Technical Support Document for the Lime Manufacturing Sector: Proposed Rule for Mandatory Reporting of Greenhouse Gases

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1. Industry Description

As described in the *Inventory of U.S. Greenhouse Gas Emissions and Sinks: 1990-2006* (EPA 2008b), lime is an important manufactured product with many industrial, chemical, and environmental applications. Its major uses are in steel making, flue gas desulfurization (FGD) systems at coal-fired electric power plants, construction, and water purification. In 2006, lime was used for the following purposes: metallurgical uses (36%), environmental uses (29%), chemical and industrial uses (21%), construction uses (13%), and to make dolomite refractories (1%) (USGS 2007). For U.S. operations, the term “lime” actually refers to a variety of chemical compounds. These compounds include calcium oxide (CaO), or high-calcium quicklime; calcium hydroxide ($Ca(OH)_2$), or hydrated lime; dolomitic quicklime ([CaO•MgO]); and dolomitic hydrate ([$Ca(OH)_2$•MgO] or [$Ca(OH)_2$•$Mg(OH)_2$]).

2. Total Emissions

Emissions from the lime industry were estimated to be 25.4 million metric tons of CO_2 equivalent ($MMTCO_2e$) in 2004 (EPA 2006). These emissions include both process-related emissions and on-site stationary combustion emissions from 89 lime manufacturing facilities across the United States, including Puerto Rico. Process-related emissions account for 14.3 $MMTCO_2e$ [1], or 56 percent of the total, while on-site stationary combustion emissions account for the remaining 11.1 $MMTCO_2e$ (EPA 2006). The 89 facilities studied covers over 65% of the National Lime Association facilities (44 out of 67 facility members) as well as several other facilities which are not participating members of the NLA. The list of U.S. lime manufacturing is presented in Table 1 as provided by EPA (2006).

2.1 Process Emissions

Lime production involves three main processes: stone preparation, calcination, and hydration. During the calcination process, lime is sufficiently heated to generate process-related CO_2 as a by-product. For example, the calcination of pure limestone is as follows:

$$CaCO_3 + \text{heat} \rightarrow CaO + CO_2$$

In certain applications, lime reabsorbs CO_2 during use. For example, sugar refineries use lime to remove impurities from the raw cane juice, and then remove excess lime through carbonation (IPCC 2006).

2.2 Stationary Combustion

Stationary combustion emissions occur when fossil fuels are combusted to provide energy for manufacturing equipment, as well as to provide heat for the manufacturing process. This heat is used in the previously discussed calcination process to produce pure lime (CaO). Coal, natural gas, distillate fuel oil, and residual fuel oil are all possible fuel inputs, though the actual mix of fuels will be site-specific.

[1] The *U.S. Inventory* (EPA 2008b) reports 15.8 Tg CO_2 Eq. of process emissions from lime manufacturing in 2006.

Table 1. U.S. Lime Manufacturing Facilities (2004)

