Methodology for the free allocation of emission allowances in the EU ETS post 2012

Sector report for the lime industry

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Disclaimer and acknowledgements

Disclaimer

The views expressed in this study represent only the views of the authors and not those of the European Commission. The focus of this study is on preparing a first blueprint of an allocation methodology for free allocation of emission allowances under the EU Emission Trading Scheme for the period 2013 – 2020 for installations in the lime industry. The report should be read in conjunction with the overall project report. This sector report has been written by Ecofys.

Acknowledgements

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1 Introduction

The activity of the sector in Annex I of the amended Directive[1] is defined as the "Production of lime or calcination of dolomite or magnesite[2] in rotary kilns or in other furnaces with a production capacity exceeding 50 tonnes per day". The respective NACE codes of the sector are:

NACE code (Rev. 1.1):	26.52
Description (NACE Rev. 1.1):	Manufacture of lime
NACE code (Rev. 1.1):	14.20
Description (NACE Rev. 1.1):	Quarrying of limestone, gypsum and chalk

The non-captive lime sector includes all companies that produce and sell quicklime and dolime (inclusive sintered dolime) as unique commercial products. CO_2 emissions from lime kilns in the following sectors are consequently excluded from the following statistics: hydraulic lime, sugar, paper, steel, refractory and chemicals (sodium bicarbonate, calcium carbide). For some characteristics of the captive lime industry, see also Section 3.1.

The European lime industry is scattered among Member States (see Figure 1) and comprises over 100 companies which operate in total about 600 kilns at 210 sites (EuLA, 2008).

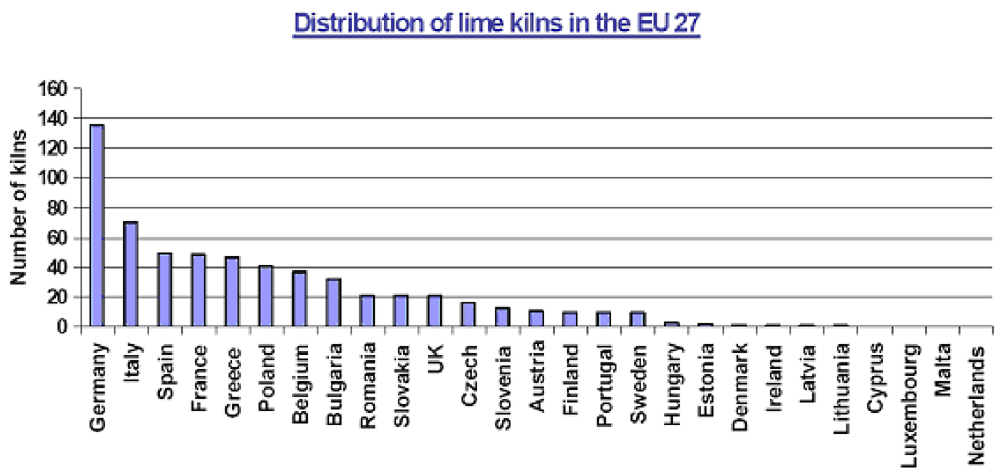

Figure 1 Distribution of lime kilns in the EU27 (EuLA, 2008)

The verified emissions of the non-captive lime sector subdivided by country can be seen in Table 1.

[1] Directive 2009/29/EC amending Directive 2003/87/EC
[2] As explained in the report on the project report and general issues, the calcination of magnesite is not covered in this sector report.

Table 1 Verified emissions of the non-captive lime sector in the EU27 from 2005 to 2007 (Source: EuLA, 2009a) based on CITL installation numbers

Country	**2005 verified emissions (kt CO_2)**	**2006 verified emissions (kt CO_2)**	**2007 verified emissions (kt CO_2)**
Austria	410	411	427
Belgium	3105	3246	3116
Bulgaria	Not included in the ETS	Not included in the ETS	Not included in the ETS
Czech Republic	1,008	1030	1117
Denmark	93	102	91
Estonia	35	40	41
Finland	720	765	717
France	2957	3087	3033
Germany	7823	8194	8392
Greece	593	573	656
Hungary	382	362	358
Ireland	102	104	124
Italy	2699	2741	2743
Latvia	6	6	6
Lithuania	49	80	68
Poland	1435	1642	1853
Portugal	309	301	346
Romania	Not included in the ETS	Not included in the ETS	770
Slovakia	943	972	1029
Slovenia	164	180	166
Spain	2063	2205	2336
Sweden	797	742	773
United Kingdom[1]	440	388	400
Total	**26133**	**27170**	**28563**

[1] Note that the UK figures do not include the opted out installations for phase 1: Tarmac (Tunstead & Hindlow); Hanson (Batts Combe); Steetley (Whitwell site); Singleton Birch (Melton Ross)

The allocation to captive lime installations is given in Table 2. The total amount of allocations is 32.4 Mt CO_2.

