels.

Other emissions outside of the project boundary include CH_4 emissions from burning of biomass residues in open fields and/or CH_4 emissions due to anaerobic decomposition of biomass residues in landfills in the absence of the project activity. These are covered under the section on leakage. Emissions of CO_2, CH_4, and N_2O due to off-site transport and preparation of alternative fuels and fossil fuels to the cement plants are also addressed in the leakage section below.

Step 1. Calculate project heat input from alternative fuels

Heat input from alternative fuels with significant moisture content is calculated first to allow for the calculation of a project-specific moisture "penalty" for alternative fuel heat input requirements.

$$HI_{AF} = \sum Q_{AF} \times HV_{AF} \quad \textbf{(1)}$$

where:

HI_{AF} = heat input from alternative fuels (TJ/yr)
Q_{AF} = quantity of each alternative fuel (tonnes/yr)
HV_{AF} = lower heating value of the alternative fuel(s) used (TJ/tonne fuel).

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

Step 2. Estimate project specific moisture "penalty"

A project specific "penalty" is applied, because the combustion of typically coarser biomass and other alternative fuels, as opposed to more finely ground coal, will reduce the heat transfer efficiency in the cement manufacturing process. This will therefore require a greater heat input to produce the same quantity and quality of cement clinker. The chemical content and ease of absorption into cement clinker of all fuel ashes also differs, and this also contributes to the need for a project specific penalty.

This project specific penalty should be determined as follows:

$$MP_y = C_{Pr,y} x (HC_{AF} - HC_{FF}) \qquad \textbf{(1)}$$

where:

MP_y moisture penalty (TJ/yr) for year y
$C_{Pr,y}$ is the clinker production for year y
$HC_{AF,y}$ is the specific fuel consumption on project case (TJ/tClinker) in year y
HC_{FF} is the specific fuel consumption in the baseline when only fossil fuel is used, in TJ/tClinker.

$$HC_{AF} = \frac{\left(\sum Q_{FF,Pr} \times HV_{FF}\right) + HI_{AF}}{(C_{Pr})} \qquad \textbf{(2)}$$

where:

$Q_{FF,pr}$ is the quantity of fossil fuel used in the project case;
HV_{FF} is the lower heating value of the fossil fuel used (TJ/tonne);
HI_{AF} is heat input from alternative fuels (TJ/yr) in project case;
C_{Pr} is the production of clinker in the project case; and

$$HC_{FF} = \frac{\left(\sum Q_{FF,Ba} \times HV_{FF}\right)}{C_{Ba}} \qquad \textbf{(3)}$$

where:

$Q_{FF,Ba}$ is the quantity of fossil fuel used in the baseline case;
HV_{FF} is the lower heating value of the fossil fuel used (TJ/tonne) used in the baseline (it would be the same as project case if the fossil fuel used in the project case is same as that in the baseline)
C_{Ba} is clinker production in the base case corresponding to the $Q_{FF,Ba}$

Step 3 Calculate GHG emissions from the use of alternative fuels in kilns:

$$AF_{GHG} = \Sigma(Q_{AF} * HV_{AF} * EF_{AF}) \qquad \textbf{(4)}$$

where:

AF_{GHG} = GHG emissions from alternative fuels (tCO_{2e}/yr)
Q_{AF} = monitored alternative fuels input in clinker production (tonnes/yr).

HV_{AF} = heating value(s) of the alternative fuel(s) used (TJ/tonne fuel).
EF_{AF} = emission factor(s) of alternative fuel(s) used (tCO_{2e}/TJ).

When several alternative fuels are burned, the GHG emissions from each fuel are aggregated to determine AF_{GHG} using respective heating values and emission factors.

For biomass residues, unless it is clearly demonstrated and documented that the biomass residues consumed by the project would in the absence of the project activity decompose anaerobically, it should be assumed that the biomass residues would be burned in the absence of the project activity. CO_2 emissions from burning of biomass residues should be considered CO_2-neutral, assuming that the generation of the biomass residues (and any associated emissions) occurs independently of the project activity. To be conservative, N_2O and CH_4 emissions from stockpiled biomass should be ignored.

For waste originating from fossil sources(e.g. tires, plastics, textiles from polymers, and rubber), unless it can be clearly demonstrated that incineration of these alternative fuels without utilization for energy purposes is the dominant practice in the area(s) from which the alternative fuels in the project activity are sourced, CO_2 emissions from these fuels should be included in project emissions. If these wastes are incinerated in the host country (in the baseline scenario), then they should be considered as CO_2-neutral fuels, unless the heat generated in the incineration plant is used for heat or electricity generation purposes. In this latter case, CO_2 emissions from these fuels are to be included in project emissions.

