Competitiveness of the European Cement and Lime Sectors

Summary of the final report

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I. Objective and approach

Objective – The aim of the study is to provide an assessment of the competitiveness of the EU cement and lime sectors. The current competitive situation of both European cement and lime industries is depicted by a description of industry value chains, sector-specific features and the relevant regulatory environment. The industry assessments include an analysis of potential threats and opportunities in trade innovation and technological innovation, and future-orientated analysis of industry performance and competitiveness using scenario-based economic modelling.

Delineation of the sectors – The sector definitions and corresponding product scope are outlined in the following table.

Table 1: Overview of definition and delineation of the sectors studied

Economic Activity	Covered product categories
Manufacture of cement (NACE 23.51)	The following categories are covered: • Cement clinker; • Portland cement and Portland cement composites, which are collectively designated Portland* cement (see note below); • Other hydraulic cements. *Note: The study has been unable to ascertain the precise correspondence between the classification of cement products used by statistical data sources (e.g. Eurostat and other international and national data sources) and existing standards for cement products; specifically the standard EN 197-1 for common cement types. In the performance of this assignment, the Research team has agreed to use the label* ***Portland* cement****, to refer to the product categories for 'Portland cement' used in public data sources[1], to cover both Portland cement (CEM I) and Portland composite cements (CEM II) as defined in EN 197-1; the category 'Other hydraulic cement' is considered to refer to other common cement types (CEM III, IV, and V) and other special cement types.*
Manufacture of lime (part of NACE 23.52)	The following categories are covered: • Quicklime; • Slaked lime; • Hydraulic lime; *Note: For the analysis of industrial structure, public data is only available at NACE 23.52 level, which combines lime manufacturing with the manufacturing of plaster.*

Methodological approach – The general methodology applied in this study consists of the collection and combination of primary and secondary sources. More details are provided in Annex B of the main report.

The starting point of the work has been the review of academic and business literature describing and analysing the development of the cement and lime industries. Subsequently, this material has been enriched by scoping interviews with sector associations and plant visits. In addition, various publicly available data sources (particularly Eurostat SBS and Eurostat

[1] Code 23511210 (Portland cement) under the European statistical classification of manufactured products (Prodcom); codes 25232100 (White Portland cement) and 25232900 (Portland cement, excluding white Portland cement) under the HS Harmonised System (HS) / Combined Nomenclature (CN) statistical classification of traded products.

Prodcom) and the AMADEUS company database were used to further develop industry profiles. As part of the assessment of regulatory conditions, a set of legislative acts were reviewed.

The analysis was deepened through the implementation of a survey of national associations and companies. In total, 26 companies were captured, representing about 30% of employment and 33% of turnover in cement; and 27% of employment and 29% of turnover in lime. In parallel, interviews with downstream industry associations were held. Moreover, interviews with representatives from relevant Directorate Generals of the European Commission were conducted to better understand the EU-level regulatory situation. In total, approximately 40 stakeholders were involved. The collected data was analysed using quantitative and qualitative analysis tools. An analysis of total productivity (using Amadeus data) was conducted, as well as the assessment of five different scenarios using the ADAGIO input-output model. In October 2017, two workshops were held with the European Commission and industry representatives to discuss the set-up of the scenarios and preliminary results.

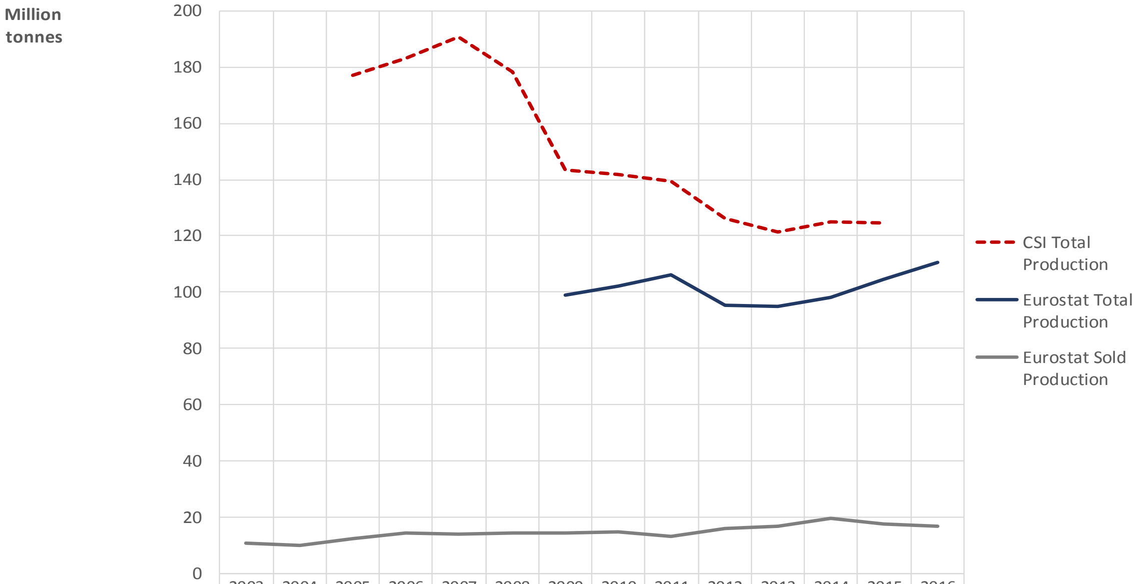
II. EU cement industry profile

Product overview – Cement is obtained by grinding cement clinker and, in some cases, supplementing it with additions. Clinker is produced through the firing/sintering (in a cement kiln) of a mixture of limestone (or other minerals containing high levels of calcium) and other materials (e.g. clay, fly ash and slag) to provide the necessary final chemical composition. Cement is a basic ingredient of concrete, mortar, stucco, and non-specialty grout. Ultimately, almost all applications of cement are linked to construction and civil engineering activities.