Table 2 Allocation to non-captive lime installations in the EU27 for 2008

Country	2008 Allocation [kt CO_2]
Austria	456
Belgium	3318
Bulgaria	Not available
Czech Republic	1032
Denmark	100
Estonia	40
Finland	788
France	3182
Germany	8982
Greece	830
Hungary	429
Ireland	233
Italy	2802
Latvia	6
Lithuania	73
Poland	1810
Portugal	464
Romania	816
Slovakia	1436
Slovenia	135
Spain	2412
Sweden	905
United Kingdom	2181
Total	**32431**

2 Production process and GHG emissions

In 2006, the non-captive lime production (lime not produced for internal use in integrated industrial facilities) in Europe was around 28.4 Mt (CIBA, 2007). Lime is used in a wide variety of applications in the iron and steel, chemical, paper and pharmaceutical industry (BREF CLM-draft, 2007).

Direct CO_2 emissions from lime making occur during the calcination of limestone. This step involves burning calcium carbonate and/or magnesium carbonate in kilns at temperatures between 900ºC and 1200ºC. The chemical reaction is as follows and CO_2 is produced as a result of the decomposition of the raw material:

$$CaCO_3 \text{ (limestone)} \rightarrow CaO \text{ (lime)} + CO_2$$
$$CaCO_3 \cdot MgCO_3 \text{ (dolomite)} \rightarrow CaO \cdot MgO \text{ (dolime)} + 2CO_2$$

The process emissions due to calcination are constant and determined by the chemical reactions given above. These process emissions are equal to 0.785 t CO_2 / t lime and 0.913 t CO_2 /t dolime.

To generate the necessary energy for the above-mentioned chemical reactions, fuels are burned. The combustion CO_2 emissions are the second source of CO_2 emissions in the lime industry and range from 0.1 to 0.8 t CO_2/ t lime.

The lime and cement industry best available techniques reference document (BREF CLM-draft, 2007) and EuLA, the European Lime Association, distinguish six types of kiln in this industry, which in turn can be grouped into two main categories: horizontal kilns and vertical kilns. The six categories are:

1. Horizontal - Long rotary kiln – LRK
2. Horizontal - Rotary kiln with pre-heater - PRK
3. Vertical - Parallel flow regenerative kiln - PFRK
4. Vertical - Annular shaft kiln - ASK
5. Vertical - Mixed feed shaft kiln -MFSK
6. Other kiln - OK (single shaft kiln, double inclined shaft kiln, multi chamber shaft kiln, travelling grade shaft kiln, top-shaped kiln, gas suspension, calcination kiln, rotating hearth kiln (This type of kiln is now almost obsolete and was designed to produce pebble lime. This technology is still used in Greece.))

According to (CIBA, 2007) there are currently 46 horizontal kilns and 551 vertical kilns in operation.

The specific energy consumption of lime production depends on the type of kiln being used. The specific fuel consumption varies for the different lime kilns, as shown in Table 3.

Table 3 Typical specific fuel consumption for lime kilns (BREF CLM-draft, 2007)

Kiln Type	Specific heat consumption (GJ / t lime)
Horizontal kilns	
PRK	5.1 - 7.8
LRK	6.4 - 9.2
Vertical kilns	
PFRK	3.6 - 4.2
ASK	3.8 - 4.6
MFSK	3.8 - 4.7
OK	3.5 - 7.0

For the special case of dead-burned sintered dolime production, specific heat consumption equals 6.5 - 13 GJ / t dolime (Ecofys/Fraunhofer 2009). One can clearly see from the overview that vertical kilns have a lower specific energy consumption than horizontal kilns.

According to (BREF CLM-draft, 2007) gas cannot be used in mixed feed shaft kilns (MFSK), which is confirmed in Table 5, while at the same time one can clearly see that gaseous and solid fuels are the dominant fuel types.

The fuel mix in the lime industry for the years 2007 and 2008 is presented in Table 4.

Table 4 Fuel mix in the lime industry for 2007 and 2008 (EuLA, 2009)

Fuel	Percentage
Gas (fossil)	38 %
Solid (fossil)	47 %
Liquid (fossil)	8 %
Waste (fossil and biomass)	6 %
Biomass	2 %

Table 5 Fuels used in lime kilns (%) in 2003 in the EU-25 (BREF CLM-draft, 2007)

Fuel	LRK	PRK	ASK	PFRK	MSFK	OK
Gas (fossil)	3	26	69	64	0	51
Solid (fossil)	81	60	6	20	100	32
Liquid (fossil)	1	3	14	10	0	10
Waste (fossil and biomass)	14	11	11	3	0	7
Biomass	0	0	0	3	0	0

3 Benchmarking methodology

3.1 Background

The PRODCOM 2007 defines four types of lime products. Below is a short description of each of them:

Main Products:

- 26.52.10.33: Quicklime (or lime): Calcium oxide (CaO) produced by decarbonising limestone ($CaCO_3$).
- 26.52.10.35: Slaked lime: Produced by reacting or slaking quicklime with water; consists mainly of calcium hydroxide. Slaked lime includes hydrated lime, milk of lime and lime putty.