Step 4 Calculate the baseline GHG emissions from the fossil fuel(s) displaced by the alternative fuel(s)

$$FF_{GHG} = [(Q_{AF} * HV_{AF}) - MP_{total}] * EF_{FF} \qquad \textbf{(5)}$$

where:

FF_{GHG} = GHG emissions from fossil fuels displaced by the alternatives ($tCO_{2/yr}$)
$Q_{AF} * HV_{AF}$ = total actual heat provided by all alternative fuels (TJ/yr)
MP_{total} = total moisture penalty (TJ/yr)
EF_{FF} = emissions factor(s) for fossil fuel(s) displaced (tCO_2/TJ).

EF_{FF} is the estimated baseline value and would be the lowest of the following CO_2 emission factors :

- the weighted average annual CO_2 emission factor for the fossil fuel(s) consumed and monitored ex ante during the year before the validation,
- the weighted average annual CO_2 emission factor for the fossil fuel(s) consumed and monitored during the corresponding verification period (e.g. the period during which the emission reductions to be certified have been achieved),
- the weighted average annual CO_2 emission factor for the fossil fuel(s) that would have been consumed according to the baseline scenario determined in section 1 and 2 of the "Additionality and baseline scenario selection" section above.

Step 5. Calculate GHG emissions due to on-site transportation and drying of alternative fuels

$$OT_{GHG} = OF_{AF} * (VEF\_CO_2 + VEF\_CH_4 * GWP\_CH_4/1000 + VEF\_N_2O * GWP\_N_2O/1000) + (FD * FD\_HV * VEF_D) \qquad \textbf{(6)}$$

where:

OT_{GHG} = GHG emissions from on-site transport and drying of alternative fuels (tCO_{2e}/yr)
OF_{AF} = transportation fuel used for alternative fuels on-site during the year (t/yr),
VEF_CO_2 = CO_2 emission factor for the transportation fuel (tCO_2/tonne),

VEF_CH_4	=	CH_4 emission factor for the transportation fuel (kg CH_4/tonne),
VEF_N_2O	=	N_2O emission factor for the transportation fuel (kg N_2O/tonne),
GWP_CH_4	=	global warming potential for CH_4 (21),
GWP_N_2O	=	global warming potential for N_2O (310),
FD	=	fuel used for drying alternative fuels (t/yr),
FD_HV	=	heating value of the fuel used for drying (TJ/t fuel), and
VEF_D	=	emission factor of the fuel used for drying (tCO_2/TJ)

Step 6. Calculate emission savings from reduction of on-site transport of fossil fuels

$$OT\_GHG_{FF} = OF_{FF} * EF_{T\ CO2e} \quad (7)$$

where:

$OT\text{-}GHG_{FF}$	=	emissions from reduction of on-site transport of fossil fuels ($tCO2_e$)
OF_{FF}	=	fuel saving from on-site transportation of fossil fuels (t/yr)
$EF_{T\ CO2e}$	=	emission factor of fuel used for transportation (tCO_{2e}/t fuel),

Leakage

Leakage emissions considered are methane emissions due to biomass residues that would be burned or decomposed anaerobically in landfills in the absence of the project, as well as CO_2 emissions from off-site transport of fuels to the cement plant and off-site preparation of alternative fuels.
Another potential source of leakage is that the project may deprive other users of alternative fuels and thereby increase fossil fuel use. To ensure that the proposed project activity will not reduce the amount of alternative fuels available to other alternative fuels users, the project proponent should demonstrate that the amount of alternative fuels is 1.5 times the amount required to meet the consumption of all users consuming the same alternative fuels, i.e. the project and other alternative fuel users.

Step 1. Calculate CH_4 emissions due to biomass residues that would be burned in the absence of the project

$$BB_{CH4} = Q_{AF\text{-}B} * BCF * CH_4F * CH_4/C * GWP\_CH_4 \quad (8)$$

where:

BB_{CH4}	= GHG emissions due to burning of biomass residue that is used as alternative fuel (tCO_{2e}/yr)
$Q_{AF\text{-}B}$	= amount of biomass residue used as alternative fuel that would have been burned in the open field in the absence of the project (t/yr)
BCF	= carbon fraction of the biomass residue (tC/t biomass) estimated on basis of default values,
CH_4F	= fraction of the carbon released as CH_4 in open air burning (expressed as a fraction),[6]
CH_4/C	= mass conversion factor for carbon to methane (16 tCH_4/12 tC), and
GWP_CH_4	= global warming potential of methane (21).