Company	Plant Location	Company	Plant Location
Carmeuse Lime	Saginaw, AL	Martin Marietta Magnesia Specialties LLC-C&S	Woodville, OH
Chemical Lime Co.	Alabaster, AL	National Lime & Stone Co.[6]	Carey, OH
Chemical Lime Co.	Montevallo, AL	U.S. Lime Co. - St. Clair[7]	Marble City, OK
Chemical Lime Co.	Calera, AL	Amalgamated Sugar Co.-C	Nyssa, OR
Cheney Lime & Cement Co.	Siluria, AL	Ash Grove Cement Co.	Portland, OR
Southern Lime Co.	Calera, AL	Carmeuse Lime	Annville, PA
Chemical Lime Co.	Douglas, AZ	Graymont (PA) Inc.	Pleasant Gap, PA
Chemical Lime Co.	Nelson, AZ	Graymont (PA) Inc.	Bellefonte, PA
U.S. Lime and Minerals, Inc. Arkansas Lime Co.	Batesville, AR	LWB Refractories Co.-C&S	York, PA
Chemical Lime Co.	Salinas, CA	Mercer Lime and Stone Co.	Branchton, PA
Spreckels Sugar Co.-C	Mendota, CA	Florida Lime Corp.	Ponce, PR
Spreckels Sugar Co.-C	Brawley, CA	Pete Lien & Sons Inc.	Rapid City, SD
Western Sugar Co.-C	Fort Morgan, CO	Bowater Southern Paper Corp.-C	Calhoun, TN
Western Sugar Co.-C	Greeley, CO	O-N Minerals Tenn Luttrell Operation	Luttrell, TN
Amalgamated Sugar Co. LLC-C	Nampa, ID	Austin White Lime Co.	McNeil, TX
Amalgamated Sugar Co. LLC-C	Paul, ID	Chemical Lime Co.	Clifton, TX
Amalgamated Sugar Co. LLC-C	Twin Falls, ID	Chemical Lime Co.	Marble Falls, TX
Carmeuse Lime	South Chicago, IL	Chemical Lime Co.	New Braunfels, TX
Carmeuse Lime	Buffington, IN	U.S. Lime and Minerals Inc. Texas Lime Co.	Cleburne, TX
Ispat Inland, Inc.-C (NOW, Mittal Steel)	Indiana Harbor, IN	Chemical Lime Co.	Grantsville, UT
Linwood Mining & Minerals Corp.	Linwood, IA	Graymont Western U.S. Inc.	Delta, UT
Carmeuse Lime	Carntown, KY	Chemical Lime Co.	Kimbalton, VA
Carmeuse Lime	Maysville, KY	O-N Minerals Chemstone Operation	Strasburg, VA
Old Castle Industrial Minerals, Inc.	Lee, MA	O-N Minerals Chemstone Operation	Clear Brook, VA
Specialty Minerals, Inc. (C&S)	Adams, MA	Graymont Western U.S. Inc. Tacoma Lime Division (C&S)	Tacoma, WA
Carmeuse Lime	River Rouge, MI	Greer Lime Co.	Riverton, WV
Michigan Sugar Co.-C	Sebewaing, MI	Cutler-Magner Corp.	Superior, WI
Michigan Sugar Co.-C	Carollton, MI	Rockwell Lime Co.	Manitowoc, WI
Michigan Sugar Co.-C	Croswell, MI	Western Lime Corp.	Green Bay, WI
Michigan Sugar Co.-C	Carrolton, MI	Western Lime Corp.	Eden, WI
Monitor Sugar Co.-C	Bay City, MI	Western Sugar Co.-C	Torrington, WY
American Crystal Sugar Co.-C	Moorhead, MN	Western Sugar Co.-C	Lovell, WY
American Crystal Sugar Co.-C	Crookston, MN	Wyoming Lime Producers	Frannie, WY

Company	Plant Location	Company	Plant Location
American Crystal Sugar Co.-C	East Grand Forks, MN	Wyoming Sugar Co. LLC-C	Worland, WY
Southern Minnesota Sugar Corp.-C	Renville, MN	Carmeuse Lime	Hanover, PA
Chemical Lime Co.	Ste. Genevieve, MO	Riverton Corp.-C	VA
Mississippi Lime Co.-S&C	Ste. Genevieve, MO	Western Lime Corp.	Green Bay, WI
Mississippi Lime Co.-S&C	Springfield, MO	Western Lime Corp.	Eden, WI
Vessell Mineral Products Co.	Bonne Terre, MO	Western Sugar Co.-C	Torrington, WY
Graymont Western U.S. Inc.	Townsend, MT	Western Sugar Co.-C	Lovell, WY
Sidney Sugars Inc.-C	Sidney, MT	Wyoming Lime Producers	Frannie, WY
Western Sugar Co.-C	Billings, MT	Wyoming Sugar Co. LLC-C	Worland, WY
Western Sugar Co.-C	Scottsbluff, NE	Carmeuse Lime	Hanover, PA
Chemical Lime Co.	North Las Vegas, NV	Riverton Corp.-C	VA
American Crystal Sugar Co.-C	Drayton, ND	Wyoming Lime Producers	Frannie, WY
American Crystal Sugar Co.-C	Hillsboro, ND	Wyoming Sugar Co. LLC-C	Worland, WY
Minn-Dak Farmers Coop.-C	Wahpeton, ND	Carmeuse Lime	Hanover, PA
Carmeuse Lime	Millersville, OH	Riverton Corp.-C	VA
Carmeuse Lime	Maple Grove, OH	Carmeuse Lime	Hanover, PA
Carmeuse Lime	Grand River, OH	Riverton Corp.-C	VA
Graymont Dolime (OH) Inc.	Genoa, OH		
Huron Lime Co.	Huron, OH		

Source: EPA DRAFT Lime Plant Database (2006)

