CLIMATE CHANGE
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Development of the cement clinker production under the EU ETS

Overview and country level analysis from 2005 to 2017

by:

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INFRAS, Zurich

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Abstract: Development of the cement clinker production under the EU ETS

The present report summarizes the main trends and drivers of the cement sector in the time period 2005-2017 in the EU28 and provides a compilation of key figures on the cement clinker industry for selected countries. The report focuses on the developments during the third trading period of the EU ETS since 2013 and analyses the countries with the highest contribution to total emissions within the EU28 (i.e. Germany, Spain, France, United Kingdom, Italy, Poland and Greece).

The factsheets show the evolution of GHG emissions and cement clinker production over time and the change in emission and energy intensity as well as shares of biomass and alternative fuels in the clinker manufacturing process. Furthermore, the evolution of the share of clinker in cement is described. Besides the characteristics of the clinker production process, the factsheets provide an overview of the development of imports and exports of cement clinker and Portland cement. In addition, the factsheets provide an overview of the largest production facilities per country.

External factors such as economic development in the construction sector and the demand for cement products seem to be the main driver of clinker production and therefore of GHG emissions in the time period 2005-2017. In most countries, there is a strong positive correlation between the production volume index of the construction sector and the production of cement clinker. Except for France and Italy, production of cement clinker increased between 2013 and 2017. In Italy, Spain and Greece, the economic and financial crisis in 2008 had a strong impact on the production of cement clinker, with production in 2017 still being substantially lower than in 2005 and many plants that ceased to operate. The clinker to cement ratio in 2005 and 2017 remained nearly unchanged. It depends primarily on the demand for certain cement products.

Kurzbeschreibung: Entwicklung der Zementklinkerproduktion im Rahmen des EU-ETS

Der vorliegende Bericht fasst die wichtigsten Trends und Einflussfaktoren der Treibhausgasemissionen des Zementsektors im Zeitraum 2005 bis 2017 in der EU28 zusammen und zeigt die wichtigsten Kennzahlen der Emissionsentwicklung für ausgewählte Länder in Form von Faktenblättern.

Der Bericht fokussiert auf die Entwicklungen der dritten Handelsperiode des EU ETS seit 2013 und analysiert die Länder mit dem höchsten Anteil an den Gesamtemissionen der EU28 (d.h. Deutschland, Spanien, Frankreich, Vereinigtes Königreich, Italien, Polen und Griechenland).

Die Faktenblätter zeigen die zeitliche Entwicklung der Treibhausgasemissionen und der Zementklinkerproduktion sowie die Veränderung der Emissions- und Energieintensität und der Anteile von Biomasse und alternativen Brennstoffen im Klinkerherstellungsprozess. Zudem ist die Entwicklung des Anteils von Klinker im Zement beschrieben. Neben den Kennzahlen des Klinkerherstellungsprozesses geben die Faktenblätter auch einen Überblick über die Entwicklung der Importe und Exporte von Zementklinker und Portlandzement. Zudem geben die Faktenblätter eine Übersicht über die größten Produktionsanlagen pro Land.

Externe Faktoren wie die wirtschaftliche Entwicklung im Bausektor und die Nachfrage nach Zement scheinen die wichtigsten Treiber der Klinkerproduktion und damit der THG-Emissionen im Zeitraum 2005-2017 zu sein. In den meisten Ländern gibt es eine starke positive Korrelation zwischen dem Index der Baukonjunktur und der Produktion von Zementklinker. Außer in Frankreich und Italien ist die Produktion von Zementklinker zwischen 2013 und 2017 angestiegen. In Italien, Spanien und Griechenland hatte die Wirtschafts- und Finanzkrise im Jahr 2008 starke Auswirkungen auf die Produktion von Zementklinker. Die Produktion lag in diesen Ländern im Jahr 2017 immer noch deutlich unter dem Niveau von 2005 und viele Werke haben

ihren Betrieb eingestellt. Das Verhältnis von Klinker zu Zement blieb zwischen 2005 und 2017 nahezu unverändert. Der Klinkeranteil ist vor allem von der Nachfrage nach bestimmten Zementprodukten abhängig.

