Calculating CO2 process emissions from Cement Production (Cement-based Methodology)

Guide to calculation worksheet (October 2001)

I. Overview

I.A. Purpose and Domain of this Section

This estimation tool is written for plant managers and site personnel to facilitate the measurement and reporting of greenhouse gas direct carbon dioxide (CO_2) emissions resulting from Portland cement production at their facility. The tool focuses on the estimation of absolute emissions from a corporate entity perspective as outlined in *The Greenhouse Gas Protocol: a corporate accounting and reporting standard.*

Recognizing the technological advances occurring in the industry and data availability constraints, the GHG Protocol Initiative offers two methodologies for greenhouse gas emission estimation. The two approaches to estimating greenhouse gas emissions from cement production are:

1. **Clinker-based GHG emission estimation methodology** based on IPCC Good Practice Guidelines (2000) presented in the *WBCSD "Cement CO2 Protocol"* (downloadable under http://www.ghgprotocol.org)
2. **Cement-based GHG emission estimation methodology** derived from the U.S. EPA's *ClimateWise* program (ICF, 1999) described in this document.

Because the primary source of greenhouse gases from cement production is clinker; *both approaches theoretically yield the same amount of CO_2 emissions*, assuming that accurate and precise data is available.

The clinker-based approach is straightforward and easy to understand, and required data is readily available at the facility level for many companies. The cement-based approach, in contrast, was designed to monitor changes in emissions from altering the production process, such as producing blended cements. This approach should only be used if the facility is confident in its data regarding the clinker content of the cement and its use of other raw materials. As the clinker-based approach is thoroughly explained in the *WBCSD "Cement CO2 Protocol"* this document is deals only with the cement-based approach.

This tool provides guidance on estimating *process related* greenhouse gas emissions from cement manufacturing. Other potential sources of greenhouse gas emissions include stationary combustion sources (energy produced on or off-site), mobile (from vehicles used for transportation purposes) and waste disposed of in landfills. Estimation tools addressing these sources of greenhouse gas emissions may be downloaded from the GHG Protocol website (www.ghgprotocol.org).

I.B. Potential Sources of Greenhouse Gas Emissions from the Cement Industry

In addition to direct process emissions, the other possible direct and indirect emissions that may be associated with your facilities are indicated below.

Direct Emissions (scope 1)

- On-site energy production (use Stationary Combustion protocol);
- Mobile combustion sources owned or controlled by the reporting company (use mobile combustion guidelines);
- Waste disposal in landfills owned or controlled by the company (use waste guidelines).

Indirect Emissions (scope 2 and/or scope 3)

- Electricity purchases (report in Scope 2 inventory - use Stationary Combustion protocol);

- Waste disposal in landfills not owned or controlled by the company (report in scope 3 inventory -use waste guidance[1]);
- Mobile combustion sources not owned or controlled by the company (report in scope 3 inventory – use mobile combustion guidelines);
- Production of imported clinkers (report in scope 3 inventory as 'production of imported materials' or 'outsourced' activity)
- Lime production (report in scope 3 as 'outsourced' activity; use Lime protocol available on the GHG Protocol website).

The choice of inventory scope (and therefore which of these other sources of greenhouses to include) will need to be decided by the reporting entity. It is vital to clearly define your boundaries and prepare records for such justification in case future inventory audits or verifications are possible. It is also important to remember that maintaining separate account records of indirect emissions reported under scope 2 and 3 may be extremely useful in showing auditors the areas where emission reductions have occurred over time. Please consult the Stationary Combustion tool to account for emissions from fuel combustion associated with cement production at your facility. Emissions attributed to combustion that occurs on-site are considered part of a Scope 1 inventory. A Scope 2 inventory will also need to consider emissions from off-site electricity generation. These emissions are also addressed in the Stationary Combustion protocol. Outsourced activities that might be considered core business activities are accounted for in a Scope 3 inventory. In the cement sector, these outsourced activities might include the production of lime used to make clinker. These emissions can be accounted for using the Lime Manufacturing protocol. Please consult Chapter 4 (setting operational boundaries) of *The Greenhouse Gas Protocol: a corporate accounting and reporting standard* for further discussion of this issue.

Accounting for GHG reductions that are outside your scope 1,2, or 3 inventory: For example, substituting fossil fuel by waste derived fuel that might otherwise be land-filled or incinerated without energy recovery. In this case the substitution may have no direct effect on (or even increase) the company's own GHG inventory, but result in savings elsewhere. These reductions should not be included in your inventory report, but may be reported separately as a supplementary information in GHG Protocol' report. The rationale for their exclusion is three-fold. First, there may be significant differences in the quality and integrity of these GHG estimates compared with emissions from a company's direct operations. Second, the corporate inventory module is not a life cycle accounting standard -- a separate module is being developed by the collaboration for this purpose. Finally, the inclusion of such reduction sources would significantly increase the complexity of the inventory accounting system, as issues like additionality, ownership, and accounting for the converse (emissions increases) are addressed.

I.C. Process Description and Assumptions

Carbon dioxide (CO_2) is emitted from both the chemical process and energy consumption associated with the manufacturing of cement. During calcination or calcining, calcium carbonate ($CaCO_3$) is heated in a cement kiln to form lime, a process that emits CO_2 as a byproduct. The resulting lime reacts in the kiln with silica, aluminum, and iron oxides present in the raw material to produce clinker. Clinker, an intermediate product, is mixed with a small amount of gypsum and/or anhydrite to make Portland cement. Some varieties of masonry cement require additional lime, and thus may additional CO_2 emissions.