3. Review of Existing Programs and Methodologies

Protocols and guidance reviewed for this analysis include the *2006 IPCC Guidelines*, *U.S. Inventory*, the World Resource Institute and World Business Council for Sustainable Development's Greenhouse Gas Protocol, the EU ETS (both the first and second reporting periods), the Technical Guidelines for the Voluntary Reporting of Greenhouse Gases (1605(b)) Program, the National Lime Association, and The Climate Registry. These methodologies coalesce around two different approaches, based on measuring either the input or output of the production process. In general, the output method is less certain, as it involves multiplying production data by default emission factors and correction factors for lime kiln dust and hydrated lime based on purity (i.e. percentage of input that is a carbonate) assumptions. In contrast, the input method is more certain as it generally involves measuring the consumption and the carbonate content of each process input and calculating the carbonate weight ratio of inputs. The existing programs and methodologies are discussed in more detail below.

3.1 2006 IPCC Guidelines

The IPCC considers three tiers of emission estimation methodologies that use either an output-based approach (Tier 1 and 2) or an input-based approach (Tier 3). The Tier 1 method applies a default emission factor to lime production. For Tier 1, the only site-specific input that is needed for the emission estimate is the mass of lime produced in the year of interest.

The Tier 2 method expands upon the Tier 1 method by including production by lime type and a correction factor for lime byproducts/wastes (such as lime kiln dust, LKD) production and hydrated lime consumption. These correction factors are implemented to account for CO_2 emitted from byproducts/wastes (which contains uncalcined carbonates) and hydrated lime (which uses alternative emission factors); neither of these factors are used in the Tier 1 methodology. For Tier 2, information on the mass of lime production (by type, including byproducts/waste products, such as lime kiln dust) is the only site-specific data necessary.

IPCC also considers a Tier 3 method, which is based upon facility-specific data. This approach requires facilities to calculate their calcination fractions and determine the weight fraction of their carbonate inputs. The fractions are applied to their carbonate consumption and byproducts/wastes production using stoichiometric emission factors. The Tier 3 method requires site-specific information on the mass and fraction of calcination achieved for both carbonate process inputs and byproducts/wastes production.

3.2 2008 NLA Protocol

The National Lime Association (NLA) has developed a protocol for calculating CO_2 emissions called, "CO_2 Emissions Calculation Protocol for the Lime Industry English Units Version", February 5, 2008 Revision. The NLA protocol improves the IPCC Tier 2 method. NLA emission calculations are based on metric tons of each type of lime and calcined byproducts/wastes (such as LKD) produced. Emissions are calculated by multiplying amounts of quicklime and calcined byproducts/wastes by an emission factor. Facilities multiply the amount of lime produced and the amount of calcined byproducts/wastes by an emission factor. The protocol requires measurements of the quantity of each type of lime produced and each type of calcined byproduct/waste product produced, as well as chemical analysis of the composition of each lime and calcined byproduct/waste type. To assess the composition of the lime and calcined byproduct/waste product, facilities would send samples to an off-site laboratory for analysis by ASTM C25-06, "Standard Test Methods for Chemical Analysis of Limestone, Quicklime, and Hydrated Lime" coupled with the procedures in the written protocol. The NLA protocol is a common business practice within the industry and NLA has prepared a document containing a spreadsheet with built in calculations and instructions for using the protocol.

3.3 2008 U.S. Inventory of Greenhouse Gas Emissions and Sinks

The U.S. inventory follows the IPCC Tier 2 approach, including any default value recommendations.

3.4 WRI/WBCSD Protocol

The World Resource Institute and World Business Council for Sustainable Development's Greenhouse Gas Protocol provides two approaches to calculating emissions from lime production which are similar to IPCC's Tier 2 and Tier 3 methods. Approach 1 estimates emissions based on lime production data and is calculated with the same values as IPCC's Tier 2. This method encourages more plant-specific data than IPCC's method, although default values are presented in the protocol and are identical to the IPCC default values for Tier 2. Approach 2 estimates emissions based on carbonate consumption. This method requires the same data and calculations as IPCC's Tier 3 and offers identical default values.

3.5 EU ETS 1st Reporting Period

European Union Emission Trading System (EU ETS) guidelines from the first reporting period offers two calculation approaches for reporting GHG emissions from this sector. Approach A is based on carbonate input and output data. In other words, the amounts of carbonates entering and exiting the process are used to determine the amount of carbonates consumed. This consumption value is then multiplied by the appropriate emissions factor and a conversion factor to account for the amount of carbon not converted to CO_2. Default emission factors are given but can be calculated with plant-specific data as well.