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List of abbreviations

CO_2	Carbon dioxide
CO_2eq	Carbon dioxide equivalent
CCS	Carbon capture and storage
CCU	Carbon capture and use
DE	Germany
ES	Spain
ETS	Emission trading scheme
EU28	Austria, Belgium, Bulgaria, Croatia, Cyprus, Czech Republic, Denmark, Estonia, Finland, France, Germany, Great Britain (EU exit on 31.01.2020), Greece, Hungary, Ireland, Italy, Latvia, Lithuania, Luxemburg, Malta, Netherlands, Poland, Portugal, Romania, Slovakia, Slovenia, Spain, Sweden
EUTL	EU Transfer Log
FR	France
GHG	Greenhouse gas
GNR	Getting the numbers right (database that provides data on the cement industry's CO_2 emissions and energy performance)
GR	Greece
IT	Italy
MSW	Municipal solid waste
ND	No data
NIR	National Inventory Report
NOx	Nitrogen oxide
PL	Poland
SCR	Selective catalytic reduction
SDG	Sustainable development goal
SRF	Solid recovered fuel
SSW	Solid shredded wastes
TOC	Total Organic Carbon
UK	United Kingdom
WtE	Waste to Energy

Summary

This report summarises the main trends and drivers of the cement sector's greenhouse gas emissions in the EU28 from 2005 to 2017, analyses the countries with the highest contribution of total EU28 emissions (i.e. Germany, Spain, France, the United Kingdom, Italy, Poland and Greece) and presents the key figures of the selected countries' emission trends in the form of fact sheets. This report aims to describe the main developments in the sector in the period from 2005 to 2017, i.e. before the end of the 3rd EU ETS[1] trading period in 2020. External factors such as economic development in the construction sector and the demand for cement products seem to be the main driver of clinker production and therefore of GHG emissions in the time period 2005-2017. In most countries, there is a strong positive correlation between the production volume index of the construction sector and the production of cement clinker. Except for France and Italy, production of cement clinker increased between 2013 and 2017. In Italy, Spain and Greece, the economic and financial crisis in 2008 had a strong impact on the production of cement clinker, with production in 2017 still being substantially lower than in 2005 and many plants that ceased to operate.

The share of emission intensive clinker in cement can be reduced by using less emission intensive substitutes, such as slag, limestone, gypsum and fly ash depending on the local availability of industrial waste and natural mineral resources. The clinker to cement ratio depends primarily on the demand for certain cement products with specific properties and clinker shares.

- The clinker to cement ratio in the EU28 has not changed significantly since the introduction of the EU ETS. While it decreased between 2005 and 2012, it has increased again to 77 % in 2017.
- The use of substitutes in cement production differs across countries, both in terms of quantity and quality, with the UK having the highest clinker to cement ratio (87 %) and Germany having the lowest clinker to cement ratio (72 %) in 2017.

Clinker exports increased between 2005 and 2017. For instance, in 2005, Spain was a net importer of cement clinker but since 2011, exports are greater than imports. Also in Italy, a slight increase in exports is observed since 2010.

Cement clinker production plants in the countries analysed in the present report show different levels of success to reduce GHG emission intensity by means of increasing the co-processing of biomass.

- The use of waste fuels in cement production strongly depends on country specific regulations and circumstances in the waste management sector. In most countries there is an increasing trend in recent years. In 2017, the highest shares of biomass are observed for Germany (21%) and Poland (23%), whilst Italy has the lowest share with only 3 % (see Table 4).
- The share of dry kilns, which exhibit the lowest emission intensity when operated at optimal conditions, shows an increasing trend in the EU28 and is at more than 80 % in 2017. There is however no substantial improvement in energy intensity of cement clinker production in the time period 2013-2017.

[1] Whenever the term EU ETS is used, it refers to the EU ETS 1 covering operators of large energy installations and energy-intensive industrial plants as well as aircraft and ship operators.

The present study provides a basis for further research on the impact of the EU ETS on GHG emissions especially after the year 2017. In the years 2018 to 2020, emissions in the cement sector in Germany and the rest of the EU developed differently - the slight increase in emissions in Germany compared to the decrease in EU ETS cement clinker production emissions in response to economic activity, which can be linked to the effects of the COVID pandemic, are not considered in this report. The decline in emissions in the cement sector since 2021 is due to declines in production, like in most sectors as a result of the effects of the Russian war of aggression in Ukraine. The associated uncertainties led to increases in energy prices, particularly for natural gas and electricity, to cost increases and thus to a decline in demand which is also not addressed in this report. Similarly, the changes in the macroeconomic framework as well as developments on the energy markets since then cannot be taken into account, nor can the potential impact of the 'Fit for 55' framework that was casted in law in 2023. Furthermore, EU allowance prices have risen substantially since 2018 (see e.g. DEHSt 2024 for a graphical illustration of the observed price developments).