Niche Products

- 26.52.10.50: Hydraulic lime: Partially hydrated lime that contains cementious compounds.
- 14.12.20.50: Calcined and sintered dolomite: more specialised products which are supplied in lump, hydrated and dead burned forms.

The emissions associated with different lime products are not distributed evenly. A first estimate prepared by EuLA gives the following results (as % of total emissions).

- Lime (26.52.10.33): 89%
- Dolime (part of 14.12.20.50): 7%
- Sintered dolime (part of 14.12.20.50): 4%
- Hydraulic lime (part of 26.52.10.50): 1%

Regarding the choice of products and the number of benchmarks to develop, the following issues need to be tackled:

1. Which of the above product groups should receive a different benchmark
2. Whether or not to have separate benchmarks for the individual kiln types that are applied in the lime industry
3. How to treat captive lime kilns in other industrial sectors

1. Products to distinguish

Lime and dolime differ significantly in process emission (0.785 t CO_2 / t lime and 0.913 t CO_2 / t dolime) and are different products, also from a chemical point of view. It is therefore proposed to develop separate benchmarks for lime and dolime at least for the process emission part of the benchmark. For the feasibility of also developing a separate benchmark for the fuel emission parts, we refer to Section 4.

Sintered dolime (or dead-burned dolime) requires higher temperatures in the kiln (sintering) showing a difference in emission intensity compared to lime and soft-burnt dolime (BREF CLM-draft, 2007). This was also acknowledged in the study on allocation principles for a benchmark-based allocation methodology performed by Ecofys / Fraunhofer institute in 2008 (Ecofys / Fraunhofer institute, 2009). Under two conditions, a separate benchmark for sintered dolime can be considered:

- Sintered dolime is a product that can clearly be distinguished based on an unambiguous product classification.
- The difference in emission intensity compared to soft-burnt dolime can be duly substantiated, either via a benchmark study for sintered dolime kilns only or via other information.

The consortium discussed these two points with EuLA, but so far no data is available to develop a separate benchmark for sintered dolime. We therefore propose to use a fall-back approach for sintered dolime production in line with the fall-back approaches as discussed in chapter 5 of the report on the project approach and general issues. It should be further assessed which product classification can be used to distinguish sintered dolime (fall-back) from soft-burnt dolime (benchmark).

Hydraulic lime is a niche product, responsible for only a very small share in the emissions of the lime sector. It is therefore proposed to apply a fall-back approach to this product.

2. Kiln-specific benchmarks for the lime industry

As discussed in the study on allocation principles (Ecofys / Fraunhofer institute, 2009), the lime industry (represented by EuLA) sees a number of constraints that influence the choice of kiln technology and could therefore be the basis for a technology-specific benchmark[3] (EuLA, 2008):

a. Fuel restrictions. Some kilns cannot use certain fuels (e.g. the MFSK kiln cannot use gaseous fuels).
b. Lime quality, for which reactivity is the main reference. This product specification does not have a direct link to kiln efficiency or specific energy use, but is related to the choice of kiln.
c. Type of limestone. Vertical kilns process medium to large pebble limestone, whereas horizontal kilns process small to medium pebble size limestone. Also soft limestone may not be suitable for calcination in vertical kilns. From an overall sustainable use of limestone resources, one can argue that the use of horizontal kilns (i.e. able to process small pebble sizes and soft limestone) cannot be avoided.

The first two arguments as reasons for technology-specific benchmarks were discarded in Ecofys / Fraunhofer (2009) using the following summarized argumentation:

[3] Only a brief description is given here. For more information, we refer to Ecofys / Fraunhofer (2009)

a. Although national and European standards exist for lime qualities, there is no-intra sectoral agreement on a lime product classification that would allow an unambiguous classification of lime types that can be coupled to specific benchmarks. Furthermore, and more importantly, no link is available that links certain types of kilns to specific types of lime qualities, making it difficult to justify a technology-specific benchmark on basis of product quality differences.
b. As a general principle, fuel-specific benchmarks are not considered.

Regarding the third argument, additional quantitative proof was provided by EuLA (2009a) on typical pebble size distribution of limestone quarries. The optimization of raw material resource use is a major element that influences the operator's decision when designing a plant. Vertical or shaft kilns (VK), process medium to large pebble limestone (generally size > 40 mm) and horizontal or rotary kilns (HK), process small to medium pebble limestone (generally > 2 mm and < 50 mm). The following Figure 2, provided by EuLA, shows a typical[4] distribution of stone size after the stone preparation operations, i.e. the relative quantity of raw materials of different sizes for kilns feeding. It compares these size distribution curves with the tolerance of each technology in terms of stone size. In this typical installation, using rotary kiln technologies enables the recovery of additional non-renewable resources of 37.8%.