Calculation approach B requires data on the amount of magnesium and calcium oxides in the lime produced. The calculation involves multiplying the amount of magnesium and calcium oxides by an emission factor and a conversion factor. If plant-specific data are not available, default factors may be used for this method.

Both approaches offer two tiers based on the amount of uncertainty allowed in measuring the perspective activity data (i.e. carbonate weights or magnesium and calcium oxide weights). EU ETS considers the two approaches to be equivalent.

3.6 EU ETS 2nd Reporting Period

EU ETS guidelines from the second reporting period are similar to the 1st reporting period. Approach A, based on carbonate input to the kilns, does not require measurement of carbonates leaving the kiln. In addition, this report's guidelines offer a 3-Tier option for approach A. The additional tier allows more uncertainty in the activity data. For Approach B based on magnesium and calcium oxide measurement, the same tiers are allowed.

3.7 The Climate Registry

The Climate Registry (General Reporting Protocol for the Voluntary Reporting Program) outlines four emission calculation approaches: (1) Mass balance based on carbonate inputs, (2) Mass balance based on production, (3) Mass balance based on carbonate inputs with default values, and (4) Mass balance based on production with default values. These methods are essentially IPCC's Tier 2 and 3 methods with options for using plant-specific factors or the use of default values.

3.8 Technical Guidelines Voluntary Reporting of Greenhouse Gases (1605(b)) Program

The Technical Guidelines 1605(b) Program uses NLA's approach to calculating emissions. In addition, they offer the default emission factor values from IPCC's Tier 2 method for use when plant-specific values cannot be determined. Default values are considered to be of a lower rating (higher uncertainty) than using plant-specific values.

4. Options for Reporting Threshold

4.1 Options Considered

4.1.1 Emissions Thresholds

Four emission threshold levels were considered for the lime manufacturing sector based on actual facility emissions. These thresholds, 100,000, 25,000, 10,000, and 1,000 $mtCO_2e$ per year, were analyzed.

4.1.2 Capacity Thresholds

Four capacity threshold levels were considered for the lime manufacturing sector based on facility capacity. These thresholds, 1,000,000, 500,000, 250,000, 80,000, and 40,000 metric tons of lime produced per year, were analyzed.

4.1.3 No Emissions Threshold

The no emissions threshold includes all lime manufacturing facilities included in this Technical Support Document regardless of their emissions or capacity.

4.2 Emissions and Facilities Covered Per Option

4.2.1 Emissions Thresholds

A summary of the emissions and facilities covered per option is presented in Table 2. Emission estimates were provided using EPA's lime plant database (EPA 2006).

Table 2. Emissions-based Threshold Analysis for Lime Manufacturing

Threshold Level (Metric Tons)	Process Emissions* (Metric Tons CO_2e/yr)	Stationary Combustion Emissions (Metric Tons CO_2e/yr)	Total National Emissions (Metric Tons CO_2e)	Number of Facilities	Emissions Covered		Facilities Covered	
					Metric Tons CO_2e/yr	Percent	Number	Percent
100,000	14,338,898	11,082,146	25,421,043	89	23,833,273	93.7%	52	58.4%
25,000	14,338,898	11,082,146	25,421,043	89	25,371,254	99.8%	85	95.5%
10,000	14,338,898	11,082,146	25,421,043	89	25,396,036	99.9%	86	96.6%
1,000	14,338,898	11,082,146	25,421,043	89	25,421,043	100%	89	100%

* Calculated based on reported production or production capacity values from listed facilities.

Under the less restrictive thresholds (i.e. 25,000 $mtCO_2e$ and less), the majority (greater than 95 percent) of relevant facilities would be required to report and the majority (greater then 95 percent) of emissions would be reported. This reporting coverage is in marked contrast to the highest threshold, which would cover 94 percent of emissions but only 58 percent of facilities.

4.2.2 Capacity Threshold

A summary of the capacity-based emissions and facilities covered per option is presented in Table 3. Emission estimates were provided using EPA's lime plant database (EPA 2006). Five reporting threshold levels were considered for the lime production sector. These thresholds were 1,000,000, 500,000, 250,000, 80,000, and 40,000 metric tons of lime produced per year.