Production and supply chain - Cement production involves multiple stages and actors from the quarry to the final product. The production process can be grouped into four basic steps: (i) extraction of raw material (limestone, chalk or marl) from quarries, (ii) processing the primary raw material (limestone) with primary and secondary crushers, (iii) the clinker production, via the calcination of limestone to lime and subsequent reaction with the other constituents from the raw material, and (iv) grinding and blending with other materials. Especially the calcination process is energy intensive, and the industry makes thereto use of both conventional fuels and (increasingly) alternative fuels – including waste and biomass. Many, if not most, cement companies show a high degree of vertical integration and are consequently involved throughout the supply chain. The majority of cement companies own the quarries. Some producers also integrate downstream industries (i.e. concrete) and associated products (e.g. aggregates). The extent of this downstream integration varies by country.

Production of cement clinker – There are large disparities in estimates of total cement clinker production between Eurostat data and those coming from industry sources. Eurostat data indicate that the total quantity of EU cement clinker production was 105 million tonnes in 2015, which compares with a figure of 125 million tonnes according to the Cement Sustainability Initiative (CSI) - see Figure 1 below. Eurostat PRODCOM (NACE, rev.2) data on total cement clinker production are only available since 2009, therefore they do not measure the impact of the 2008 economic crisis on total production. Data from CSI indicate a sharp fall from 191 million tonnes in 2007 to 144 million tonnes in 2009, followed by a continuing decline to only 122 million tonnes in 2013, after which there has been a slight increase to 125 million tonnes. Volumes of sold clinker have generally increased over time, from 11 million tonnes in 2003 to 20 million tonnes in 2014, but show some decline for the last two years for which data are available.

Figure 1: EU28 Cement clinker – quantity of production 2003-2016

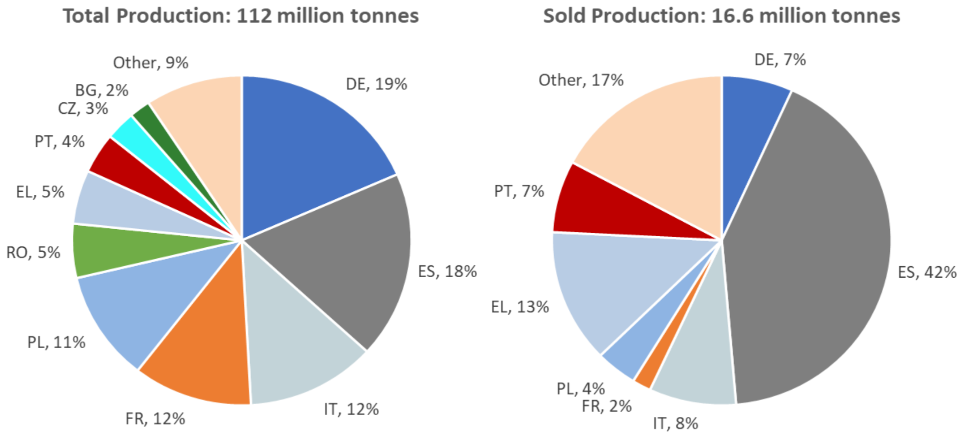


	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016
CSI Total Production			177.3	183.3	190.8	178.3	143.5	141.8	139.6	126.3	121.5	125.1	124.8	
Eurostat Total Production							99.0	102.2	106.1	95.3	94.8	98.3	104.5	110.8
Eurostat Sold Production	10.8	10.1	12.4	14.2	14.0	14.5	14.5	14.9	13.0	15.9	16.7	19.6	17.5	16.6

Source: Ecorys based on Eurostat Prodcom and CSI[2]

The majority of EU clinker production is not sold in the market but goes directly into the production of cement. For the EU as a whole, Eurostat data indicate that sold production of cement clinker was around 16.6 million tonnes or 15% of the Eurostat estimated total EU production in 2016. Volumes of sold clinker (production sold domestically and exports) have generally increased over time, from 11 million tonnes in 2003 to 20 million tonnes in 2014, but show some decline for the last two years for which data are available (Figure 2). Both Eurostat data and data from industry sources (CSI) indicate that Germany, Spain, Italy, France and Poland are the largest producers of cement clinker in the EU. In terms of sold production, Spain is by far the most important EU supplier of cement clinker, followed by Greece, Italy and Portugal.

Figure 2: EU28 Cement clinker production - breakdown by country in 2016



[2] CSI Global Cement Database on CO_2 and Energy Information "Getting the Numbers Right" (GNR) available at: http://www.wbcsdcement.org/index.php/key-issues/climate-protection/gnr-database.

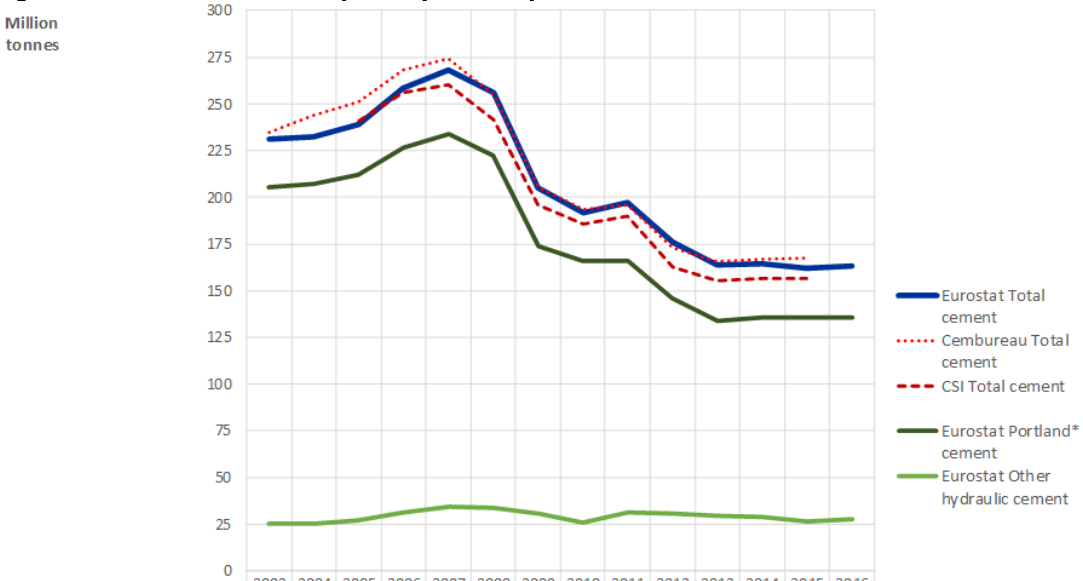
Notes:
a. Zero production indicated for CY, DK, FI, LT, LU, MT, NL, and UK;
b. Data unavailable for AT, BE, EL, IE, LV, SE, SI, SK.