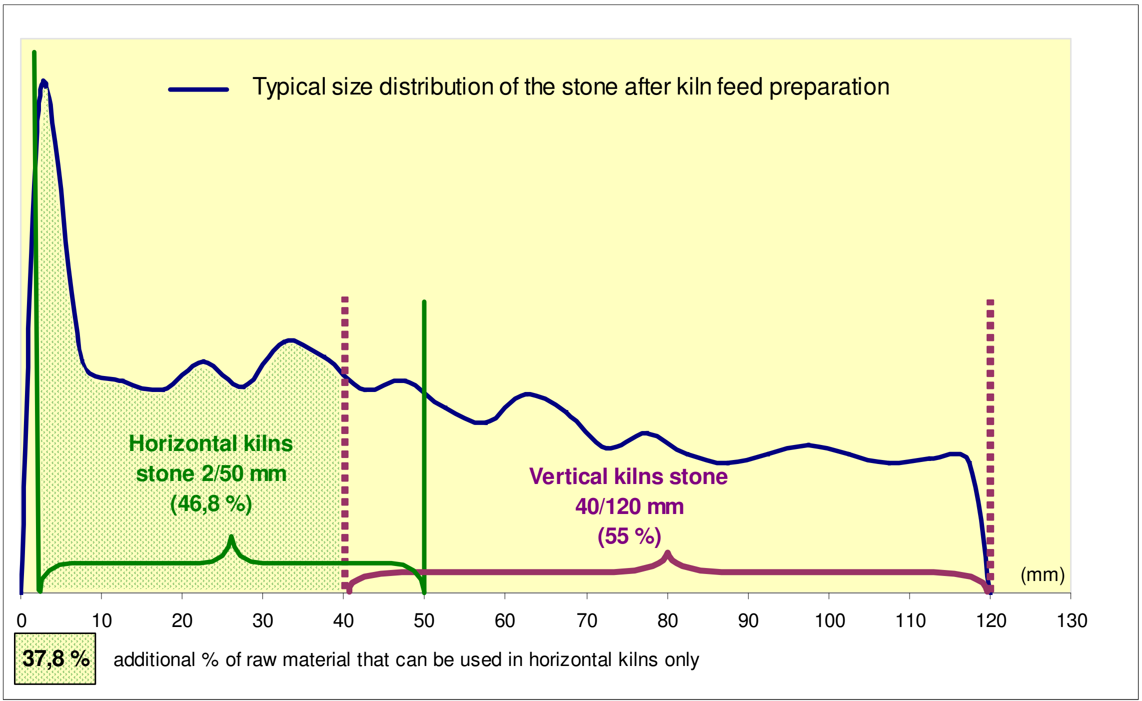

Figure 2 Typical size distribution of the stone after kiln feed preparation

In view of the following arguments, we propose not to have technology-specific benchmarks for lime production:

[4] Obviously the size distribution is very site-specific.

- Due to the significant contribution of process emissions in the specific benchmark for lime and dolime, there are indications that the overall benchmark for horizontal and vertical kilns respectively, would differ by less than 20% with regard to total emissions (NB the benchmark for fuel related emissions only would differ by more than 20%). In view of the overall transparency of the free allocation methodology, this is a reason not to develop technology-specific benchmarks (see also the report on the project approach and general issues).
- Small pebble limestone also has alternative uses. This can already be seen from the fact that the typical installation indicated a share of 37.8% small pebble size limestone whereas the total lime production with horizontal kilns is only approximately 20% (BREF CLM-draft, 2007). A further assessment including also these alternative uses is thus necessary to substantiate that “a sustainable use of limestone resources does require horizontal kilns” as such (see also the next bullet-point). However, it could also be argued that the full potential for using all excavated limestone in the most value added way (i.e. by producing lime) is not yet fully exploited in the EU[5].
- Although the sustainable use of limestone can be an argument for the existence of horizontal kilns, it does not directly justify “all” horizontal lime kilns. In the US, for example, horizontal kilns are the standard technology which is caused mainly by economy of scale considerations. More generally, it is obvious that the choice for kiln technology depends on many factors such as economy of scale, regional fuel costs and availability etc. A technology-specific benchmark for horizontal kilns as such creates an incentive for horizontal kilns regardless whether or not this is beneficial from the point of view of sustainable limestone use. Correcting for this (e.g. by allocating for horizontal kilns only up to a certain percentage), further complicates the methodology which is not desirable from a transparency point of view.

3. How to treat captive lime kilns in other industrial sectors

EuLA has a clear view on the performance of non-captive lime kilns (see also Section 4), but does not have information on captive lime kilns in e.g. the iron and steel, pulp and paper, sugar and chemical industry. At present, the consortium does not have a clear overview of the number of non-captive lime kilns in different industries. Some information is however available on the lime kilns in the sugar, in the pulp and paper industry and in the production of sodium bicarbonate (see below).

The following possibilities can be distinguished for dealing with captive lime production in other sectors.