Table 3. Capacity-based Threshold Analysis for Lime Manufacturing

Capacity Threshold (metric tons lime produced per year)	Process CO_2 Emissions** ($mtCO_2e/yr$)	Number of Facilities	Process CO_2 Emissions Covered		Facilities Covered	
			$mtCO_2e/yr$	%	Number	%
1,000,000	15,954,608	89	3,163,839	19.83%	3	3.4%
500,000	15,954,608	89	7,031,718	44.07%	10	11.2%
250,000	15,954,608	89	11,599,349	72.70%	28	31.5%
80,000	15,954,608	89	15,830,776	99.22%	86	96.6%
40,000	15,954,608	89	15,954,608	100.00%	89	100.0%

** Calculated based on production capacity values from reporting facilities.

The capacity-based threshold analysis exhibits the range of lime production facility sizes. Again, under the less restrictive thresholds (i.e. 80,000 metric tons and less), the majority (greater than 95 percent) of relevant facilities would be required to report and the majority (greater then 95 percent) of emissions would be reported. At the highest thresholds (i.e. 500,000 metric tons and more), less than 50 percent of emissions are covered and only 11 percent of facilities would be required to report. A threshold of zero (requiring all facilities to report) is thus consistent with these less restrictive thresholds.

5. Options for Monitoring Methods

Five separate monitoring methods were considered for this technical support document: a simplified emission calculation (Option 1), an input-based method (Option 2), a method calculating emissions by lime type (using default factors) (Option 3), a method calculating emissions by lime type (using NLA's facility-level data method) (Option 4), and direct measurement (Option 5). All of these options could be carried out on an annual basis.

5.1 Option 1: Simplified Emissions Calculation

A simplified emissions calculation is based upon the IPCC Tier 1 methodology (IPCC 2006). The Tier 1 method is an output-based approach applying an emission factor to the total quantity of lime produced. This approach uses country specific data on the ratio of lime types produced. However, in the absence of country specific values, a facility may assume a production of 85 percent high calcium lime (quicklime) and 15 percent production of dolomitic lime. The Tier 1 equation is as follows:

$$E_{CO2} = M_L \cdot EF_L$$

Where:

E_{CO2} = process emissions of CO_2 (metric tons)

M_L = mass of lime produced (metric tons)

EF_{lime} = emission factor for lime (metric tons CO_2 / metric tons lime)

This method also relies upon the emission factors to calculate an overall lime production emissions factor. The default emissions factor is calculated below:

$$\begin{aligned} EF_{lime} &= 0.85*EF_{quicklime} + 0.15*EF_{dolomitic\ lime} \\ &= 0.85*0.75+0.15*0.77 \\ &= 0.75 \text{ metric tons } CO_2\text{/metric ton of lime produced} \end{aligned}$$

In this equation, the emission factor for dolomitic lime was assumed to be 0.77. According to IPCC, the default emission factor for dolomitic lime may be 0.86 or 0.77 depending on the technology used for lime production.

5.2 Option 2: Input-based Method

This approach is based upon the IPCC Tier 3 method, which is an input-based approach. This approach requires facilities to calculate their calcination fractions and determine the weight fraction of their carbonate inputs, and then apply this information to their carbonate consumption and lime kiln dust production using stoichiometric emission factors. In other words:

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

Where:

E_{CO2} = process emissions of CO_2 (metric tons)
EF_i = emission factor for carbonate *i* (metric tons CO_2 / metric tons carbonate)
M_i = mass of carbonate *i* consumed (metric tons)
F_i = fraction calcination achieved for carbonate *i*, fraction
M_d = mass of lime byproducts/wastes (metric tons)
C_d = fraction of original carbonate in the byproducts/wastes (fraction)
F_d = fraction calcination achieved for the byproducts/wastes (fraction)
EF_d = emission factor for the uncalcined carbonate in the lime kiln dust (metric tons CO_2 / metric tons carbonate)

The 2006 IPCC Guidelines contain emission factors for common carbonates, which are presented in Table 4. Calcite (limestone) and dolomite are the only two carbonates used to produce lime in the United States. (Miller 2008).

Table 4. CO_2 Emission Factors for Common Carbonates

Mineral Name - Carbonate	CO_2 Emission Factor (metric tons CO_2 / metric tons carbonate)
Calcite/aragonite - $CaCO_3$	0.43971
Dolomite - $CaMg(CO_3)_2$	0.47732

Source: IPCC (2006) 2006 IPCC Guidelines for National Greenhouse Gas Inventories

5.3 Option 3: Emissions Based on Lime Type (default factors)

IPCC's Tier 2 method offers an output based calculation based on production by lime type. Default factors are used for the calcium oxide and magnesium oxide content in calculating the emission factors. The Tier 2 equation is as follows:

$$E_k = \sum_{n=1}^{p} \left((EF_{k,n} * M_{k,n} * CF_{lkd,k,n}) * 0.97 \right) \frac{2000}{2205}$$