Source: Ecorys based on Eurostat Prodcom

It is to be noted that the Research Team identified some important discrepancies between Eurostat clinker production data and those available from industry sources. Some of the roots of these discrepancies could be identified as well.

Production of cement – Eurostat production data indicate that EU28 total production of cement products amounted to an estimated 163 million tonnes (of which 136 million tonnes of Portland* cement) in 2016, with a value of €11.9 billion. These amounts compare with a peak production volume of 268 million tonnes (see Figure 3) and a sales value of €20.2 billion in 2007. Eurostat production estimates are broadly comparable with data from CEMBUREAU, the European cement association, which estimates EU28 cement production at 167 million tonnes in 2015, and data from the Cement Sustainability Initiative (CSI).

Figure 3: EU28 cement – quantity of sold production 2003-2016



	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016
Eurostat Total cement	231.0	232.5	239.0	258.3	268.1	256.0	204.9	191.7	197.1	176.1	163.6	164.4	162.3	163.2
Cembureau Total cement	234.5	243.7	251.1	268.3	274.4	254.9	205.7	193.5	195.7	172.6	165.5	166.8	167.2	
CSI Total cement			240.7	255.8	260.3	241.4	196.0	185.6	190.0	162.6	155.4	156.7	156.7	
Eurostat Portland* cement	205.6	207.1	212.2	226.8	234.1	222.4	174.1	165.9	166.0	145.7	134.0	135.7	135.7	135.7
Eurostat Other hydraulic cement	25.4	25.4	26.8	31.5	34.0	33.6	30.8	25.8	31.1	30.4	29.6	28.7	26.5	27.5

Source: Ecorys based on Eurostat Prodcom, CEMBUREAU and CSI

In terms of the geographical distribution of cement production, the largest EU producer is Germany (13% of Portland* cement production and 53% of other hydraulic cement by weight). Looking at Portland* cement alone, the main EU producers are Italy, Germany, Spain, France and Poland, which collectively account for 57% of total EU production.

Industry size, structure and performance – In 2015, the most recent year of available comparative Eurostat data, the cement manufacturing industry in the EU represented an estimated €15.2 billion turnover and €4.8 billion in value added. Germany, France, Italy, Spain, Poland and Belgium together accounted for 71% of EU's turnover, 68% of EU's value added, 70% of EU's enterprises and 68% of EU's employment in the cement sector. In 2015, the sector offered employment to 47 thousand persons in the EU, distributed over around 350 enterprises. The average number of employees per enterprise for the EU was 137 persons. However, for individual countries, this number varied from above 400 in France to less than 50 in Ireland.

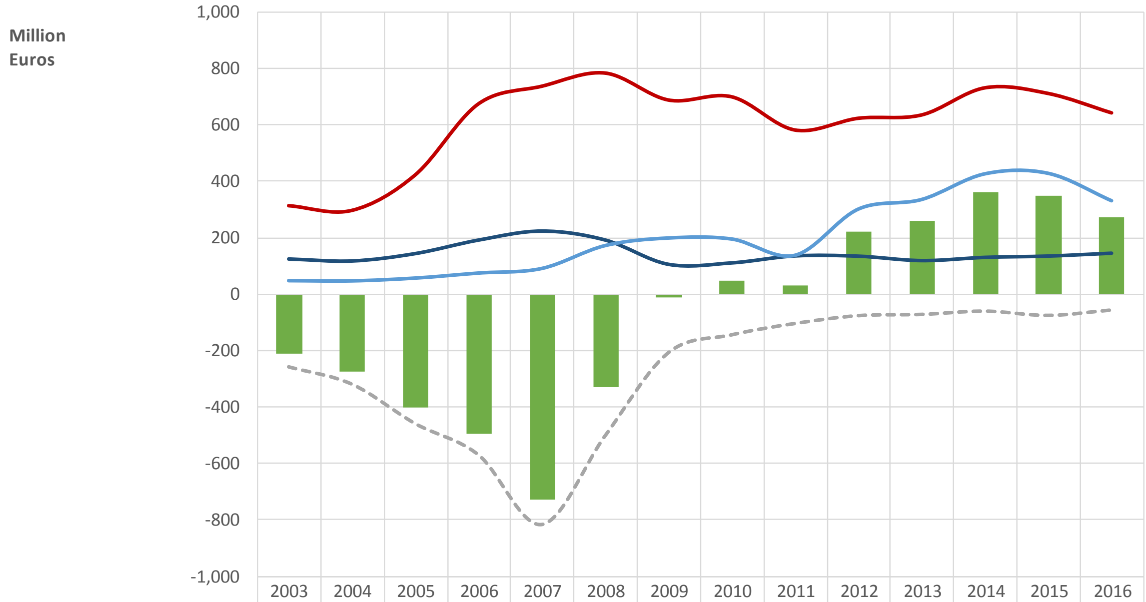
The generated turnover of €15.2 billion resulted in an average turnover per person employed of €320 thousand; this compares to an estimated average for manufacturing as a whole of €238 thousand. The industry was seriously affected by the 2008 economic crisis: between 2008 and 2015, turnover declined by 37%, value added by 49%, employment by 25% and the number of enterprises by 20%. After stabilising somewhat between 2013 and 2015, there is evidence of some limited improvement between 2015 and 2016. It appears that the modest improvement in construction activity since 2013 is slowly feeding through to production volumes for 'articles of concrete, cement and plaster' and, in turn, cement production.