Step 2. Calculate the CH_4 emissions due to anaerobic decomposition of biomass residues at landfills

This step will only be relevant for a project activity that burns biomass residues that would otherwise be landfilled. The emission reductions are achieved by avoiding CH_4 emissions from anaerobic decomposition of the biomass residues. There is a possibility that the methane is completely or partially flared in the absence of the project activity. If all landfill gas is being flared, then CH_4 emission reductions cannot be

[6] The IPCC 1996 guidelines recommend using 0.005% as a default value.

claimed. If a portion of the methane is flared, then only the non-flared portion (NFL) of the CH_4 can be claimed by the project proponent.

The amount of methane that is generated each year ($LW_{CH4,y}$) is calculated for each year with a multi-phase model. The model is based on a first order decay equation. It differentiates between the different types of biomass residues *j* with respectively different decay rates k_j (fast, moderate, slow) and fraction of degradable organic carbon (DOC_j). The model calculates the methane generation based on the actual biomass residue streams $QAFL_{j,x}$ disposed in the most recent year (y) and all previous years since the project start (x=1 to x=y). The amount of methane produced in the year *y* ($LW_{CH4,y}$) is calculated as follows:

$$LW_{CH4,y} = \varphi \cdot \frac{16}{12} \cdot F \cdot DOC_f \cdot MCF \cdot \sum_{x=1}^{y} \sum_{j=A}^{D} QAFL_{j,x} \cdot DOC_j \cdot \left(1 - e^{-k_j}\right) \cdot e^{-k_j \cdot (y-x)} \cdot NFL \cdot GWP_{CH4} \quad \textbf{(9)}$$

where:

$LW_{CH4,y}$	Baseline GHG emissions due to anaerobic decomposition of biomass residues in landfills during the year y (tCO_2e/yr)
$QAFL_{j,x}$	amount of biomass residues of type j used as alternative fuel that would be landfilled in the absence of the project in the year x (t/yr)
φ	is model correction factor (default 0.9) to correct for the model-uncertainties
F	is fraction of methane in the landfill gas
DOC_j	is per cent of degradable organic carbon (by weight) in the biomass type j
DOC_f	is fraction of DOC dissimilated to landfill gas
MCF	is Methane Correction Factor (fraction)
k_j	is decay rate for the biomass residue stream type j
j	is biomass residue type distinguished into the biomass residue categories (from A to D), as illustrated in Table 2 below
x	is year during the crediting period: x runs from the first year of the first crediting period (x=1) to the year for which emissions are calculated (x=y)
y	is year for which LFG emissions are calculated
NFL	is the non-flared portion of the landfill gas produced (%)
GWP_{CH4}	Global warming potential valid for the relevant commitment period

Model Correction Factor (φ)

Oonk et el. have validated several landfill gas models based on 17 realized landfill gas projects.[7] The mean relative error of multi-phase models was assessed to be 18%. Given the uncertainties associated with the model and in order to estimate emission reductions in a conservative manner, a discount of 10% should be applied to the model results.

Methane correction factor (MCF)

The methane correction factor (MCF) accounts for the fact that unmanaged landfills produce less methane from a given amount of waste than managed landfills, because a larger fraction of waste decomposes aerobically in the top-layers of unmanaged landfills. The proposed default values for MCF are listed in Table 1 below.

Table 1: Solid Waste Disposal Site (SDWS) Classification and Methane Correction Factors

Type of site	MCF default values
Managed site	1.0
Unmanaged site – deep (> 5 m waste)	0.8
Unmanaged site – shallow (< 5 m waste)	0.4
Note: Managed SWDS must have controlled placement of waste (i.e. waste directed to specific deposition areas, a degree of control of scavenging and a degree of control of fires) and will include some of the following: cover material, mechanical compacting or levelling of waste.	

Source: Table 5.1 in the 2000 IPCC Good Practice Guidance

Project participants should use 0.4 as default MCF, unless they can demonstrate that the baseline-scenario would be disposal of the waste at an unmanaged site- with a wastepile of more than 5m depth (MCF in that case would be 0.8) or a managed landfill (MCF in that case would be 1.0).

Fraction of degradable organic carbon dissimilated (DOC_f)

The decomposition of degradable organic carbon does not occur completely and some of the potentially degradable material always remains in the site even over a very long period of time. The revised IPCC Guidelines propose a default value of 0.77 for DOCf. A lower value of 0.5 should be used if lignin-C is included in the estimated amount of degradable organic carbon.[8]

Degradable carbon content in waste (DOC_j) and decay rates (k_j)

In the Revised 1996 IPCC Guidelines for National Greenhouse Gas Inventories (module 6), default values for degradable organic carbon are presented, as shown in Table 2 below. These values should be used by project participants.[9]

[7] Oonk, Hans et al.:Validation of landfill gas formation models. TNO report. December 1994
[8] IPCC Good Practice Guidance and Uncertainty Management in National Greenhouse Gas Inventories – chapter 5
[9] For the categories of waste considered as well as the values of DOC, project participants should consider any revisions to the Revised 1996 IPCC Guidelines and the 2000 IPCC Good Practice Guidance.