1. Incorporate the captive lime kilns in the benchmark calculations for the lime sector (see Section 4) in order to develop a uniform benchmark for all lime production.
2. Regard the benchmark based on the EuLA benchmark study (Section 4) as a representative lime benchmark and apply this benchmark to both captive and non-captive lime production.

[5] EuLA commented in this way to an earlier draft version of the report (EuLA 2009b)

3. Develop separate benchmarks for captive lime production for certain sectors.

The first and second method best complies with the overall "one product, one benchmark" principle (see report on the project approach and general issues). In view of the limited time available to come to an adopted allocation methodology and due to the lack of an organization bringing data from the captive and non-captive lime production together, the first method will be very difficult to apply. The second methodology could be a good alternative, but the rather specific captive uses of lime and the corresponding carbon flows might justify separate approaches for captive lime production (third methodology).

EuLA stated its opinion on this topic as follows: "EuLA agrees with Ecofys that lime produced in other industry sectors as part of their production process (captive lime production) may have different features and may require a separate approach.

In order to ensure a level-playing field in which each producer faces similar constraints, EuLA recommends applying the lime benchmark developed for non-captive lime production to captive lime production in case that one of the following two conditions applies:

- The captive lime producer uses the same technology or production process as non-captive lime producers.
- The captive lime producer sells his surplus production on the market, outside his own sector (and thus enters into competition with the non-captive lime producers)."

Information on lime kilns in the sugar industry was taken from a study by Bocek (2009). Lime kilns in the sugar industry are used for juice purification. The quick lime and carbon dioxide which are needed for the process stage „juice purification" are generated from lime within the sugar factories. The lime is burnt in a mixed fuel lime kiln. The calcium carbonate of the limestone ($CaCO_3$) is broken down into quick lime (CaO) and carbon dioxide (CO_2). The heat required to trigger the thermal scission – about 1,100 to 1,250 °C – is generated by the burning of coke. The sugar industry uses coke to burn lime because this allows for a particularly high yield of CO_2 in the lime kiln gas. The quick lime which is discharged to the cooling zone and contains about 91% of CaO is screened and freed from impurities and then quenched with thin juice. The result of this process is lime milk of about 20 percent (lime hydrate $Ca(OH)_2$). During 'liming', this lime milk is added to the raw juice. The next step of carbonatation consists of introducing the CO_2 containing gas into the limed juice. Calcium carbonate crystals are precipitated; the resulting precipitates are regular and coarse which makes it easy to filter them off. Both constituents – quick lime and carbon dioxide – are part of the final product calcium carbonate, a natural lime fertiliser much sought after by farmers; it contains a number of additional nutrients like magnesium, phosphorus and organic nitrogen compounds. When determining and monitoring the emissions, it can therefore be assumed that there are <u>no process-dependent CO_2 emissions released from the limestone that is used</u>, and that the CO_2 levels emitted during the juice purification process are exclusively energy-dependent emissions from the process of burning the coke that is used.

Information on lime kilns in paper mills was taken from a study by Miner (2002). The CO_2 emitted from kraft mill lime kilns originates from two sources, namely fossil fuels burned in the kiln and the conversion of calcium carbonate to calcium oxide. The emissions from the fossil fuel usage can be accounted for by the use of standard emission factors and accepted methodologies. The correct characterization of calcium carbonate-derived CO_2 emissions requires an understanding of the origin of the carbon contained in the calcium carbonate. In the kraft pulping and the chemical recovery process, biomass carbon residing in the non-fibrous portions of wood is dissolved and either emitted as biomass CO_2 from the recovery furnace or captured in sodium carbonate. In the process of converting the sodium carbonate into new pulping chemicals, this biomass carbon (in the form of the carbonate ion) is transferred to calcium carbonate. In the lime kiln, the calcium carbonate is converted to calcium oxide, a material needed in the chemical recovery process, and biomass CO_2, which is released to the atmosphere. Because the origin of the carbon in kraft mill calcium carbonate is wood, the process CO_2 released from this calcium carbonate is CO_2 from biomass and should not be included in estimates of emissions contributing to increased atmospheric levels of greenhouse gases.

For the production of lime in sodium bicarbonate production, we refer to the sector report for the chemical sector. Also there, the production of lime is fully embedded in the overall production process of sodium bicarbonate and parts of the process emissions are captured.

Based on this information, we conclude that for captive lime production in at least these three captive lime applications, a separate approach is justified, because the characteristics of the captive lime process are directly linked to the overall production process for sugar and kraft pulp respectively and the lime is not sold as product by these installations. For kraft pulping, we include the fuel combustion part of the benchmark in the pulp benchmark. For sugar, currently a fall-back approach is envisioned (see section 5 of the report on the project approach and general issues). For sodium bicarbonate, a separate benchmark including the calcination of limestone is envisioned (see sector report for the chemical industry for more details).