Production costs – The average EU production cost is around €48 per tonne (2012 official data), but within the sample, the costs per tonne range within the EU from €35 (minimum) to €73 (maximum). Main cost components are the energy costs, raw materials, maintenance costs and labour costs; these costs vary per kiln and per region. Industry representatives indicate that cement is currently (2017) sold for an average ex-factory price around € 60 per tonne, although this may vary significantly.

Global production - In 2015, according to CEMBUREAU, cement production in the EU28 amounted to 167 million tonnes, representing 4% of global production, placing the EU as the third largest producer behind India with a production of 270 million tonnes. China dominates global production with an estimated volume of 2.35 billion tonnes representing 51% of global production in 2015.

International trade – Cement clinker is a crucial intermediary product for cement, which tends to be used directly as input for the production of cement on-site and therefore often does not reach the market. However, there have been large shifts in the EU trade position for cement clinker over the past decade and a half (see Figure 4). Prior to the economic crisis in 2007, the EU28 maintained an increasing trade deficit. Since 2010, however, the EU enjoys a trade surplus in cement clinker, while intra-EU trade has remained relatively stable, hovering around €120 to 150 million per year. Since 2009, cement clinker has increasingly found its way to non-EU28 partners, leading to an extra-EU export value exceeding €400 million in 2014 and 2015, accounting for over half of the value of sold clinker production.

Figure 4 **Trade pattern for cement clinker, for EU28 (in € million)**



	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016
Extra-EU trade balance	-212	-274	-404	-497	-727	-332	-11	49	31	222	261	363	350	272
Sold production	315	299	425	676	739	785	690	701	583	625	637	733	713	644
Intra-EU trade (exports)	124	116	143	193	225	193	104	109	135	134	118	129	134	145
Extra-EU export	47	47	57	74	91	171	198	195	137	300	334	425	427	330
Extra-EU [-] imports	-259	-321	-460	-571	-817	-503	-209	-146	-106	-78	-74	-62	-77	-58

Source: Eurostat Comext for trade data, Prodcom for production data. Ecorys calculations.

Key trade indicators (import penetration, export ratio, trade intensity) for cement clinker[3] demonstrate the overall high trade intensity for cement clinker, which remains an important indicator for the sector. The data also reveal a switch from a high trade intensity driven by imports to a high trade intensity driven by exports; between 2007 and 2015 the EU import intensity for cement clinker fell by 35 percentage points, while the export ratio increased from 12% to 60% of sold production.

Traditionally, Belgium, Germany and France have been among the largest traders in cement clinker, but in more recent years Spain and Greece have emerged as most important exporters. The top-10 destinations for cement clinker exports from the EU are mostly in Africa, completed by Israel, the USA and Brazil. Import sources are much less diversified, with Colombia and Turkey accounting for two thirds of EU clinker cement imports. At a global scale, only two EU Member States make it to the top-10 list of largest exporters on the global scale (Spain – 3rd, and Greece – 10th).

The value of Portland* cement production decreased drastically over the last decade, though it has been rather stable since 2013 at some €10 billion per year. Internal EU-trade has remained relatively stable at around 10% of the production, while extra-EU exports are at half this level. As there is hardly any import from non-EU countries, the trade balance with the rest of the world has been positive for every year between 2006 and 2015. Trade to non-EU partners has been steadily increasing over time, and extra-EU exports increased by almost 75% between 2011 and 2015. Portugal, Greece and Italy are the main sources of this increase in exports. In 2015, Algeria was the main export destination, accounting for a little over a quarter of the total EU exports in Portland* cement. EU imports are predominantly sourced from neighbouring Turkey and Switzerland (more than half of the imports).

[3] Based on the value of sold production and extra-EU trade flows. As shown in the background report, if total production data is used instead of sold production, the calculated trade indicators (import penetration, export ratio, trade intensity) are substantially lower.

Product substitution - Product substitution is a highly relevant aspect for the competitiveness analysis of the sector. As concrete is currently the most widely used construction material, it is nearly impossible to completely replace it with other materials. Nevertheless, concrete as a sustainable construction material has been challenged due to its association with the CO2 inherent in the production of cement, despite cement only accounting for 10-12% of the composition of most concrete. Cement/concrete also has complementarities with other types of construction products, such as steel. In order to allow for a fair assessment of cement in relation to competing products, the study points to the need for comprehensive and comparable life cycle assessments (LCAs) which include all assessments of sustainability.

R&D&I – Research and innovation is present throughout the European cement and concrete supply chain and, according to several publications coming from industry associations, prioritises efforts to reduce the sector's environmental footprint. The areas for R&D activities commonly mentioned are related to resource and energy efficiency (circular economy), carbon sequestration and reuse and product efficiency.