Table 2: Waste stream decay rates (k_j) and associated IPCC default values for DOC_j

Waste stream A to E	Per cent DOC_j (by weight)	Decay-rate (k_j)
A. Paper and textiles	40	0.023
B. Garden and park waste and other (non-food) perishables	17	0.023
C. Food waste	15	0.231
D. Wood and straw waste 1)	30	0.023
E. Inert material	0	0

1) this factor applies to the non-lignin part of the waste

The most rapid decay rates are associated with high moisture conditions and rapidly degradable material such as food waste. The slower decay rates are associated with dry site conditions and slowly degradable waste such as wood or paper. For this methodology, food waste (C) is considered as fast degradable waste, while paper and textiles (A), Garden and park waste and other (non-food) perishables (B), Wood and straw waste (D) are considered as slow degradable waste. Inert materials (E) are assumed not to degrade (k=0).

If local measurements have been undertaken for decay rates and if these are documented, and can be considered as more reliable, these may be used instead of the default-values of table 2. Project participants should consider future revisions to the decay-rate constants (kj) when available, including revisions to IPCC guidelines.

For all biomass residues used in the project plant that would be dumped on landfills in the absence of the project activity, project participants shall determine the composition of the biomass residues in accordance with the categories in Table 2 above, measuring the fractions of each of the following waste types: paper and textile (A); garden and park waste and other (non-food) organic putrescibles (B); food waste (C); wood and straw (D) and; inert/inorganic waste (E). The size and frequency of sampling should be statistically significant with an maximum uncertainty range of 20% at a 95% confidence level. As a minimum, sampling should be undertaken four times per year.

Calculation of F

The project participants apply a default value of 0.5.

Step 3. Calculate emissions from off-site transport of alternative and fossil fuels

The emissions from transportation should be calculated as follows:

$$LK_{trans} = LK_{AF} - LK_{FF} \quad \textbf{(10)}$$

$$LK_{AF} = (Q_{AF}/CT_{AF}) * D_{AF} * EF_{CO2e}/1000 \quad \textbf{(11)}$$

$$LK_{FF} = (RQ_{FF}/CT_{FF}) * D_{FF} * EF_{CO2e}/1000 \quad \textbf{(12)}$$

where:

LK_{trans} = leakage from transport of alternative fuel less leakage due to reduced transport of fossil fuels (tCO_2/yr)
LK_{AF} = leakage resulting from transport of alternative fuel (tCO_2/yr)
LK_{FF} = leakage due to reduced transport of fossil fuels (tCO_2/yr)
Q_{AF} = quantity of alternative fuels (tonnes)
CT_{AF} = average truck or ship capacity (tonnes/truck or ship)
D_{AF} = average round-trip distance between the alternative fuels supply sites and the cement plant sites (km/truck or ship)
RQ_{FF} = quantity of fossil fuel (tonnes) that is reduced due to consumption of alternative fuels

estimated as:

CT_{FF} = average truck or ship capacity (tonnes/truck or ship)

D_{FF} = average round-trip distance between the fossil fuels supply sites and the cement plant sites (km/truck or ship)

EF_{CO2e} = emission factor from fuel use due to transportation (kg CO_{2e}/km) estimated as:

$$EF_{CO2e} = EF_{T\ CO2} + (EF_{T\ CH4} * 21) + (EF_{T\ N2O} * 310) \quad \textbf{(13)}$$

where:

$EF_{T\ CO2}$ = emission factor of CO_2 in transport (kg CO_2/km)

$EF_{T\ CH4}$ = emission factor of CH_4 in transport (kg CH_4/km)

$EF_{T\ N2O}$ = emission factor of N_2O in transport (kg N_2O/km)

21 and 310 are the Global Warming Potential (GWP) of CH_4 and N_2O respectively

Step 4. Calculate emissions from off-site preparation of alternative fuels

The GHG emissions generated during the preparation of alternative fuels outside the project site are estimated as follows:

$$GHG_{PAFO} = FD_{AFO} * HV_{FDAFO} * EF_{FDAFO} + PD_{AFO} * EF_{pO} \quad \textbf{(14)}$$

where:

GHG_{PAFO} = GHG emissions that could be generated during the preparation of alternative fuels outside the project site (tCO_2/yr)

FD_{AFO} = fuel used in drying of alternative fuels outside the project site (t/yr)

HV_{FDAFO} = heating value of fuel used for drying alternative fuels outside the project site (TJ /tonne)

EF_{FDAFO} = emission factor for the fuel used for drying of alternative fuels outside the project site (tCO_2/TJ)

PD_{AFO} = power consumption in drying the alternative fuels (MWh/yr) outside the project site

EF_{pO} = CO_2 emission factor due to power generation outside the project where the drying of alternative fuels takes place, determined according to the methodology presented in AM0002 (tCO_2/MWh).