3.2 Final proposal for products to be distinguished

Summarizing, we propose to develop benchmarks for the following products:

- Lime, consisting of a fuel combustion part and a fixed process emission part, PRODCOM code 26.52.10.33
- Dolime, consisting of a fuel combustion part and a fixed process emission part, part of PRODCOM code 14.12.20.50

For sintered dolime, no data is available on the performance of kilns producing this product. Therefore, also in view of the relatively small contribution of this project to the overall sector emissions, a fall-back approach (chapter 5 of the report on the project approach and general issues) is proposed for this product.

For hydraulic lime (being a niche product produced only by a very limited amount of producers), a fall-back approach is envisioned (see chapter 5 of the report on the project approach and general issues). A fall-back approach should also be used for those installations that are taken out of the benchmark curve, because less carbonised materials are produced that cannot be regarded as lime or dolime according to standard product classifications (see Section 4 and 6).

According to EuLA, no CHP plants are operated in the sector and the sector does not sell heat to other sectors (EuLA, 2009a).

4 Benchmark values

4.1 Background and source of data

EuLA is and has been working together with CIBA (a Swiss consultant) to develop approaches for benchmarking in the lime industry. EuLA has expressed its preference for a benchmark approach based on a combination of energy efficiency combined with a European fuel mix of the lime industry and provided in the stakeholder contacts during this study only data following this approach (see Section 6 for the reasoning behind this choice). In 2007, however, the industry published a report containing performance data in t CO_2 / t lime.

Based on our interpretation of the amended Directive, we base our benchmark directly on the greenhouse gas (GHG) efficiency (see report on the project report and general issues). EuLA has therefore been asked to supply updated data on the overall GHG efficiency comparable to the method used in CIBA (2007), but so far, this information has not been supplied. The values as given in the next paragraph are therefore taken from the CIBA study from 2007.

The overall production reported by the producers included in the CIBA study (including also Norway, Croatia, Turkey and Switzerland) amounts to 25.7 Mt, which is 91% of CIBA estimation of the EU-27 production for the investigated year 2006. The coverage of the different kiln types is also high. With the exception of the kiln type "Other Kilns", the reporting level exceeds 85% for each kiln type (CIBA 2007).

The database contains among others the following information:

- Type of kilns in operation in the installation
- Number of kilns (in case of grouped reporting)
- Annual lime production in 2006, in tonnes
- Annual dolime production in 2006, in tonnes
- Annual process CO_2 emissions in 2006, in tonnes
- Annual combustion CO_2 emissions in 2006, in tonnes
- Amount of biomass used in the kiln(s) in 2006, in GJ
- Amount of waste fuels used in the kiln(s) in 2006, in GJ

Based on this information, we conclude that the information available in the CIBA study is in principle sufficient to derive a GHG intensity curve. Building on the past work, additional work needs in our opinion to be done in the following areas:

- Collect data for the timeframe 2007 – 2008, in line with the amended Directive[6]
- Prepare curves on GHG efficiency in which biomass is regarded a non emitting fuel[7]

[6] Since historical production data for 2005 might play a role in the allocation formula as well, it is strongly recommended to collect information for the complete time frame 2005 – 2008

[7] In the CIBA study, reference is made to a study done for CEPI on the shortfall of wood supply resulting from the EU's 20% renewable target. For this reason, all biomass use reported by the installations is included in the CO_2 performance curve using an emission factor based on the average fossil fuel mix applied in the lime industry.

- Exclude non EU-27 countries from the assessment with the exception of Norway and Iceland
- Collect, if feasible, individual data for dolime kilns to facilitate an individual benchmark for combustion emissions in dolime production[8]
- Plot data on an EU ETS installation level rather than as a function of cumulative production
- Prepare a list of lime kilns in which less decarbonised materials are produced which are wrongly classified as lime or dolime products without reaching the standard quality and document (e.g. based on considerations regarding the technical minimal energy consumption) why these are taken out. In the final allocation, these kilns could be treated with a fall-back approach (see chapter 5 of the report on the project approach and general issues).

4.2 Final proposed benchmark values

As no separate data for fuel use in dolime and lime production can be provided (see previous section), the benchmark for both lime and dolime will be based on one single fuel use benchmark.

The CIBA study provides benchmark curves for both vertical and horizontal kilns. They show specific combustion CO_2 emissions versus cumulated production. Below in Figure 3 the specific combustion CO_2 emissions versus cumulated production for vertical kilns is presented as calculated in the CIBA study.