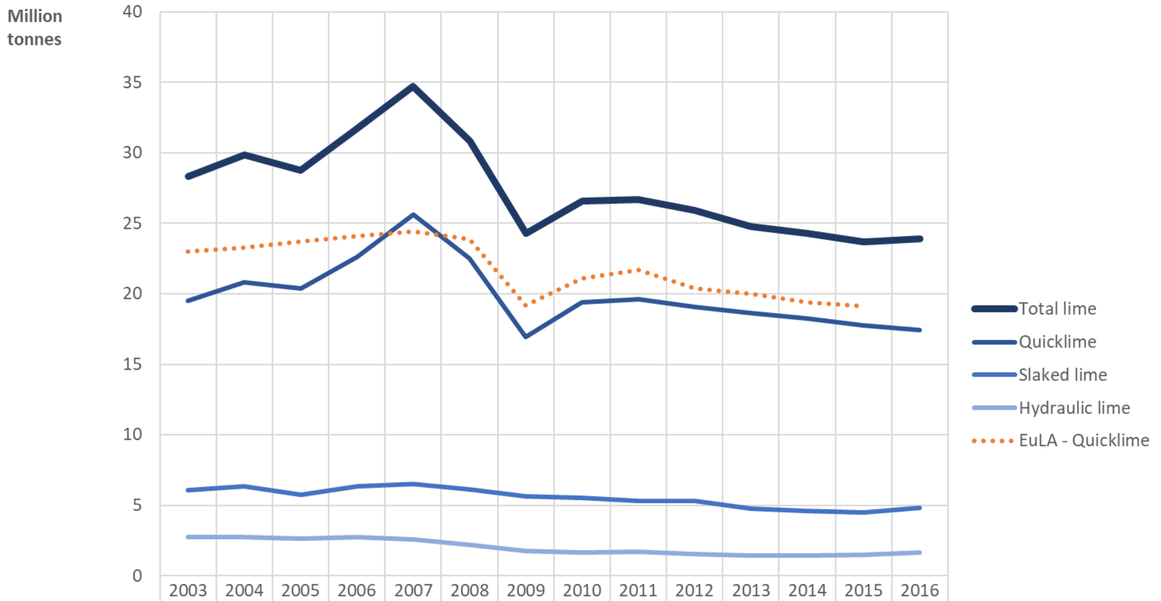
III. EU lime industry profile

Product overview – Due to its particular chemical characteristics, lime is a fundamental raw material used for a multitude of industrial processes and different economic activities. The iron and steel industry is the most important customer for lime products, followed by environmental protection services, such as water treatment or agricultural applications. The potential relocation of steel production to locations outside of the EU is seen as a serious threat by the industry.

Production and supply chain - In most cases, quarrying and lime production activities are integrated, with production plants situated close to sources of raw material (i.e. limestone quarries), so as to minimise transport costs. Typically lime producers will own the quarrying site, although quarrying activities may be contracted out to a separate specialist company. Lime production is highly energy intensive, while carbon dioxide (CO2) is an inevitable bi-product of the calcination process. In contrast to cement production processes, lime production has limited flexibility in use of alternative fuels, due to the impact of energy sources on the purity and cleanliness of final products.

Production of lime – EU28 total production of lime products amounted to an estimated 23.9 million tonnes in 2016 (Figure 5), with a value of €2.0 billion. These amounts compare with a peak production volume of 34.7 million tonnes in 2007 and a sales value of €2.4 billion in 2008. Within these totals, quicklime accounts for three-quarters (75%) of total sales volumes and values in 2016, slaked lime accounts for a further fifth (20%) of sales, and hydraulic lime around 5%. In terms of the geographical distribution of lime production, the largest EU producer is Germany (29% of total lime production by weight), followed by France, Italy, Poland, Spain and Belgium).

Figure 5: EU28 lime – quantity of sold production 2003-2016



	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016
Total lime	28.3	29.9	28.7	31.7	34.7	30.9	24.3	26.6	26.7	25.9	24.8	24.3	23.7	23.9
Quicklime	19.5	20.8	20.4	22.6	25.6	22.5	16.9	19.4	19.6	19.1	18.6	18.2	17.7	17.4
Slaked lime	6.1	6.3	5.7	6.3	6.5	6.1	5.6	5.5	5.3	5.3	4.7	4.6	4.5	4.8
Hydraulic lime	2.8	2.7	2.6	2.8	2.6	2.2	1.7	1.7	1.7	1.5	1.4	1.4	1.5	1.7
EuLA - Quicklime	23.0	23.3	23.7	24.1	24.4	23.9	19.2	21.1	21.7	20.4	20.0	19.4	19.1	

Source: Ecorys based on Eurostat Prodcom and EuLA.

Size, structure and performance[4] – In 2015, the most recent year of available comparative Eurostat data, the lime and plaster manufacturing industries in the EU represented an estimated €4.2 billion turnover and €1.4 billion in value added, with approximatly 600 enterprises offering employment to almost 15 thousand persons in the EU. The average turnover per person employed is around €290 thousand (this compares to an estimated average for manufacturing as a whole of €238 thousand). In 2014, the average number of employees per enterprise for the EU was 24 persons, indicating the small size of the majority of EU lime and plaster companies. In 2015, Germany, Belgium, Italy, France, Spain and Poland together accounted for 76% of total EU turnover of lime and plaster manufacturing, 74% of value added, 64% of employment but only 43% of enterprises. Since 2008, Italy and Spain have seen the most significant decline in their share of total EU lime and plaster manufacturing turnover, which has fallen by 6 and 5 percentage points respectively.

The industry faced a decline in turnover between 2008 and 2009, with a fall of around 14%, followed by a slight rebound in 2010. It has remained relatively stable thereafter at around 90% of its 2008 (pre-crisis) level. Value added generated by the industry shows a more persistent decline that continued until 2012 but that appears to have been strongly reversed since 2013. By contrast, both employment and the number of enterprises show a persistent decline with possible levelling off after 2013; between 2008 and 2015, employment is estimated to have fallen by 24%, to around 14.7 thousand employees, while the number of enterprises declined by 32%. It is notable that despite some improvement in production volumes for construction (and manufacturing) since 2013, and an apparent rebound in iron and steel production in 2010 and 2011 following the slump in the previous two years, lime and plaster production has endured a more persistent decline than that of its main downstream client industries. Therefore, the lime sector appears to be subject to structural forces rather than cyclical one's.

