Calculating CO_2 Emissions from the Production of Lime (Version 2.0)

Guide to calculation worksheets (December 2007)

Table of Contents

I. Overview

I.A. Purpose and Domain of this Section

This guideline is written for plant managers and site personnel to facilitate the measurement and reporting of greenhouse gas direct emissions resulting from lime manufacturing. This sector guideline should be applied by the industries whose operations involve lime production.

I.B. Process Description

Lime is used in a variety of industrial, chemical, and environmental applications. Major consumption stems from steel making, flue gas desulfurization at coal-fired electric power plants, construction, pulp and paper manufacturing, and water purification. Lime is produced in a two or three step process: stone preparation, calcination, and hydration. Calcination is the process by which limestone, which is mostly calcium carbonate ($CaCO_3$) is heated in a kiln to produce quick lime (CaO). Carbon dioxide is a byproduct of this reaction and is usually emitted to the atmosphere. However, some facilities recover a portion of the emissions- e.g. for use in sugar refining and precipitated calcium carbonate production.

High-calcium limes are derived from limestone that contain 0 to 5 percent by weight of magnesium oxide, and thus have a proportionally high calcium content. In contrast, dolomitic limes are usually 35 to 45 percent magnesium oxide. Hydraulic limes undergo partial hardening by reaction with water so, unlike non-hydraulic limes, they are capable of setting underwater.

I.C. Applicability of the tool

Greenhouse gases are also emitted from the fuel combustion process used to heat the kiln for the calcination process. These emissions are not accounted for the guidelines described below. Please see the Stationary Combustion guidelines for more details and for the methodology used to estimate these emissions.

II. Overview of methods

This tool offers two approaches for calculating the CO_2 emissions from lime production and both are implemented in the associated Excel workbook:

II.A. Approach 1. Approach 1 estimates emissions using production data. Emission estimates are disaggregated on the basis of the types of lime produced. The emissions calculation considers the CaO or CaO·MgO content and the stoichiometric ratio of each lime type. The stoichiometric ratio is a measure of the amount of CO_2 that is released from the calcination of one tonne of a specific type of lime. Finally, the emission estimates are corrected for the production of any hydrated lime and any uncalcined Lime Kiln Dust (LKD) that is not recycled to the kiln.

Approach 1 is based on the following equation:

$$E_{CO2} = [Q_i \bullet (SR_i \bullet CaO_i)] \bullet [1 - (H_i \bullet H2O_i)] \bullet CF$$

Where:
E_{CO2} = Emissions of CO_2 in metric tonnes
Q_i = Quantity of lime type *i* produced (metric tonnes)
SR_i = Stoichiometric ratio of lime type *i* (fraction)
CaO_i = CaO or CaO·MgO content of lime type *i* (fraction)
H_i = Proportion of hydrated lime in lime type *i* (fraction)
H_2O_i = Water content of the hydrated lime in lime type *i*
CF = Lime Kiln Dust (LKD) correction factor

If plant-specific values for *Hi*, H_2Oi and CaO_i are not available, then companies may use the default values provided in the tool.

II.B Approach 2. Approach 2 estimates emissions using data on the carbonate composition of the raw material feed that enters the lime kiln. Emissions are disaggregated on the basis of the types of carbonates used and are corrected for LKD and the fraction of each carbonate species that remains uncalcined following lime production. Approach 2 requires more specific data than Approach 1 and may lead to more accurate estimates of CO_2 emissions when facility-specific data are used throughout the calculation process.

Approach 2 is based on the following equation:

$$E_{CO2} = \sum_i (EF_i \bullet M_i \bullet F_i) - M_d \bullet C_d \bullet (1 - F_d) \bullet EF_d$$

Where:
E_{CO2} = emissions of CO_2 from lime production (tonnes)
EF_i = emission factor for carbonate *i* (tonnes CO_2/tonne carbonate).
M_i = weight or mass of carbonate *i* consumed (tonnes)
F_i = fraction calcination achieved for carbonate *i* (fraction).
M_d = weight or mass of LKD (tonnes)
C_d = weight fraction of original carbonate in the LKD (fraction).
F_d = fraction calcination achieved for LKD (fraction).
EF_d = emission factor for the uncalcined carbonate in LKD (tonnes CO_2/tonne carbonate).

If plant-specific values are not available for EF_i, F_i, *Cd, Fd* or EF_d, then companies may use the default values provided in the tool.

III. CO_2 Emissions from Fuel Combustion Associated with Lime Manufacture

Lime 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 lime production methodology. Please use the Stationary Combustion guideline to estimate these greenhouse gas emissions.

IV. References

IPCC (2006), 2006 IPCC Guidelines for National Greenhouse Gas Inventories (Volume 3, Chapter 2). To download this documentation as a PDF file please go to http://www.ipcc-nggip.iges.or.jp/public/2006gl/pdf/3_Volume3/V3_2_Ch2_Mineral_Industry.pdf.