Emission Reductions

Total emission reductions are given by the following formula:

$$AF_{ER} = FF_{GHG} - AF_{GHG} - OT_{GHG} - LK_{trans} + OT\_GHG_{FF} + BB_{CH4} + LW_{CH4,y} - GHG_{PAFO} \quad \textbf{(15)}$$

where:

FF_{GHG} = GHG emissions from fossil fuels displaced by the alternatives ($tCO_{2/yr}$)

AF_{GHG} = GHG emissions from alternative fuels (tCO_{2e}/yr)

OT_{GHG} = GHG emissions from on-site transport and drying of alternative fuels (tCO_{2e}/yr)

LK_{trans} = leakage from transport of alternative fuel less leakage due to reduced transport of fossil fuels (tCO_2/yr)

$OT\text{-}GHG_{FF}$ = emissions from reduction of on-site transport of fossil fuels ($tCO2_e$)

BB_{CH4} = GHG emissions due to burning of biomass residue that is used as alternative fuel (tCO_{2e}/yr)

$LW_{CH4,y}$ = baseline GHG emissions due to anaerobic decomposition of biomass residues at landfills (tCO_{2e}/yr)

GHG_{PAFO} = GHG emissions that could be generated during the preparation of alternative fuels outside the project site (tCO_2/yr)

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  (b) Biomass residues[10] where they are available in surplus and would in the absence of the project activity be dumped or left to decay or burned in an uncontrolled manner without utilizing them for energy purposes;
  -
  - CO_2 emission reduction relates to CO_2 emissions generated from fuel burning requirements only and is unrelated to the CO_2 emission from decarbonisation of raw materials (i.e. $CaCO_3$ and $MgCO_3$ bearing minerals);
  - The methodology is applicable only for installed capacity (expressed in tonnes clinker/year) that exists by the time of validation of the project activity;
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[10] In the context of this methodology, *biomass residues* means *biomass* by-products, residues and waste streams from agriculture, forestry and related industries and the non-fossilized and biodegradable organic fractions of industrial and municipal wastes. *Biomass* means non-fossilized and biodegradable organic material originating from plants, animals and micro-organisms. This shall also include products, by-products, residues and waste from agriculture, forestry and related industries as well as the non-fossilized and biodegradable organic fractions of industrial and municipal wastes. Biomass also includes gases and liquids recovered from the decomposition of non-fossilized and biodegradable organic material..

This monitoring methodology shall be used in conjunction with the approved baseline methodology ACM0003 ("Baseline methodology for emissions reduction through partial substitution of fossil fuels with alternative fuels in cement manufacture").

Monitoring methodology
Baseline and project emissions

ID number	Data Type	Data Variable	Symbol	Data Unit	Measured (m), calculated (c) or estimated (e)	Recording Frequency	Proportion of Data to be Monitored	How will the Data be Archived (electronic/paper)	For How Long is the Archived Data Kept?	Comment	Instrument used to record
Monitoring of parameters related to clinker production											
1.	mass	Clinker production	C_{Pr}	Ton	measured, calculated	recorded/ calculated and reported monthly	100%	electronic, paper	2 years after the end of the crediting period		Weighing feeders
Monitoring of emissions related to the use of alternative fuels in kilns during the crediting period (for each type of fuels - and each kiln independently)											
2.	quantity	Fuel type	$Q_{AF,}$	Units of mass or volume	measured	recorded continuously and reported monthly and adjusted according to stock change	100%	electronic, paper	2 years after the end of the crediting period		Scale
3.	heat value	Fuel Heating value	HV_{AF}	TJ/tonne	measured, calculated	monthly	100%	electronic, paper	2 years after the end of the crediting period		Calorimeter
4.	heat	Alternative fuel heat input	HI_{AF}	TJ	calculated	calculated and reported monthly	100%	electronic, paper	2 years after the end of the crediting period	For each kiln	

ID number	Data Type	Data Variable	Symbol	Data Unit	Measured (m), calculated (c) or estimated (e)	Recording Frequency	Proportion of Data to be Monitored	How will the Data be Archived (electronic/paper)	For How Long is the Archived Data Kept?	Comment	Instrument used to record
5.	emission factor	Emission Factor	EF_{AF}	tCO2/TJ	IPCC default	fixed	100%	electronic, paper	The entire crediting period		
6.	fraction	Share of heat input from alternative fuels	S_{AF}	%	calculated	calculated monthly	100%	electronic, paper	2 years after the end of the crediting period		
7.	ratio	Moisture penalty	mp	MJ/tonne/ 10% alt fuel share	calculated	at start of crediting period	100%	electronic, paper	2 years after the end of the crediting period		