[4] Eurostat's Structural Business Statistics (SBS) database does not allow for a separation between lime and plaster manufacturing. On average we assess that lime accounts for approximately 70% of the combined production value. See section 3.4 in the main report.

Production costs – Data suggests that the average production costs vary between €55 and €70 per tonne of lime, depending on the type of kiln used and variations in the main cost elements. Main cost components are energy, raw materials and labour costs.

Global production & international trade – Data from the US Geological Survey (USGS), which is also reported by the International Lime Association, reveals that China dominates global lime production, producing an estimated 230 million tonnes in 2014 an increase of 64% since 2004 – and a volume about 10 times higher than in the EU. India has also seen a rapid expansion of lime production, with USGS data indicating a near 17-fold increase since 2004, although most of this increase occurred prior to 2010. Countries with the highest estimated growth rates over recent years (2009 to 2015) are Russia, Malaysia and South Korea.

International trade in lime products is limited as the wide geographical availability of raw materials (i.e. limestone) and the low value to weight ratio means that lime is typically produced close to markets and is not transported over long distances. International trade in lime is also limited relative to EU production. This applies to both trade within the EU (intra-EU trade) as well as the exports out of the EU (extra-EU exports). Trade within the EU fluctuates between €250 and €320 million and exports to partners outside the EU between €50 and €80 million. The EU has a small trade surplus in lime, which peaked at €60 million in 2008. Extra-EU exports in lime are spread among a number of Member States, with the five largest exporters (UK, Belgium, France, Spain, Germany) representing 65% of the total. The destination of EU exports is highly diversified. Over recent years, the main destinations for EU lime exports have been Russia, Switzerland, Ghana and Singapore. Norway is the main source of EU imports of lime, accounting for 84% of all imports sourced from outside the EU. Switzerland and Belarus, which together account for 11% of imports, are the next largest suppliers of lime to the EU market.

R&D&I – The lime industry R&D&I investments are mostly directed towards improvements in production process, innovative new products or applications and increased energy efficiency. A key cross-cutting focus is put on the reduction in the environmental footprint of the industry, for instance by cutting GHG emissions. Findings from the interviews indicate that in some cases – especially with regards to CO2 emission reduction technologies – research is too expensive for single companies.

IV. Regulatory and other framework conditions

The operation of cement and lime companies is affected by a set of rules defining standards and form of production, their location and output. This study focuses on EU rules and hence only touches upon national specificities or laws where they are in a direct relationship with EU "acquis". For the prioritisation, the Research Team used the responses to the questionnaires. The four most pressing issues identified by the companies are the same as the ones by the industry associations. Climate and the EU ETS[5], (access to) natural resources, energy legislation and industrial emissions are seen as the most important legislative areas. Climate and ETS are seen by the companies as the most relevant regulatory issue.

[5] The EU emissions trading system (EU ETS) is a cornerstone of the EU's policy to combat climate change and its key tool for reducing greenhouse gas emissions cost-effectively.

Climate and ETS – The production of cement and lime causes CO2 emissions. Approximately two thirds of the emissions are 'process emissions' and one third 'combustion emissions'. The current set-up of the ETS system causes an interlinked opportunity and a threat to the competitiveness of both industries. Even though currently protected by the carbon leakage list, the potential future impact of the ETS system may cause increased cost for the industries and therefore provide an incentive to innovate in the field of GHG reduction. Both the cement and lime industries currently receive free allowances (based on a benchmark) as they are on the carbon leakage list. Based on the current proposals being discussed in the context of the ETS revision for phase IV, it seems likely that both sectors will remain on the carbon leakage list, however this is subject to the final decision by Council and European Parliament. With regard to the future, given their high emissions and long-term use of capital investments (e.g. investments for each adjustment of technology amount to several million euro and is therefore intended to be used for many years - a kiln's lifetime is between 30-50 years), the industries perceive potential policy changes in the ETS segment (including those post 2030) as a risk for business operations and thus call for long-term policy stability.

(Access to) natural resources – A number of legislative acts have been developed through time to preserve and strengthen the EU environment. Those which limit the access or form of access to raw materials are the most relevant for the cement and lime industries (e.g. Natura 2000 and the Mining Waste Directive). Specific concerns relate mainly to often complex and unpredictable permitting procedures at national, regional and local level as well as differences in the transposition of EU provisions among Member States.

Energy legislation – The manufacturing of cement and lime is highly energy intensive, particularly in heating the kilns (heating and cooling) and electricity use in the grinding process. The broad set of EU energy legislation impacts the competitive position of both the cement and lime industries. The identified key impacts are differences in energy costs internally (between MS) and externally (between EU and non-EU) and the increased potential for the use of alternative fuels. However, the specific impacts depend on the supply strategies chosen by industries. In contrast to cement production processes, lime production has limited flexibility in use of alternative fuels, due to the impact of energy sources on the purity and cleanness of final products.

Industrial emissions – The Industrial Emission Directive (IED) is the main piece of EU legislation in the area of industrial emissions. The legislation impacts the industry competitiveness by providing harmonised requirements that are technically and economically viable for industry in order to improve their environmental performance, and creating a level playing field and harmonizing costs and benefits within the EU. Towards outside EU competitors, these requirements can lead to differences in production costs.

The above regulatory and other framework conditions tend to change over time. Changes in the regulatory framework of outstanding importance have been taken as a basis for the scenarios. Changes in other framework conditions are taken as ceteris paribus, because their effect is understood by the Research Team, stakeholders and the Commission as of lesser importance.