CO_2 might also be emitted from cement kiln dust (CKD) that is not recycled to the production process. CKD refers to the portion of the cement raw materials that does not become part of the clinker, and, thus, is lost to the system. CKD that is not recycled is often used for other purposes (e.g. masonry cement, road bases, soil liming agent) or is disposed of in landfills. CKD is

[1] Waste guidance is under development

produced in all cement kilns, to one degree or another. The amount of CKD recycled to the cement process varies according to plant-specific operating conditions such as production technologies, raw materials, and fuel consumption.

II. CO_2 Direct Process Emissions from Cement Production (cement-based methodology)

Direct emissions are emissions from sources that are owned or controlled[2] by the reporting facility. In most cases, emissions directly associated with the production of Portland cement will be direct emissions. This document deals only with *process emissions* from the cement Production. Please refer to the GHG Protocol website (www.ghgprotocol.org) for the calculation of emissions from other sources.

II.A. Required Data and Calculation

As mentioned before, this document is a guide for the Cement-based calculation tool. (For documentation on the clinker-based methodology, please refer to the guide of the WBCSD WGC Cement Protocol).

This cement-based approach requires data on three variables:

1. cement production
2. clinker content of the cement
3. raw material content of the clinker

The cement-based methodology was originally designed to monitor emissions from changes in the production process, such as adding pozzolans and other admixtures to Portland cement to reduce clinker content in the final product. This approach should only be used if reliable raw material and clinker to cement ratio data are available and reliable. The cement-based methodology has been adopted from U.S. EPA's ClimateWise program (ICF, 1999).

CO_2 Emissions = Cement Production x Clinker to Cement Ratio x Raw Material Ratio x $CaCO_3$ Equivalent x CO_2 to $CaCO_3$ Stoichiometric Ratio

Where:

Cement Production: total amount of cement produced (tonnes)
Clinker to Cement Ratio: clinker content of the cement (%)
Raw Material Ratio: tonne of raw material used in a tonne of clinker (tonnes of raw material/tonne of clinker)
$CaCO_3$ Equivalent: lime content of the raw materials (%)
$CO_2/CaCO_3$ Stoichiometric Ratio: 0.44 = atomic weight of CO_2 (44 g) / atomic weight of $CaCO_3$ (100 g)

II.B. Limitations and Uncertainties

The credibility of the inventory always depends on the accuracy of the data. If there are major uncertainties with the data, such as in the clinker to cement ratio, then these should be documented. The methodology used here assumes that the CKD is fully calcined, and thus slightly overestimates its contribution to CO_2 emissions. In most cases, CKD is only partially calcined. If such is the case an adjustment factor might be considered, but typically is not necessary if this were to enter more uncertainty into the calculations.

As stated in the introduction, this protocol is designed to address *absolute emissions of CO_2* from cement manufacturing from a corporate entity perspective. This document does not consider performance ratios associated with variations in the production process such as blended

[2] See chapter 3 (setting organizational boundaries) in GHG Protocol – a corporate accounting and reporting standard, October' 2001

cements, substitution of limestone by other Ca containing raw materials, or substitution of clinker by mineral products. The omission of performance ratios by no means implies that these are not useful to companies as benchmarks of changes in emission intensities over time, but rather reflects the decision by the Initiative to focus initially on total emission estimation.

II.C. Using the Forms and Worksheet for the cement-based tool

1. Enter the amount of cement produced (tonnes) during the reporting period in Column A.

2. Enter the clinker content of the cement (%) in Column B. A default values are provided in Table 1 from ICF (1999).

3. Enter the raw material ratio (tonne of raw material per tonne of clinker) in Column C. A default value is provided in Table 1 from ICF (1999).

4. Enter the CaCO3 equivalent of the raw material (%) in Column D. A default value of is provided in Table 1 from ICF (1999).

5. Annual CO_2 emissions from clinker production should be automatically calculated in Column F. If Column F does not display properly, press “F9” to calculate.

6. Adjusted annual CO_2 emissions from cement production should be automatically calculated in Column G. If Column G does not display properly, press “F9” to calculate.

III. CO_2 Emissions from Fuel Combustion Associated with Cement Production

Cement production consumes various types of fuels to heat the kiln for the calcination process. Greenhouse gas emissions associated with this fuel combustion are not directly accounted for in the cement production methodology. Please consult the Stationary Combustion guidelines to estimate these greenhouse gas emissions.

References

ICF (1999), Climate Wise – Cement Industry Reporting Plan and Workbook. Version 1.2, April 1999. Prepared by ICF Consulting for U.S. EPA.

IPCC (1997), Revised 1996 IPCC Guidelines for National Greenhouse Gas Inventories, Greenhouse Gas Inventory Reference Manual.

IPCC (2000), Good Practice Guidance and Uncertainty Management in National Greenhouse Gas Inventories. Available on-line at: http://www.ipcc-nggip.iges.or.jp/gp/report.htm

US EPA (1999). Inventory of U.S. Greenhouse Gas Emissions and Sinks: 1990 – 1997. EPA 236-R-99-003.