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Monitoring of emissions related to the project as well as baseline GHG emissions from the fossil fuel(s) displaced by the alternative fuel(s)											
8.	quantity	Fuel type	Q_{FF}	Units of mass or volume	measured	recorded continuously and reported monthly and adjusted according to stock change. For baseline based on record of 3 years prior to project start.	100%	electronic, paper	2 years after the end of the crediting period	For each of the fossil fuels consumed: (i) in the year prior to the validation, (ii) during the project activity, (iii) in the baseline scenario	Scale

ID number	Data Type	Data Variable	Symbol	Data Unit	Measured (m), calculated (c) or estimated (e)	Recording Frequency	Proportion of Data to be Monitored	How will the Data be Archived (electronic/paper)	For How Long is the Archived Data Kept?	Comment	Instrument used to record
9.	heat value	Fuel Heating value	HV_{FF}	TJ/tonne	measured, calculated	monthly	100%	electronic, paper	2 years after the end of the crediting period	For each of the fossil fuels consumed: (i) in the year prior to the validation, (ii) during the project activity, (iii) in the baseline scenario	Calorimeter
10.	quantity	Clinker production	C_{Ba}	tonne	from records	at start of project				Three years data from the records of the project plant.	

ID number	Data Type	Data Variable	Symbol	Data Unit	Measured (m), calculated (c) or estimated (e)	Recording Frequency	Proportion of Data to be Monitored	How will the Data be Archived (electronic/paper)	For How Long is the Archived Data Kept?	Comment	Instrument used to record
11.	emission factor	Emission Factor	EF_{FF}	tCO2/TJ	IPCC default	fixed	100%	electronic, paper	2 years after the end of the crediting period	For each of the fossil fuels consumed: (i) in the year prior to the validation, (ii) during the project activity, (iii) in the baseline scenario	
Monitoring of emissions related to on-site transportation and drying of alternative fuels											
12.	quantity	Transportation of fuel used on-site	OFv	Kg	measured	recorded and reported monthly	100%	electronic, paper	2 years after the end of the crediting period		Fuel record
13.	emission factor	Emission Factor	VEF_{CO2}	g CO2/kg	IPCC default	fixed	100%	electronic, paper	The whole crediting period	Ref. notes below	
14.	emission factor	Emission Factor	VEF_{CH4}	g CH4/kg	IPCC default	fixed	100%	electronic, paper	The whole crediting period	Ref. notes below	

ID number	Data Type	Data Variable	Symbol	Data Unit	Measured (m), calculated (c) or estimated (e)	Recording Frequency	Proportion of Data to be Monitored	How will the Data be Archived (electronic/paper)	For How Long is the Archived Data Kept?	Comment	Instrument used to record
15.	emission factor	Emission Factor	VEF_{N2O}	g N2O/kg	IPCC default	fixed	100%	electronic, paper	The whole crediting period	Ref. notes below	
16.	quantity	Fuel used for any drying of alternative fuels	FD	Kg	measured	recorded and reported monthly	100%	electronic, paper	2 years after the end of the crediting period		Flowmeter, weigher
17.	heat	Heating Value for fuel for drying alt. Fuels	FD_HV	TJ/tonne	measured, C	monthly	100%	electronic, paper	2 years after the end of the crediting period		Calorimeter
18.	emission factor	Emission factor for the fuel used for drying	VEF_D	tCO2/TJ	IPCC default	fixed	100%	electronic, paper	The whole crediting period	Ref. notes below	
Monitoring of emissions reduction from reduction of on-site transport of fossil fuel											
19.	quantity	Fuel saving from on-site transportation of fossil fuel	OF_{FF}	kg	measured	measured monthly and reported monthly	100%	electronic, paper	2 years after the end of the crediting period		Fuel consumption records

ID number	Data Type	Data Variable	Symbol	Data Unit	Measured (m), calculated (c) or estimated (e)	Recording Frequency	Proportion of Data to be Monitored	How will the Data be Archived (electronic/paper)	For How Long is the Archived Data Kept?	Comment	Instrument used to record
20.	emission factor	Fuel emission factor	$EF_{T\ CO2e}$	$kgCO_{2e}$ /kg fuel	default value		100%	electronic, paper	2 years after the end of the crediting period		NA