V. Assessment of industry competitiveness and scenarios for the future

The analysis points to the cement and lime industries as mature sectors, which are vital for a range of downstream industries, products and services. Over the last 10 years, both sectors have witnessed major downturns, and future prospects are less than certain. Additional analysis has pointed to a sharp decline in profitability over the period 2007-2009 for both sectors, followed by some recovery since 2010. A key issue for both the cement and lime sectors and, in turn, for policy makers, is to better understand how resilient the sectors are when responding to external shocks, notably changes in demand, but also regulatory reforms and new initiatives (at EU, national, regional and local levels). The research to date points to the possibility of further regulatory changes, and a number of parameters are at play. It is yet uncertain how these will work out for the sectors, and projecting a single forecast for these industries appears less than appropriate.

Scenario development - In the context of this study, a number of scenarios were developed to explore the potential impact of a variety of potential exogenous as well as policy changes on the cement and lime industries and on the EU's trade position in these products. The scenarios were developed with the aim to test the 'resilience' of the EU cement and lime industries vis-à-vis exogenous as well as policy-driven changes. The scenarios and their underlying assumptions have been developed on the basis of exchanges with the European Commission and industry representatives accompanying this study. The scenarios have been constructed around fictive possible future changes each of them intersecting distinct points in the value chain. These fictive policy interventions are not to be confused or compared with the development of real EC policy initiatives - which would require a systematic and formal impact analysis [6]. However they are considered informative as the scenarios produce distinct reactions in terms of outputs, imports/exports and employment. Nevertheless, when interpreting the results of a model it should always be borne in mind that it will always paint a simplied situation of the reality, and that other factors outside the model may play a role in the business reality as well. The results of this model exercise can therefore only be indicative.

Several scenarios have been assessed with the ADAGIO-model[7]:

- Scenario I: Targeted energy prices: The cement and lime sectors are confronted with a tax increase on their energy inputs amounting to 25% of previous energy costs;
- Scenario II: Blanket energy prices: all economic sectors are confronted with an energy tax increase equivalent to 10% of energy costs;
- Scenario III: Product tax: A product tax of 25% is levied on cement and lime. Changes in legislation do not affect the cement industry directly, but rather the users of their output;
- Scenario IV: Production tax: The cement and lime sector is faced with new legislation whose implementation raises production costs by 5%. This implies that, contrary to scenario II, non-cement and non-lime industries will not be directly affected;
- Scenario V: Delocalisation of downstream industries (lime only): The steel industry, a major customer of the lime industry, continues to reduce its operations from the EU.

ADAGIO-model – The scenarios have been simulated using the ADAGIO-model, which is described in the main report, including details of the assumptions underlying the model. It is important for the interpretation of the modelling results to note the following: (i) simulated interventions are assumed to be introduced on top of the existing state of the economy; (ii) the simulation set-up does not include reactions of final demand, for example it is assumed that any

[6] For example with the help of dedicated energy models such as PRIMES, the European Commission is developing analysis tools in the areas of energy, climate and transport. It allows policy-makers to analyse the long-term economic, energy, climate and transport outlook based on the current policy framework. It is not designed as a forecast of what is likely to happen in the future, but it provides a benchmark against which new policy proposals can be assessed. Detailed results on the 2016 Reference Scenario and EUCO scenarios are available under the following links:
https://ec.europa.eu/energy/sites/ener/files/documents/ref2016_report_final-web.pdf
https://ec.europa.eu/energy/sites/ener/files/documents/20170125_-_technical_report_on_euco_scenarios_primes_corrected.pdf

[7] See section 5.2 of the full Final Report for more details. Please note that the sectors 'lime and plaster' could not be divided in the statistics.

additional tax revenues are not distributed in a way that affects final demand; (iii) the own price elasticities of demand for cement and lime are assumed to be in the range of -0.5 (low estimate) to -1.5 (high estimate); (iv) cross-price elasticities with other sectors, such as wood and building material (+0.2) and steel (-0.2), reflect the balance between their demand complementarity and demand substitutability towards cement and lime (and plaster) products; (v) the simulation model assumes average factor shares for energy in the cement industry of 24% and 31% for the lime & plaster industries, based on estimates obtained from various sources. Given their importance for the model simulation results, sensitivity analyses of the assumed energy factor shares have been carried out; for example with a 30% energy factor share for cement (in scenario 1 and 2). In addition, sensitivity analyses have been performed using different long-run elasticities (in scenario 3) and other 'impact' percentages (e.g. for the price decrease in scenario 1).

Scenario 1: Targeted Energy Prices - Increasing the energy costs by 25% (e.g. by implementing new energy taxes) would result in output prices rising by around 4.7% for cement and 4.5% for lime & plaster. This upward pressure on output prices would apply to resident firms, but leave import prices unchanged. This leads to a disadvantage for domestic production, which would drop by around 3-4% in volume terms, while imports from outside the EU would increase by 5.3% for cement and 6% for lime. An intended (favourable) impact would therefore be substantially dampened ("carbon leakage" in the case of emissions). According to the model, the results are roughly linear with respect to the increase in energy prices – a doubling of the increase would have around double the effect on output prices, and double the effect on real production volumes.

Scenario 2: Blank Energy Prices - The economy-wide effect of a 10% increase in energy costs would according to the model lead to an increase of 1.8% in cement prices and 1.9% of lime & plaster. This would lead further to a reduction of real output of 2.6% for lime & plaster and 2.8% for cement. The cement and lime sectors being among the most energy intensive ones, the impact on prices and real output is markedly above average. Price increases lead to even higher reductions in output (partially compensated by higher import volumes). This (partial) substitution of domestic production by imports might dampen the (favourable) impact on the energy content of cement and lime demand ('carbon leakage').

Scenario 3: Product tax – According to the model, there is a substantial impact on demand driven by the price increase for cement and lime users. The price increase combines both an indirect impact that results in an increase in output prices (+1.7% cement, +1.2% lime & plaster) and the 25% tax, such that user prices increase by 26.7% for cement and 26.2% for lime & plaster. Assuming short-run price elasticity of -0.5, the demanded quantity is simulated to fall by more than a tenth; if a long-run elasticity of -1.5 is used, the drop in demand and output would rise to a quarter. In contrast to Scenarios I, II, and IV, the product tax applies to all products, domestic and imported. This would avoid trade distortions and "unintended consequences" ('carbon leakage' in the case of emissions).