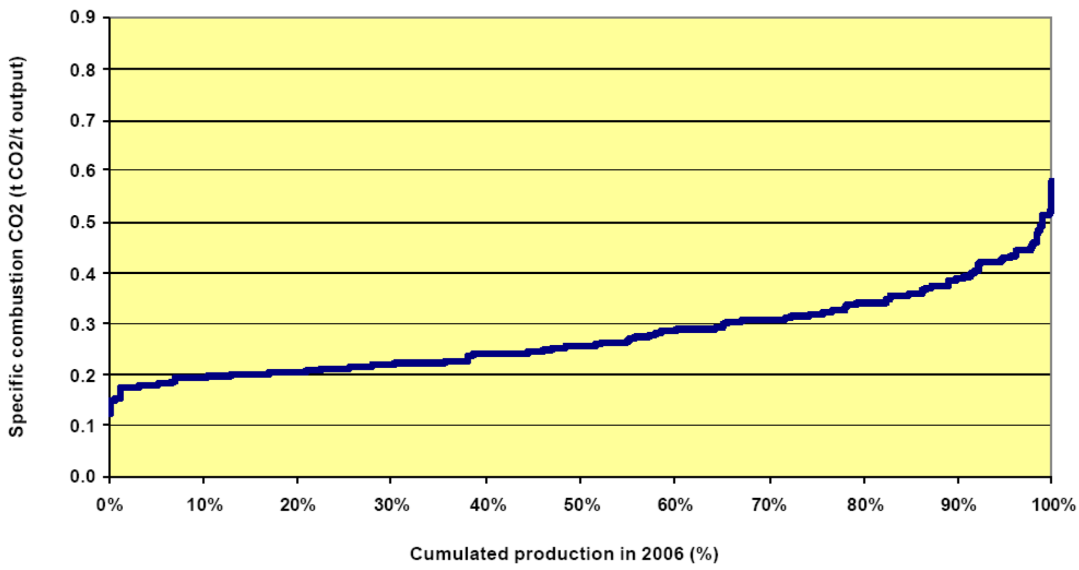

Figure 3 Specific combustion CO_2 emissions versus cumulated production for vertical kilns (CIBA, 2007)

[8] Following stakeholder interaction (EuLA, 2009b), it became clear that separate curves for lime and dolime production cannot be made, because the same kilns are alternatively used to produce both lime and dolime. Neither EuLA nor CIBA has any data on the energy utilization rate of lime and dolime production separately. Besides, the combustion emissions are very similar.

Below in Figure 4 the specific combustion CO_2 emissions versus cumulated production for horizontal kilns are shown.

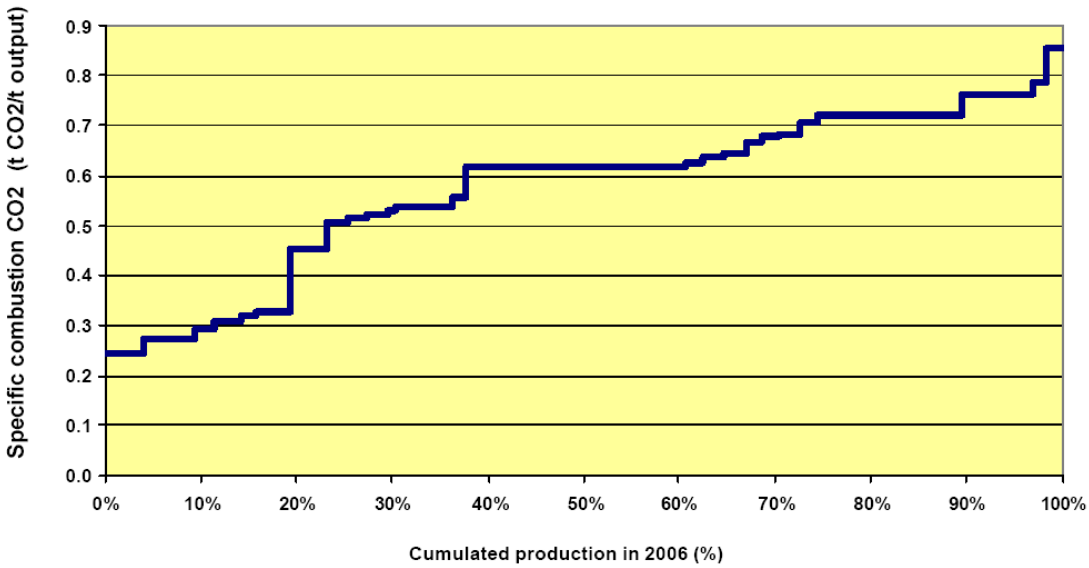

Figure 4 Specific combustion CO_2 emissions versus cumulated production for horizontal kilns (CIBA, 2007)

To derive the average performance of the 10% most efficient installation from these curves, the cumulative production on the x-axis should be replaced by the number of installations and the data points from the horizontal and vertical kilns would need to be combined. We estimate that the resulting combustion process would be close to 0.2 t CO_2 / t lime or dolime, a conclusion also already drawn in the 2008 study (Ecofys / Fraunhofer-ISI, 2009). Hence the following preliminary benchmark values are envisioned based on the CIBA study:

Table 6 Preliminary benchmark values for the lime industry based on 2006 data

Benchmark	**Value**
Fuel combustion	
Lime	0.2 t CO_2/t lime
Dolime	0.2 t CO_2/t lime
Process Emissions	
Lime	0.785 t CO_2/t lime
Dolime	0.913 t CO_2/t lime
Resulting Benchmark values	
Lime	0.985 t CO_2 /t lime
Dolime	1.113 t CO_2/t lime