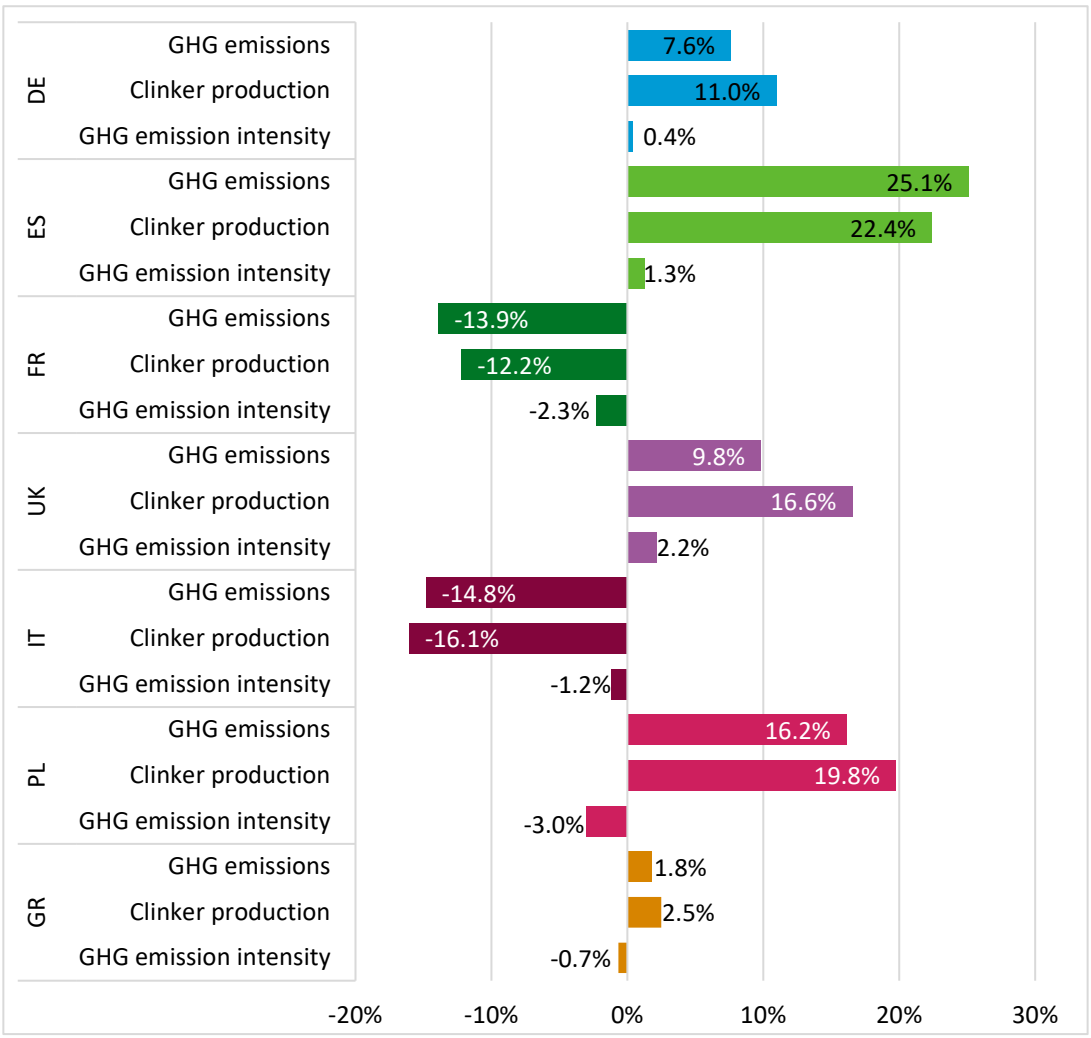
Table 1: Selected Member States: Key figures of cement clinker production in 2017

Cement clinker industry characteristics	Unit	DE	ES	FR	UK	IT	PL	GR	Source
GHG emissions	Mt CO_2eq	20	15	10	7	12	10	6	EEA 2019
Clinker production	Mt	25	18	11	8	13	13	7	UNFCCC 2019/GCCA 2020
GHG emission intensity	t CO_2eq/ t clinker	0.81	0.82	0.83	0.84	0.84	0.79	0.84	GCCA 2020
Energy consumption	PJ	95	40	46	25	43	48	ND	GCCA 2020
Energy intensity	GJ/t clinker	3.8	3.0	3.9	3.8	3.2	3.7	ND	GCCA 2020, EEA 2019, UNFCCC 2019
Number of cement clinker production plants	-	35	31	33	12	32	10	6	EEA 2019

Key figures of the cement clinker production in 2017 in the analysed countries. ND for no data.

Source: Own table based on various sources. UNFCCC 2019 stands for the following references: Germany (2019); Spain (2019); France (2019); United Kingdom (2019); Italy (2019); Poland (2019); Greece (2019).