Scenario 4: Production tax - A fictive (unspecified) regulation adding 5% to the costs of production would result in output prices rising by around 3% for lime and 4.2% for cement. This upward pressure on output prices applies to resident firms, but they leave import prices unchanged. This leads to a disadvantage for domestic production, which would drop by around 2.3% for lime and 3.5% for cement. In parallel, import would increase by 3.5 - 4%. Any intended (favourable) impact would therefore be substantially dampened ("carbon leakage" in the case of emissions).

Scenario 5: De-localisation of downstream industries (lime only) - This scenario focuses on steel production which has high regional variability, which implies, naturally, high regional variability of demand for lime from this source. Thus, the importance of the steel industry for its European suppliers is sizable. The lime industry, however, represents only a small part of these interlinkages in absolute numbers. A drop of steel output by 10% would lead to an average drop of lime by 1.2%, however impacts on individual lime plants could be larger.

VI. Conclusions and recommendations

EU Cement industry - Cement so far remains (despite existing and expected potential further tradability) within the EU context above all a local product which is usually sold in relatively close geographical proximity to the production site. Being part of the civil engineering and construction value chain, the EU cement sector is highly cyclical and external shocks on demand can have substantial consequences for the sector. This is shown by the turnover decline by 38% between 2008 and 2015, value added by 47%, employment by 27% and the number of enterprises by 2013. Only recently, signs of recovery from the crisis have occurred. Access to international markets can serve as an important possibility to cushion the fluctuations on domestic markets, but also contains a risk as facilitated trade goes both ways.

EU competitiveness vs. Non-EU in cement – China is producing more than 50% of the world's cement, while countries neighbouring the EU competitors may face lower costs. Under the modelling framework and specific scenario set-up, there is a risk of increased import penetration as a consequence of policy measures such as targeted or blanket energy taxes or production taxes. Only one scenario (nr. 3) points toward a level playing field between the EU industry versus non-EU players. Another aspect influencing EU competitiveness is long-term stability and predictability of policy frameworks. Particularly concerning ETS policies, companies call for further long-term stability (post 2030). In response to this situation, policy makers are required to actively monitor neighbouring countries and transport costs, launch initiatives to retain a level playing field between EU and non-EU producers and consider actions to address the problem of carbon leakage for all industries.

Competitiveness between EU Member States – Cement remains largely a local market, not being affected by national borders, but proximity to clients. Due to the crisis in the Spanish construction market, local producers cut costs and shifted towards exports. This situation requires from policy makers to remain attentive to regional impacts of EU policy changes.

Competitiveness of cement versus other products – Main potential substitutes of cement are wood and steel. Both products are however not only substitutes, but also complementary products. Existing LCAs suggest different priorities of construction materials, depending on the scope and methodology of the LCA. Policy makers should therefore support the development of a comprehensive life cycle costing approach at the level of construction works and adhere to material neutrality. In light of the ambitions as formulated in the Paris Agreement, more will need to be done to reduce the CO2 emissions of the sector. Thereto, 'out of the box' but cost-effective solutions to address CO2 emissions will need to be developed in the years to come, taking into account a full supply chain approach.

Overall conclusions for EU Lime industry - Lime so far remains (despite existing and expected potential further tradability) within the EU context above all a local product which is usually sold in relatively close geographical proximity to the production site. The structural decline in the EU industrial basis (particularly steel industry) has already had a profound impact on the EU lime sector. Lime prices vary fairly strongly within the EU, underlining the broad product differentiation, the wide divergence in terms of productivity, as well as limited trade intensity due to the rather low value/weight ratio. Nevertheless, an upward trend can be identified in both export and import intensity of lime.

EU competitiveness vs. Non-EU in Lime – The current development is driven by sluggish domestic demand in the EU. Low transport costs (particularly sea transport) support the EU manufacturers' activities to export surplus production based on high value speciality products. The foreign trade balance is fragile and remains vulnerable to changes in price differentials, induced by changes in input costs, taxes or duties. Under the modelling framework and specific scenario set-up, there is a risk of increased import penetration as a consequence of policy measures such as targeted or blanket energy taxes or production taxes. Only one scenario (nr. 3) points toward a level playing field between the EU industry versus non-EU players. In response to this situation, policy makers are required to actively monitor neighbouring countries and transport costs, launch initiatives to retain a level playing field between EU and non-EU producers and consider actions to address the problem of carbon leakage for all industries and promote investments in innovation based on long-term policy stability.

Competitiveness between EU Member States – Lime remains largely a local market, not being affected by national borders, but proximity to clients. In 2015, France, Germany and Belgium accounted for more than 69% of EU trade (exports), revealing a higher concentration than for production. The most cost-competitive Member States are Hungary, Romania and Slovakia, all being in border regions facing strong price competition from outside the EU. Competitiveness between EU Member States is hence affected by impacts of regional policy measures, but also proximity to outside EU competition. The model exercise points to more pronounced impacts of policy measures to Southern and Eastern European regions. Consequently, policy makers should remain very attentive to regional impacts of EU policy changes.

Competitiveness of Lime versus other products – Currently, fear for substitution of lime products appears to be not founded, despite partial substitution through e.g. chemicals. However, this may change in the future. More important for lime is its interdependent relationship with downstream production processes. Its main client, the steel industry is facing serious and structural problems in recent years and shows concentration effects. This causes challenges for the lime industry as it might lose major clients or end up in situations where the client dictates the price. Policy makers should thus consider the impact on up- and downstream industries in policy making and monitor the development of downstream industries.

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