Where:

E_k	=	Annual CO_2 emissions from lime production at kiln k (metric tons/year)
$EF_{k,n}$	=	Emission factor for lime in calendar month n (tons CO_2/tons carbonate)
$M_{k,n}$	=	Weight or mass of lime calendar month n (tons/calendar month)
$CF_{lkd,k,n}$	=	Correction factor for lime byproducts/wastes (such as LKD) in calendar month n
0.97	=	Default correction factor for the proportion of hydrated lime (Assuming 90 percent of hydrated lime produced is high-calcium lime with a water content of 28 percent)
2000/2205	=	Conversion factor for tons to metric tons
i	=	Each of the specific lime types
p	=	Months per year.

5.4 Option 4: Emissions Based on Lime Type (NLA Method)

The NLA's proposed method for calculating CO_2 emissions from lime manufacturing is similar to IPCC's Tier 2, but differs in that it uses facility-level data to calculate emission factors as opposed to default emission factors. Calcium oxide and magnesium oxide content of the lime products including byproducts and waste products (such as LKD) are required at the facility-level. The emission factors are calculated as follows:

$$EF_{\mathrm{lim}e,i} = (SR_{CaO} \cdot CaO) + (SR_{MgO} \cdot MgO)$$

Where:

$EF_{lime,i}$	=	Emission factor for lime type i, metric tons CO_2/ metric tons lime
SR_{CaO}	=	Stoichiometric ratio of CO_2 and CaO (See Table 1 of §98.199), metric ton CO_2/ metric ton CaO
SR_{MgO}	=	Stoichiometric ratio of CO_2 and MgO (See Table 1 of §98.199), metric ton CO_2/ metric ton MgO
CaO	=	CaO content (percent total CaO), metric tons CaO/ metric tons lime
MgO	=	MgO content (percent total MgO), metric tons MgO/ metric tons lime.

5.5 Option 5: Direct Measurement using Continuous Emission Monitoring Data (CEMS)

Direct measurement constitutes measurements of the GHG concentration in the stack gas and the flow rate of the stack gas using a CEMS. Under a CEMS approach, the emissions measurement data could be reported annually and would account for both combustion and process-related emissions. Currently, the lime industry does not use CEMS for CO_2 monitoring, although there are few plants which do have CEMS for NOx and CO monitoring.

Elements of a CEMS include a platform and sample probe within the stack to withdraw a sample of the stack gas, an analyzer to measure the concentration of the GHG (e.g., CO_2) in the stack gas, and a flow meter within the stack to measure the flow rate of the stack gas. The emissions are calculated from the concentration of GHGs in the stack gas and the flow rate of the stack gas; both stationary and process emissions are captured and calculated. The CEMS continuously withdraws and analyzes a sample of the stack gas and continuously measures the GHG concentration and flow rate of the stack gas.

6. Options for Estimating Missing Data

Options and considerations for missing data will vary depending on the proposed monitoring method. Each option would require a complete record of all measured parameters as well as parameters determined from company records that are used in the GHG emissions calculations (e.g., carbon contents, fuel consumption, etc.).

6.1 Procedures for Option 1: Simplified Emissions Calculation

For process sources in the lime manufacturing category that use Option 1, facility-specific production data is required. Businesses closely track production so the likelihood for missing data is low; therefore, 100 percent data availability could be required.

6.2 Procedures for Option 2: Input Method

For process sources in the lime manufacturing category that use Option 2, the data requirements include the mass, carbonate content, and fraction of calcination achieved for lime kiln dust and each process input. It is assumed that a facility will be able to supply facility-specific data.

6.3 Procedures for Option 3: Emissions Based on Lime Type (default factors)

For process sources in the lime manufacturing category that use Option 3, only lime production data is required. It is assumed that a facility will be able to supply facility-specific production data. Businesses closely track production so the likelihood for missing data is low; therefore, 100 percent data availability could be required.

6.4 Procedures for Option 4: Emissions Based on Lime Type (NLA method)

For process sources in the lime manufacturing category that use Option 4 the calcium oxide and/or magnesium oxide content are required. If a chemical is lost or missing, the analysis would have to be repeated. It is assumed that a facility will be able to supply facility-specific production data. Businesses closely track production so the likelihood for missing data is low; therefore, 100 percent data availability could be required. The NLA protocol does not provide any recommendations for periods of missing data; however, it does recommend monthly sampling of calcium and magnesium oxide measurements to use in annual calculations.