Because lime and dolime production is combined in the curves, it is difficult to estimate the spread (i.e. the difference between lowest and highest value in the curve). Assuming all data points to represent lime production, the overall (combustion and process) emissions from lime making range between 0.935 to 1.635, corresponding to a spread of 1.75. Similarly, if all data points would represent dolime production, overall emissions range from 1.063 to 1.763, corresponding to a spread of 1.66. As already discussed in the 2008 report (Ecofys / Fraunhofer-ISI, 2009), the benchmark value as proposed here is ambitious compared to the values of 1.00, 1.09, and 1.31 t CO_2 / t lime and 1.33 t CO_2/ t dolime used as new entrant benchmarks in the UK (ENTEC, 2006).

5 Additional steps required

The benchmark values for lime and dolime as derived here are adequate benchmark values that are in our opinion very close to the average performance of the 10% most efficient installations. Still, the estimates could be made more exact based on the database developed by CIBA for EuLA, following the suggestions as summarized in Section 4.1. Although the difficulties encountered with this database as outlined by EuLA in the next section are understood, the consortium believes that the data basis of the sector (i.e. the data they have via CIBA) should be sufficient for calculating the 2007/2008 benchmark values expressed in t CO_2 / t lime or dolime based on actual performance data of the installations. Regarding production definition, it should further be assessed how sintered dolime for which a fall-back approach is envisioned can be distinguished from soft-burnt dolime for which a benchmark is proposed.

6 Stakeholder comments

This section is based on EuLA comments provided to the consortium (EuLA, 2009b).

According to EuLA, the GHG intensity curve currently held by CIBA discloses incoherent results. The primary explanation refers to the production of less decarbonised materials, undoubtedly wrongly classified as lime or dolime products but without reaching the expected standard quality. CIBA cannot enter in a controversial discussion amongst lime companies on such a sensitive issue. CIBA must also acknowledge that even in the case where outliers are excluded from the graph, the curve shows results below expected theoretical GHG emission values. CIBA is not in a position to challenge the veracity of the declaration of a certain number of installations and cannot provide a reliable GHG intensity curve in such a context. It primarily belongs to Members States to ensure a high level of verification of installations declarations.

Accordingly CIBA confirms that the best evaluation of a realistic GHG emission benchmark for the lime industry must refer to a combination of data analysis and technical literature. To comply with this exercise, the two-step approach (energy specific consumption combined with specific energy emission factor) does provide a higher level of the quality of the results.

Following from the above assumptions EuLA proposes the following two part benchmark values:

Technical documentation has been used to define the minimum specific energy consumption, which is required to characterise the production of lime and dolime. These values are 3.4 GJ/t for vertical kilns and 4.8 GJ/t for horizontal kilns. Kilns with an energy consumption below this technical minimum have been excluded from the exercise. Next, for those kilns for which data was available for both 2007 and 2008, a new database was created by taking into account the average of the specific emissions of the installation in 2007 and 2008.

This leads to the following results:

- Benchmark (10% best performing Vertical Kilns) : 3.47 GJ/t
- Benchmark (10% best performing Horizontal Kilns) : 5.37 GJ/t

CIBA has identified the average fuel mix 2007-2008 from a large sample of companies across the EU representing more than 50% of the European lime production (Table 7).

Table 7 Fuel mix in the European lime industry

Fuel type	Average European fuel mix in 2007-2008	Emission factor[1] (t CO_2/TJ)	Equivalent emission factor (t CO_2/TJ)
Gas	37.67%	56.1	
Liquid	8.14%	77.4	
Solid	47.06%	101.2	79.16
Waste fuels	5.55%	74.0	
Biomass	1.60%	0	

[1] In line with monitoring and reporting guidelines

Because of the limited availability of Biomass and Coke Oven Gas (COG), EuLA suggests not taking into account these fuels for calculating the emissions associated with the average fuel mix for 2007-2008. When biomass and Coke Oven Gas (COG) are eliminated, the emissions of the fuel mix would be 80.44 t CO_2 / TJ.

The most appropriate way for defining a combustion CO_2 benchmark is to multiply the equivalent CO_2 emissions per GJ, resulting from the average European fuel mix 2007-2008 in the lime sector without biomass and coke oven gas (COG) with the energy efficiency value of the 10% most efficient installations

This results in the following benchmarks (combustion) for the lime sector

Table 8 Proposed benchmark values for combustion emissions in lime making by EuLA (2009b)

Kiln Family	Energy benchmark [GJ / t output]	CO_2 benchmark (combustion) based on the European fuel mix [t CO_2 / t output]
Vertical kilns	3.47	0.279
Horizontal kilns	5.37	0.432

EuLA's recommendation is that the benchmark formula should consist of a EU-wide CO_2 emission factor proportionate to the relative capacity in vertical (x %) and horizontal (y %) kilns at installation level.

7 References

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