Workshop CDM in Industrial Processes

Example CDM Project in the Cement Industry

Indocement's Sustainable Cement Production Project

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Indocement's Sustainable Cement Production Project

Approved baseline methodology ACM0003 "Emissions reduction through partial substitution of fossil fuels with alternative fuels in cement manufacture"

Methodology 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 ("Component 2").

Applicability

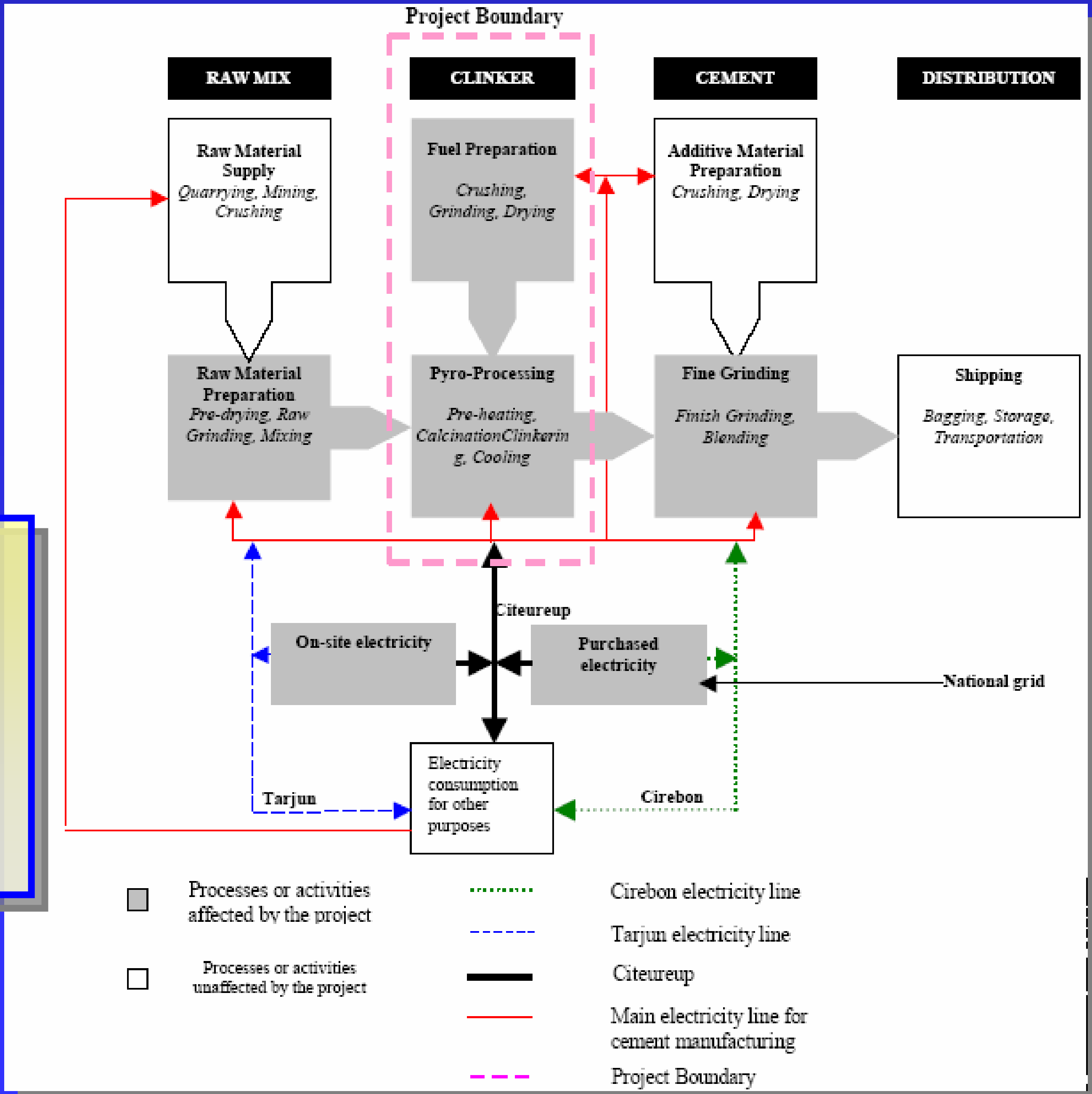
The methodology is applicable to the cement industry with the following conditions:

- Fossil fuel(s) used in cement manufacture are partially replaced by alternative fuels, including renewable biomass[1], where renewable biomass residues are in surplus and leakages in other uses of the renewable biomass will not occur;
- 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.