6.5 Procedures for Option 5: CEMS

For options involving direct measurement of CO_2 emissions using CEMS, Part 75 establishes procedures for the management of missing data. Specifically, the procedures for managing missing CO_2 concentration data are specified in §75.35. In general, missing data from the operation of the CEMS may be replaced with substitute data to determine the CO_2 emissions during the period for which CEMS data are missing. Section 75.35(a) requires the owner or operator of a unit with a CO_2 CEMS to substitute for missing CO_2 pollutant concentration data using the procedures specified in paragraphs (b) and (d) of §75.35; paragraph (b) covers operation of the system during the first 720 quality-assured operation hours for the CEMS, and paragraph (d) covers operation of the system after the first 720 quality-assured operating hours are completed.

During the first 720 quality-assured monitor operating hours following initial certification at a particular unit or stack location, the owner or operator would be required to substitute CO_2 pollutant concentration data according to the procedures in §75.31(b). That is, if prior quality-assured data exist, the owner or operator would be required to substitute for each hour of missing data, the average of the data recorded by a certified monitor for the operating hour immediately preceding and immediately following the hour for which data are missing. If there are no prior quality-assured data, the owner or operator would have to substitute the maximum potential CO_2 concentration for the missing data.

Following the first 720 quality-assured monitor operating hours, the owner or operator would have to follow the same missing data procedures for CO_2 specified in §75.33(b). The specific methods used to estimate missing data would depend on the monitor data availability and the duration of the missing data period.

7. QA/QC Requirements

Facilities should conduct quality assurance and quality control of the production and consumption data, supplier information (e.g., carbon contents), and emission estimates reported. Facilities might be required to prepare an in-depth quality assurance and quality control plan which would include checks on production data, the carbon content information received from the supplier and from the lab analysis, and calculations performed to estimate GHG emissions. Several examples of potential QA/QC procedures that might be required are listed below.

7.1 Stationary Emissions

Facilities should refer to the Stationary Fuel Combustion TSD (EPA-HQ-OAR-2008-0508-004).

7.2 Process Emissions

Options and considerations for QA/QC will vary depending on the proposed monitoring method. Each option would require unique QA/QC measures appropriate to the particular methodology employed to ensure proper emission monitoring and reporting.

For units using CEMS to measure CO_2 emissions, the equipment should be tested for accuracy and calibrated as necessary by a certified third party vendor. These procedures should be consistent in stringency and data reporting and documentation adequacy with the QA/QC procedures for CEMS described in Part 75 of the Acid Rain Program.

7.3 Data Management

Data management procedures could be included in the QA/QC Plan. Elements of the data management procedures plan could include:

- For measurements of carbonate content, assess representativeness of the carbonate content measurement by comparing values received from supplier and/or laboratory analysis with IPCC default values.
- Check for temporal consistency in production data, carbonate content data, and emission estimate.
  - A monitoring error is probable if differences between annual data cannot be explained by:
    - Changes in activity levels,
    - Changes concerning fuels or input material,
    - Changes concerning the emitting process (e.g. energy efficiency improvements) (European Commission 2007).

- Determine the “reasonableness” of the emission estimate by comparing it to previous year’s estimates and relative to national emission estimate for the industry:
  - Comparison of data on fuel or input material consumed by specific sources with fuel or input material purchasing data and data on stock changes,
  - Comparison of fuel or input material consumption data with fuel or input material purchasing data and data on stock changes,
  - Comparison of emission factors that have been calculated or obtained from the fuel or input material supplier, to national or international reference emission factors of comparable fuels or input materials,
  - Comparison of emission factors based on fuel analyses to national or international reference emission factors of comparable fuels, or input materials,
  - Comparison of measured and calculated emissions (European Commission 2007).

- Maintain data documentation, including comprehensive documentation of data received through personal communication:
  - Check that changes in data or methodology are documented.

7.4 Calculation Checks

Checks could be performed for all reported calculations. Elements of calculation checks include:

Perform calculation checks by creating a representative sample of emissions calculations or building in automated checks such as computational checks:

- Check whether emission units, parameters, and conversion factors are appropriately labeled
- Check if units are properly labeled and correctly carried through from beginning to end of calculations
- Check that conversion factors are correct
- Check the data processing steps (e.g., equations) in the spreadsheets
- Check that spreadsheet input data and calculated data are clearly differentiated
- Check a representative sample of calculations, by hand or electronically
- Check some calculations with abbreviated calculations (i.e., back of the envelope checks)
- Check the aggregation of data across source categories, business units, etc.
- When methods or data have changed, check consistency of time series inputs and calculations (EPA 2007).