Leakage

ID number	Data Type	Data Variable	Symbol	Data Unit	Measured (m), calculated (c) or estimated (e)	Recording Frequency	Proportion of Data to be Monitored	How Will the Data be Archived (electronic/paper)	For How Long is the Archived Data Kept?	Comment	Instrument used to record
Monitoring of emissions due to burning of biomass residues in the field in the baseline scenario											
21.	quantity	Biomass residues which would have been burnt in the absence of the project	$Q_{AF\text{-}D/B}$	Tonnes	estimated		100%	electronic, paper	2 years after the end of the crediting period		
22.	fraction	Carbon fraction of the biomass residue	BCF	Tonnes C per tonnes biomass	IPCC default						
23.	fraction	Carbon released as CH_4 in open air burning	CH_4F		IPCC default						

ID number	Data Type	Data Variable	Symbol	Data Unit	Measured (m), calculated (c) or estimated (e)	Recording Frequency	Proportion of Data to be Monitored	How Will the Data be Archived (electronic/paper)	For How Long is the Archived Data Kept?	Comment	Instrument used to record
Monitoring of emissions due to landfilling of biomass residues in the baseline scenario											
24.	quantity	Biomass residue that would have been landfilled without project	$QAFL_{j,x}$	Tonnes	estimated		100%	electronic, paper	2 years after the end of the crediting period		
25.	fraction	Methane conversion factor	MCF		IPCC default				2 years after the end of the crediting period	Default = 0.4 for un-managed shallow waste sites under 5 m.	
26.	fraction	Degradable organic carbon content of the biomass residue	DOC_j	tC/tonnes of biomass.	IPCC default				2 years after the end of the crediting period	Default value is 0.3.	

ID number	Data Type	Data Variable	Symbol	Data Unit	Measured (m), calculated (c) or estimated (e)	Recording Frequency	Proportion of Data to be Monitored	How Will the Data be Archived (electronic/paper)	For How Long is the Archived Data Kept?	Comment	Instrument used to record
27.	fraction	Portion of DOC that is converted to landfill gas	DOC_F		IPCC default				2 years after the end of the crediting period	Default value is 0.77.	
28.	fraction	Landfill gas portion that is flared	NFL		estimated				2 years after the end of the crediting period	Obtained from host country	
Monitoring of emissions due to off-site transport of fuels											
29.	quantity	Alternative Fuels	Q_{AF}	Ton	measured	recorded continuously and reported monthly based on actual silo stock level changes	100%	electronic, paper	2 years after the end of the crediting period		Weighing feeders

ID number	Data Type	Data Variable	Symbol	Data Unit	Measured (m), calculated (c) or estimated (e)	Recording Frequency	Proportion of Data to be Monitored	How Will the Data be Archived (electronic/paper)	For How Long is the Archived Data Kept?	Comment	Instrument used to record
30.	specific quantity	Average truck capacity for transport of alternative fuels	CT_{AF}	Tonnes per truck	calculated	monthly	100%	electronic, paper	2 years after the end of the crediting period	The quantity can be estimated based on additive material hauling distance and estimated fuel consumption per shipment	
31.	distance	Average distance for transport of alternative fuels	D_{AF}	Km/truck	calculated	monthly	100%	electronic, paper	2 years after the end of the crediting period	In certain cases other means of transportation which require that other formulas be used	
32.	emission Factors	Emission factors	EF_{CO2e}	Kg CO2eq per km or per kg of fuel	calculated	monthly	100%	electronic, paper	2 years after the end of the crediting period	Ref. notes below	

ID number	Data Type	Data Variable	Symbol	Data Unit	Measured (m), calculated (c) or estimated (e)	Recording Frequency	Proportion of Data to be Monitored	How Will the Data be Archived (electronic/paper)	For How Long is the Archived Data Kept?	Comment	Instrument used to record
33.	quantity	Fossil fuels which is reduced due to consumption of alternative fuels	RQ_{FF}	Ton	calculated	calculated monthly	100%	electronic, paper	2 years after the end of the crediting period		
34.	quantity	Average truck capacity for transport of Q_{FF}	CT_{FF}	Tonnes per truck	calculated	monthly	100%	electronic, paper	2 years after the end of the crediting period		
35.	distance	Average distance for transport of Q_{FF}	D_{FF}	Km/truck	calculated	monthly	100%	electronic, paper	2 years after the end of the crediting period	In certain cases other means of transportation which require other formulas be used	