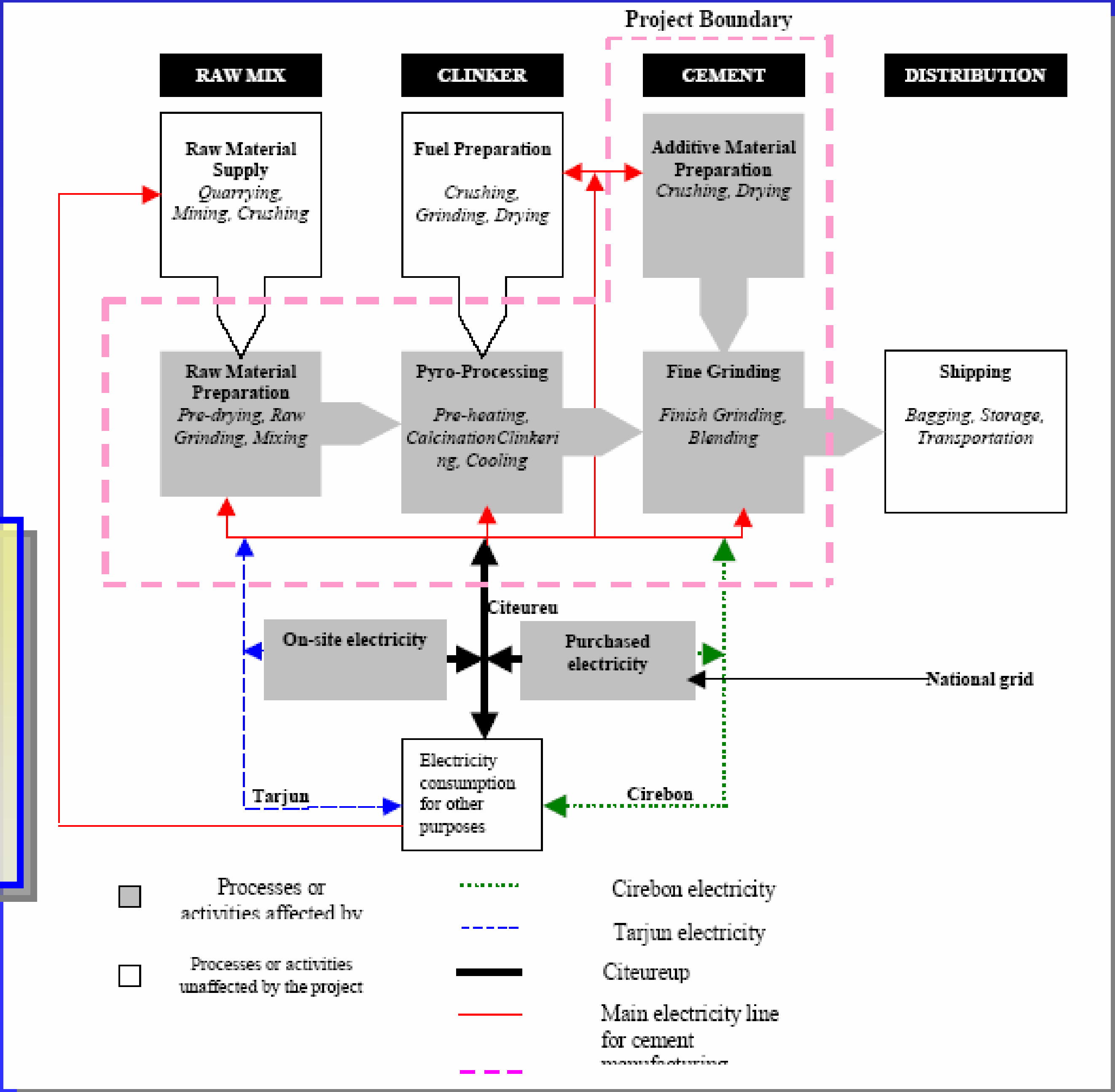
Project Boundary

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 CO2 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.