Figure 1: Selected Member States: Change in key figures of cement clinker production between 2013 and 2017



Change in key figures of the cement clinker production between 2013 and 2017 in the analysed countries.

Source: EEA 2019, Germany (2019); Spain (2019); France (2019); United Kingdom (2019); Italy (2019); Poland (2019); Greece (2019), GCCA 2020

Zusammenfassung

Dieser Bericht fasst die wichtigsten Trends und Einflussfaktoren der Treibhausgasemissionen im Zementsektor in der EU28 von 2005 bis 2017 zusammen, analysiert die Länder mit dem höchsten Anteil an den Gesamtemissionen der EU28 (d. h. Deutschland, Spanien, Frankreich, das Vereinigte Königreich, Italien, Polen und Griechenland) und stellt die wichtigsten Zahlen zu den Emissionstrends der ausgewählten Länder in Form von Faktenblättern vor. Ziel dieses Berichts ist es, die wichtigsten Entwicklungen des Sektors im Zeitraum von 2005 bis 2017 zu beschreiben, d. h. vor dem Ende der dritten Handelsperiode des EU ETS[2] im Jahr 2020.

Externe Faktoren, wie die wirtschaftliche Entwicklung im Bausektor und die Nachfrage nach Zement scheinen die wichtigsten Treiber der Klinkerproduktion und damit der Treibhausgasemissionen (THG-Emissionen) im Zeitraum 2005-2017 zu sein. In den meisten Ländern gibt es eine starke positive Korrelation zwischen dem Index der Baukonjunktur und der Produktion von Zementklinker. Außer in Frankreich und Italien ist die Produktion von Zementklinker zwischen 2013 und 2017 angestiegen. In Italien, Spanien und Griechenland hatte die Wirtschafts- und Finanzkrise im Jahr 2008 starke Auswirkungen auf die Produktion von Zementklinker. Die Produktion lag in diesen Ländern im Jahr 2017 immer noch deutlich unter dem Niveau von 2005 und viele Werke haben ihren Betrieb eingestellt.

Der Anteil des emissionsintensiven Klinkers im Zement kann durch die Verwendung von weniger emissionsintensiven Ersatzstoffen wie Schlacke, Kalkstein, Gips und Flugasche verringert werden, je nach der lokalen Verfügbarkeit von Industrieabfällen und natürlichen mineralischen Ressourcen. Das Klinker-Zement-Verhältnis hängt in erster Linie von der Nachfrage nach bestimmten Zementprodukten mit spezifischen Eigenschaften und Klinkeranteilen ab.

- Der Klinkeranteil hat sich in der EU28 seit der Einführung des EU-ETS nicht wesentlich verändert. Während er zwischen 2005 und 2012 zurückging, ist er 2017 wieder auf 77 % gestiegen.
- Die Verwendung von Ersatzstoffen in der Zementproduktion unterscheidet sich von Land zu Land, sowohl in Bezug auf die Menge als auch auf die Qualität, wobei das Vereinigte Königreich 2017 den höchsten Klinkeranteil (87 %) und Deutschland den niedrigsten Anteil (72 %) aufwies.

Die Klinkerexporte sind zwischen 2005 und 2017 gestiegen. Spanien war beispielsweise im Jahr 2005 ein Nettoimporteur von Zementklinker, aber seit 2011 sind die Ausfuhren größer als die Einfuhren. Auch in Italien ist seit 2010 ein leichter Anstieg der Exporte zu beobachten.

Die Zementklinkerproduktionsanlagen in den untersuchten Ländern zeigen unterschiedliche Erfolge bei der Verringerung der THG-Emissionsintensität durch den Einsatz von Biomasse und alternativen Brennstoffen.

- Der Einsatz von alternativen fossilen Brennstoffen und Biomasse in der Zementherstellung hängt stark von den länderspezifischen Vorschriften und Gegebenheiten im Bereich der Abfallwirtschaft ab. In den meisten Ländern ist in den letzten Jahren ein steigender Trend zu verzeichnen. Im Jahr 2017 wurden die höchsten Biomasseanteile in Deutschland (21 %) und Polen (23 %) verzeichnet, während Italien mit nur 3 % den niedrigsten Anteil aufweist (siehe Table 4).

[2] Wenn der Begriff EU-ETS verwendet wird, bezieht er sich auf das EU-ETS 1, das die Betreiber von großen Energieanlagen und energieintensiven Industrieanlagen sowie die Betreiber von Flugzeugen und Schiffen umfasst.