8. Types of Emission Information to be Reported

8.1 Types of Emissions to be Reported

Based on the review of existing programs and the emission sources at lime manufacturing facilities, GHG reporting is limited to process-related CO_2 produced from the facility. There are potentially other sources of GHG emissions at facilities that manufacture lime. The data to be reported would depend on the threshold implemented. For reporting options for stationary fuel combustion (CO_2, CH_4, and N_2O), refer to EPA-HQ-OAR-2008-0508-004. In some cases, such as with CEMS, a reporting option may estimate process CO_2 emissions and combustion related CO_2 emissions.

8.1.1 Option 1: Simplified Emissions Calculation

For the simplified emissions calculation, the facility would report its lime production in addition to GHG emissions.

8.1.2 Option 2: Input-based Approach

For the input method, in addition to GHG emissions the facility would report its carbonate consumption, lime kiln dust production, and the fraction of calcination achieved for each carbonate input and lime kiln dust in addition to calculated GHG emissions.

8.1.3 Option 3: Emissions Based on Lime Type (default factors)

The default output-based method would require reporting of: annual lime production by lime type, default emission factors, total annual CO_2 process emissions, total lime production for each lime type, total calcined byproducts/wastes produced, correction factor for byproducts/waste products, chemical composition analyses (by lime type) and the number of operating hours in the calendar year, in addition to calculated GHG emissions. This data could be collected on a weekly, monthly, or quarterly basis.

8.1.4 Option 4: Emissions Based on Lime Type (NLA method)

The NLA output-based method requires reporting of: annual lime production by lime type, calculated emission factors, total annual CO_2 process emissions from all kilns from monthly averages, total lime production by lime type per month, total calcined byproducts/wastes produced by month, correction factor for byproducts/waste products, chemical composition analyses by month, and the number of operating hours in calendar year in addition to calculated GHG emissions.

8.1.5 Option 5: Direct Measurement using Continuous Emission Monitoring Data (CEMS)

For options based on direct measurement, using a CEMS, the GHG emissions are directly measured at the point of emission.

For direct measurement using CEMS, the facility would report the GHG emissions measured by the CEMS for each monitored emission point and should also report the monitored GHG concentrations in the stack gas and the monitored stack gas flow rate for each monitored emission point. These data would illustrate how the monitoring data were used to estimate the GHG emissions.

The facility might be required to report the following data for direct measurement of emissions using CEMS:

- The unit ID number (if applicable);
- A code representing the type of unit;
- Maximum product production rate and maximum raw material input rate (in units of metric tons per hour);
- Each type of raw material used and each type of product produced in the unit during the report year;
- The calculated CO_2, CH_4, and N_2O emissions for each type of raw material used and product produced, expressed in metric tons of each gas and in metric tons of CO_2e;
- A code representing the method used to calculate the CO_2 emissions for each type of raw material used (e.g., part 75, Tier 1, Tier 2, etc.);
- If applicable, a code indicating which one of the monitoring and reporting methodologies in part 75 of this chapter was used to quantify the CO_2 emissions;
- The calculated CO_2 emissions from sorbent (if any), expressed in metric tons; and
- The total GHG emissions from the unit for the reporting year, i.e., the sum of the CO_2, CH_4, and N_2O emissions across all raw material and product types, expressed in metric tons of CO_2e.

8.2 Other Information to be Reported

In order to check the reported GHG emissions for reasonableness and for other data quality considerations, additional information about the emission sources is needed. It is recommended that, in addition to CO_2 emissions, each reporting lime facility should also report lime generation and, if applicable, CO_2 combustion annual quantities. Additionally, it is recommended that the data pertaining to a specific option also be submitted with the annual report.

8.3 Additional Data to be Retained Onsite

Facilities should be required to retain data concerning monitoring of GHG emissions onsite for a period of five years from the reporting year. For CEMS these data could include CEMS monitoring system data including continuous-monitored GHG concentrations and stack gas flow rates, calibration, and quality assurance records. Process data including process raw material and product feed rates and carbonate contents could also be retained on site for a period of at least three years from the reporting year. EPA could use such data to conduct trend analyses and potentially to develop process or activity-specific emission factors for the process.

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