Project Boundary (Component 2: Alternative Fuels)



Project Boundary (Component 1: Blended Cement)



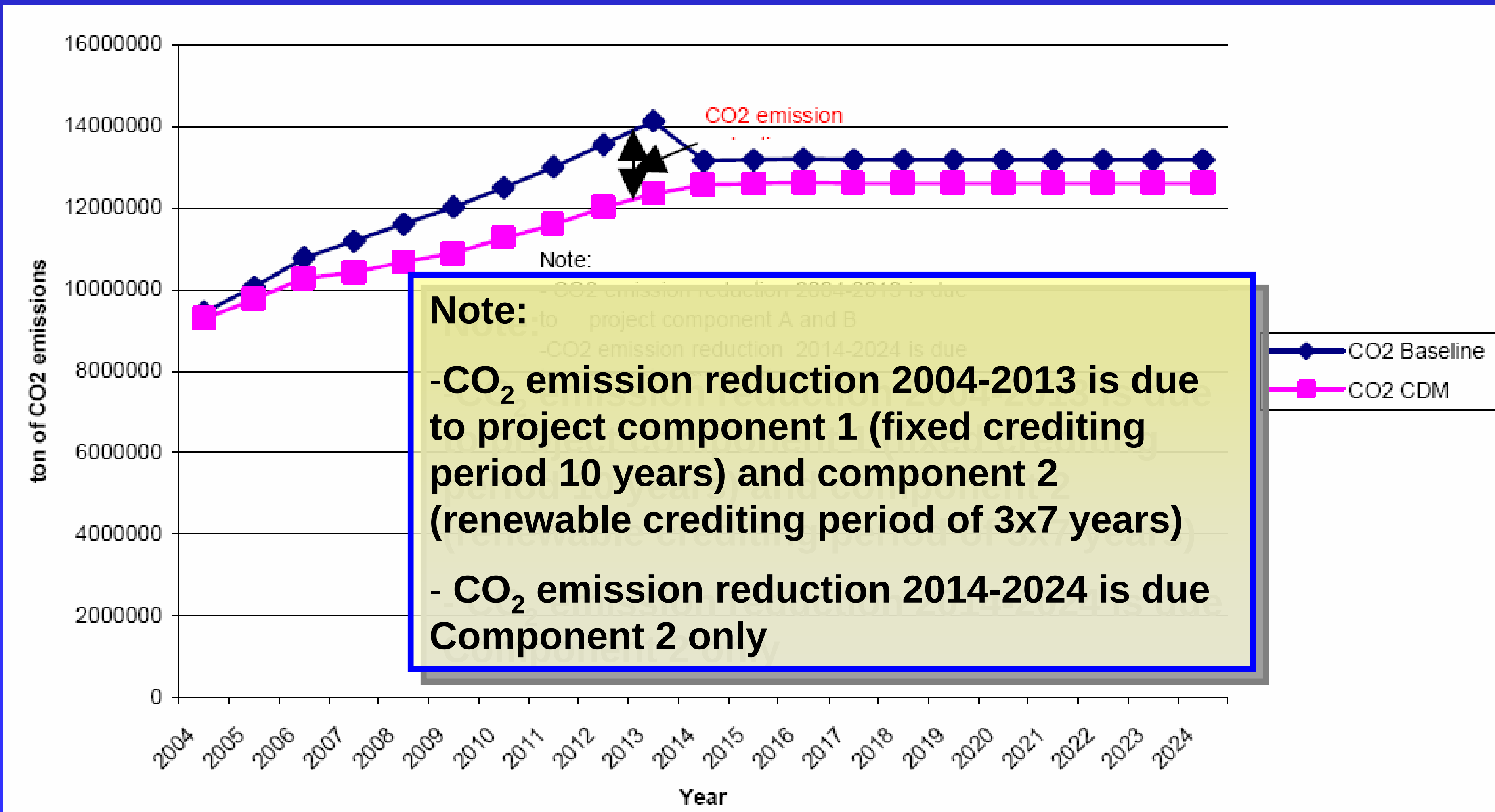
Project Boundary: Accounting of Direct CO_2 Emissions in Baseline and CDM-Project

Source of CO_2 Emissions	Baseline Emissions	Project Emissions
Raw material calcination		
CO_2 due to calcination of raw meal.	Included.	Included.
CO_2 from by-pass dust that is discarded.	Excluded.	Excluded.
CO_2 from cement kiln dust (CKD) that is sold or discarded.	Excluded.	Excluded.
Kiln fuel		
CO_2 from fossil fuel.	Included.	Included.
CO_2 from "non-CO_2 neutral" alternative fuel.	Excluded; the use of alternative fuels is not "business-as–usual."	Included, if non-CO_2 neutral alternative fuels are used.
CO_2 from biomass fuels.	Excluded; the use of biomass is not "business-as–usual."	Excluded.
Non-kiln fuel		
CO_2 from equipment and on-site vehicles.	Excluded.	Excluded.
CO_2 from on-site power generation. CO_2 from power consumption in the production process.	Included.	Included.