ID number	Data Type	Data Variable	Symbol	Data Unit	Measured (m), calculated (c) or estimated (e)	Recording Frequency	Proportion of Data to be Monitored	How Will the Data be Archived (electronic/paper)	For How Long is the Archived Data Kept?	Comment	Instrument used to record
Monitoring of alternative fuel reserves that may be used by other users (data to be completed for each type of fuel independently)											
36.	quantity	Alternative fuel used by other users		Ton	estimated	yearly	100%	electronic, paper	2 years after the end of the crediting period	Track whether project activity reduces alternative fuel available to other users groups so that their GHG emissions will increase.	Based on data from local, national, and/or international government institutions; industry associations; and other reliable sources of information
37.	quantity	Alternative fuel reserve available in the region		Ton	estimated	yearly	100%	electronic, paper	2 years after the end of the crediting period		
Monitoring of preparation of alternative fuel outside the project site/outside the cement plant sites											
38.	quantity	Fuel used in drying of alternative fuels outside the project site	FD_{AFO}	Ton, kg or litre	measured	monthly	100%	electronic, paper	2 years after the end of the crediting period	To be estimated for each type of fuel indepen-dently	

ID number	Data Type	Data Variable	Symbol	Data Unit	Measured (m), calculated (c) or estimated (e)	Recording Frequency	Proportion of Data to be Monitored	How Will the Data be Archived (electronic/paper)	For How Long is the Archived Data Kept?	Comment	Instrument used to record
39.	heat	Heating Value of fuel used for drying alternative fuels outside the project site	HV_{FDADO}	TJ or Tcal/unit of fuel	estimated	monthly	100%	electronic, paper	2 years after the end of the crediting period	To be estimated for each type of fuel indepen-dently	
40.	emission factor	Emission factor for the fuel used for drying of alternative fuels outside the project site	EF_{ADO}	T of CO2/TJ	calculated based on default value	monthly	100%	electronic, paper	2 years after the end of the crediting period	To be estimated for each type of fuel indepen-dently	
41.	quantity	Power consumption of drying the alternative fuels outside the project site	PD_{ADO}	Kwh	measured	monthly	100%	electronic, paper	2 years after the end of the crediting period		

ID number	Data Type	Data Variable	Symbol	Data Unit	Measured (m), calculated (c) or estimated (e)	Recording Frequency	Proportion of Data to be Monitored	How Will the Data be Archived (electronic/paper)	For How Long is the Archived Data Kept?	Comment	Instrument used to record
42.	emission factor	Emission factor for power generation outside the project site where drying of alternative fuels takes place	EFpO	Ton CO_2 per MWh	calculated	calculated and reported yearly	100%	electronic, paper	2 years after the end of the crediting period	To be calculated from each type of fuel	

Notes:

1. In order to estimate the quantity of biomass residues that would have been landfilled without project and the quantity of biomass residues which would have been burnt in the absence of the project, project participants should carry out a survey before and after the project activity implementation.

2. Emission factors to be used to calculate leakage from transportation emissions:

Transportation emissions from trucks*	Truck capacity	To be measured
	Return trip distance	To be measured
	CO_2 emission factor[a]	1097 g/km 3172.31 g/kg
	CH_4 emission factor[a]	0.06 g/km 0.18 g/kg
	N_2O emission factor[a]	0.031 g/km 0.09 g/kg

* These values are illustrative examples and should be replaced by corresponding specific project data, as necessary.
[a] IPCC default values for US heavy diesel vehicles, uncontrolled.
Due to fuel sourcing from various locations even within a single fuel type (e.g. coal from 2 regions), distances for each source should be measured, and any changes due to contract renewal also reflected.

3. If ships are used to deliver fuels, then assume that ship fuel is HFO380 with a heat content of 41.868 GJ/tonne and emission factor of 77.4 $kgCO_2$/GJ, as per IPPC default values. Ships are collecting another material close by and so fuel is for one-way trip.

4. ID.37-38. This monitoring task tracks whether the project activity may reduce the amount of biomass residues available to other users groups so that they might shift their productive or other activities in ways that would lead to increased GHG emissions. To demonstrate that there is an abundance of surplus biomass residues a proposed project activity should demonstrate that: The amount of biomass residue for which there are no users/off-takers should be 1.5 times the amount required to meet the consumption of all users consuming the same biomass residue type.

5. Power system data and information: If available, data and information on generation, fuel types, fuel consumption, energy content and carbon emission factors from government ministries and agencies should be used. If unavailable, information from neighbouring countries may be used. If the latter is unavailable, international best practice data may be used together with IPCC default calorific values and carbon emission factors.

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

Data	**Uncertainty level of data (High/Medium/Low)**	**Are QA/QC procedures planned for these data?**	**Outline explanation why QA/QC procedures are or are not being planned.**
1-3, 11, 15-16, 18	Low	Yes – According to ISO 9000 or similar quality systems	
20-23, 29	Medium	No	Fraction of biomass residue that would have been decayed/burnt and/or landfilled will be estimated
5, 10, 12-14. 17, 19, 21-22, 24-26	Low	No	While IPCC fractions are reliable defaults, the project proponent should validate these default values
Other leakage data	Medium	No	An independent expert should validate the data quality.