Project Boundary: Accounting of Indirect CO_2 -Emissions in Baseline and CDM-Project

Source of CO_2 Emissions	Baseline Emissions	Project Emissions
CO_2 from off-site transport (transport of additive materials and alternative fuels).	Excluded; the use of additive materials and alternative fuels is not "business-as-usual."	Included.
CO_2 from external power purchase. CO_2 from power consumption in the production process.	Included.	Included.

Component 2: Alternative Fuels - CO_2 emissions of baseline and CDM (all alternative fuels are considered CO_2 neutral)

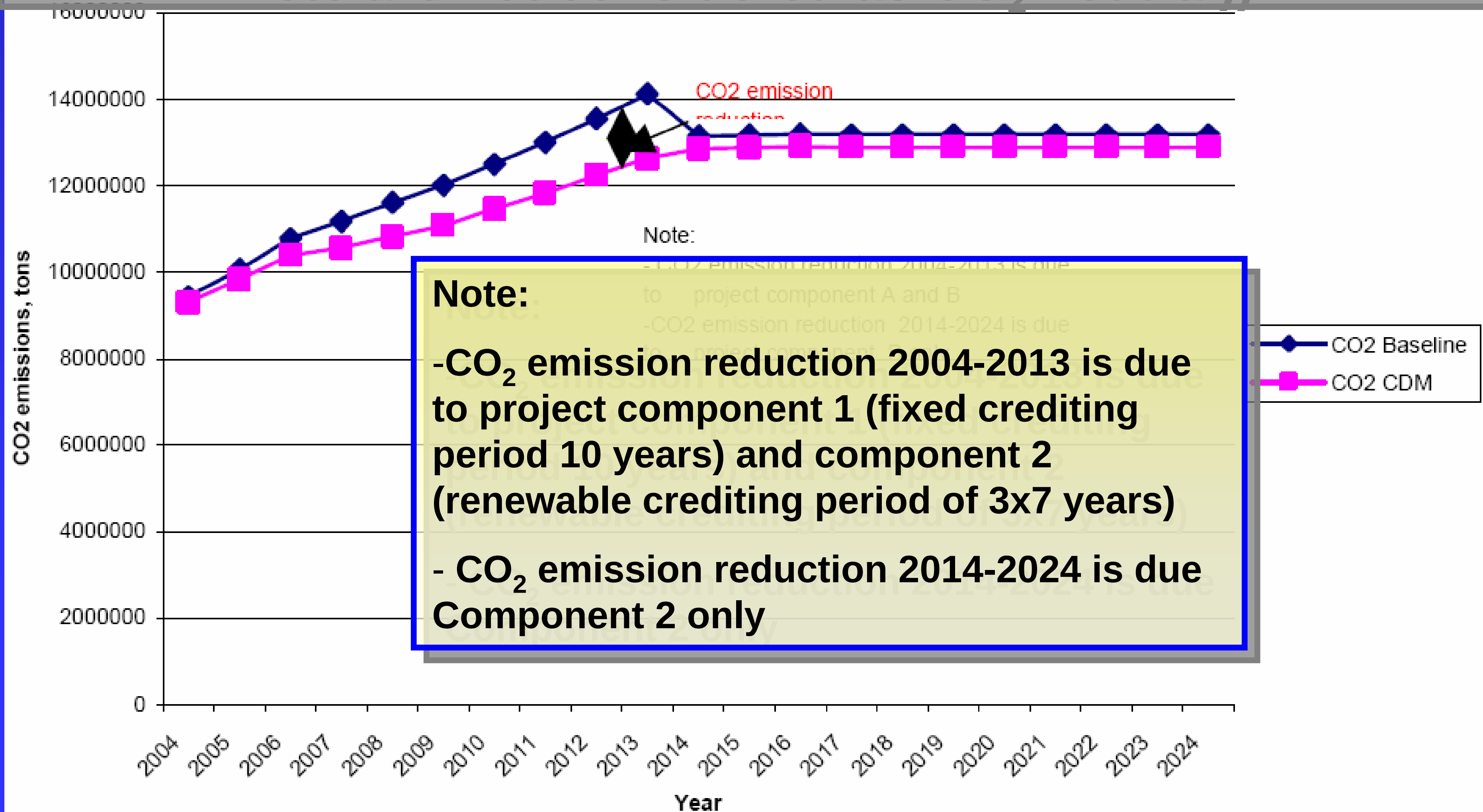


Note:

-CO_2 emission reduction 2004-2013 is due to project component 1 (fixed crediting period 10 years) and component 2 (renewable crediting period of 3x7 years)

- CO_2 emission reduction 2014-2024 is due Component 2 only

Component 2: Alternative Fuels - CO_2 emissions of baseline and CDM (Biomass fuels are CO4 neutral; the wastes partially made of biomass, such as tyres, plastics, etc are not considered as CO_2 neutral))



Note:

-CO_2 emission reduction 2004-2013 is due to project component 1 (fixed crediting period 10 years) and component 2 (renewable crediting period of 3x7 years)

- CO_2 emission reduction 2014-2024 is due Component 2 only

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.

Baseline Scenario Selection

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.

Baseline Scenario Selection

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.**
- **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.**

Emission Reductions

Total emission reductions are given by the following formula:

$$AF_{ER} = FF_{GHG} - AF_{GHG} - OT_{GHG} - LK_{trans} + OT\_GHG_{FF} + BB_{CH4} + LW_{CH4} - GHG_{PAFO} \quad \textbf{(16)}$$

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 that is used as alternative fuel (tCO_{2e}/yr)
LW_{CH4}	=	baseline GHG emissions due to anaerobic decomposition of biomass wastes in 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)

Leakage

- Leakage emissions considered are methane emissions due to biomass that would be burned or decomposed anaerobically in landfills in the absence of the project, as well as CO2 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.

Baseline and project emissions calculations
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.

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

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).

Baseline and project emissions calculations
Step 2: Calculate alternative heat input as a share of total baseline fossil fuel heat input

$$S_{AF} = \frac{HI_{AF}}{\left(\sum Q_{FF} \times HV_{FF}\right) + HI_{AF}} \qquad (2)$$

where:

S_{AF} = alternative heat input share of total baseline fossil fuel heat input

HI_{AF} = heat input from alternative fuels (TJ/yr)

Q_{FF} = quantity of each fossil fuel used in baseline (tonnes/yr)

HV_{FF} = lower heating value of the fossil fuel(s) used in baseline (TJ/tonne fuel).

Baseline and project emissions calculations
Step 3: Application of 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 (mp) should be determined by a comparison heat and mass balance for the cement manufacturing equipment when producing equal quantity and quality of cement clinker with and without alternative fuels. This penalty can be determined at an average % alternative fuel replacement and expressed as a relationship between the amounts of alternative fuel fired as % of total fuel input vs. amount of cement clinker produced. For example, for cement process requiring 3.3 MJ/kg cement clinker during baseline conditions and 3.4 MJ/kg cement clinker when using 10% of alternative fuel, the penalty is 0.1 MJ/kg clinker per 10% alternative fuel used. The product of this and the mass of clinker produced results in an absolute heat penalty per 10% alternative fuel for this specific alternative fuel in this specific process.

Baseline and project emissions calculations
Step 3: Application of project specific moisture "penalty"

$$mp = \frac{HC_{AF}(i) - HC_{FF}}{S_i} \times 10 \quad (3)$$

where:

mp = moisture penalty (MJ/tonne/10% alternative fuel share of total heat input)
HC_{AF}(i) = specific heat consumption using i % alternative fuel (MJ/tonne clinker)
HC_{FF} = specific heat consumption using fossil fuels only (MJ/tonne clinker)
S_i = alternative fuel heat input share of total baseline heat input in the moisture penalty test

The total moisture penalty is therefore calculated as follows:

$$MP_{Total} = \frac{S_{AF}}{10\%} \times C \times mp \quad (4)$$

where:
MP_{total} = total moisture penalty (TJ/yr)
S_{AF} = alternative fuel heat input share of total baseline heat input
C = total clinker production (tonnes/yr)
mp = moisture penalty (MJ/tonne-10% alternative fuel share of total heat input)

Baseline and project emissions calculations
Step 4: Calculate GHG emissions from the use of alternative fuels in kilns

$$AF_{GHG} = \Sigma(Q_{AF} * HV_{AF} * EF_{AF}) \qquad \textbf{(5)}$$

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).

Baseline and project emissions calculations
Step 4: Calculate GHG emissions from the use of alternative fuels in kilns

- **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 fuels, unless it is clearly demonstrated and documented that biomass consumed by the project will decompose anaerobically, it should be assumed that the biomass would be burned. CO_2 emissions from biomass burning should be considered CO_2-neutral, i.e. these emissions are part of the natural carbon cycle because the carbon released to the atmosphere during burning is reabsorbed during the next growing season. To be conservative, N_2O and CH_4 emissions from stockpiled biomass should be ignored.**
- **For non-biogenic carbon (e.g. tires, plastics, textiles, and rubber/leather), unless it can be clearly demonstrated that incineration of these alternative fuels 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 heating or electricity generation purposes. In this latter case, CO_2 emissions from these fuels are to be included in project emissions.**

Baseline and project emissions calculations
Step 5: Calculate the baseline GHG emissions from the fossil fuel(s) displaced by the alternative fuel(s)

$$FF_{GHG} = [(Q_{AF} * HV_{AF}) - MP_{total}] * EF_{FF} \quad (6)$$

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.

Baseline and project emissions calculations
Step 6: Calculate GHG emissions due to on-site transportation and drying of alternative fuels

$$OT_{GHG} = OF_{AF} * (VEF\_CO_2 + VEF\_CH_4 * GWP\_CH_4/1000 + VEF\_N_2O * GWP\_N_2O/1000) + (FD * FD\_HV * VEF_D) \quad (7)$$

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)

Baseline and project emissions calculations
Step 7: Calculate emission savings from reduction of on-site transport of fossil fuels

$$OT\_GHG_{FF} = OF_{FF} * EF_{T\ CO2e} \qquad (8)$$

where:

OT_GHG_{FF} = emissions from reduction of on-site transport of fossil fuels (tCO_2e)
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
Step 1: Calculate CH_4 emissions due to biomass that would be burned in the absence of the project

(9)

where:

BB_{CH4} = GHG emissions due to burning of biomass that is used as alternative fuel (tCO_2e/yr)

Q_{AF-B} = amount of biomass 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 fuel (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)

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).

Leakage
Step 2: Calculate the CH_4 emissions due to anaerobic decomposition of wastes in landfills

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

$$Q_{AF\text{-}L} * DOC * DOC_F * MCF * F * C * (1\text{-}OX) * NFL * GWP\_CH_4 \quad \textbf{(10)}$$

where:

LW_{CH4} = baseline GHG emissions due to anaerobic decomposition of biomass wastes in landfills (tCO_2e/yr)

$Q_{AF\text{-}L}$ = amount of wastes (e.g. biomass) used as alternative fuel that would be landfilled in the absence of the project (t/yr)

DOC = degradable organic carbon content of the waste (%)

DOC_F = portion of DOC that is converted to landfill gas (0.77 default value)

MCF = methane conversion factor for landfill (%)

F = fraction of CH4 in landfill gas (0.5 default value)

C = carbon to methane conversion factor (16/12)

OX = oxidation factor (fraction – default is 0)

NFL = non-flared portion of the landfill gas produced (%)

GWP_CH_4 = global warming potential of methane (21).

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

The emissions from transportation should be calculated as follows:

LK_{trans}	$= LK_{AF} - LK_{FF}$	**(11)**
LK_{AF}	$= (Q_{AF}/CT_{AF}) * D_{AF} * EF_{CO2e}/1000$	**(12)**
LK_{FF}	$= (RQ_{FF}/CT_{FF}) * D_{FF} * EF_{CO2e}/1000$	**(13)**

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:

$$EF_{CO2e} = EF_{T\,CO2} + (EF_{T\,CH4} * 21)+(EF_{T\,N2O} * 310) \quad \textbf{(14)}$$

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

Leakage
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:

$$GHG_{PAFO} = FD_{AFO} * HV_{FDAFO} * EF_{FDAFO} + PD_{AFO} * EF_{pO} \quad \textbf{(15)}$$

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).