- Der Anteil der Drehrohröfen mit Trockenverfahren, die bei optimalem Betrieb die geringste Emissionsintensität aufweisen, zeigt in der EU28 einen steigenden Trend und liegt 2017 bei über 80 %. Bei der Energieintensität der Zementklinkerproduktion ist im Zeitraum 2013-2017 jedoch keine wesentliche Verbesserung zu verzeichnen.

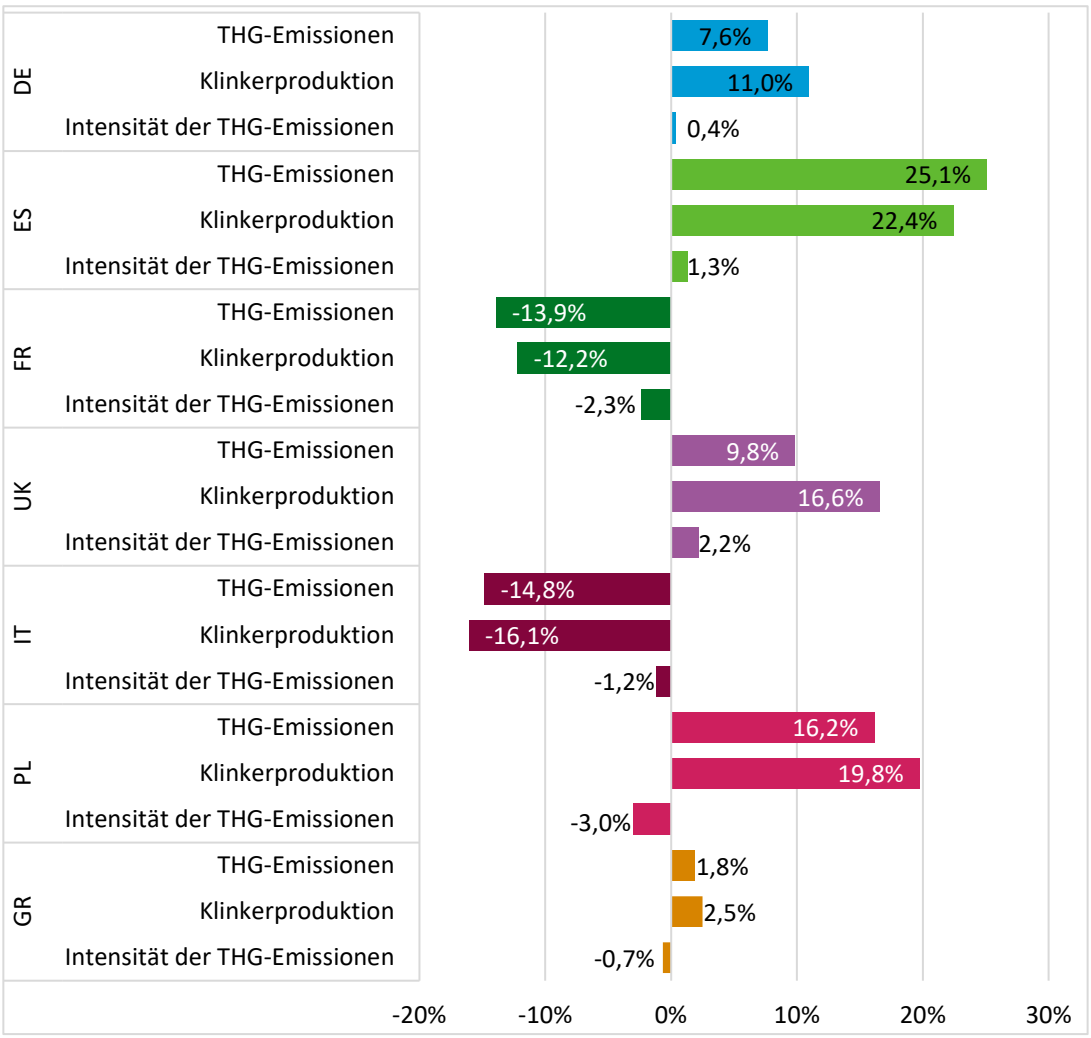
Die vorliegende Studie bildet eine Grundlage für weitere Untersuchungen zu den Auswirkungen des EU-ETS auf die Treibhausgasemissionen, vor allem nach dem Jahr 2017 und für eine weitere Verbesserung des Emissionshandelssystems der EU. In den Jahren 2018 bis 2020 haben sich die Emissionen des Zementsektors in Deutschland und in der übrigen EU unterschiedlich entwickelt - der leichte Anstieg der Emissionen in Deutschland im Vergleich zum Rückgang der Emissionen der Zementklinkerproduktion in den restlichen vom EU-ETS erfassten Ländern als Reaktion auf die Wirtschaftstätigkeit, die mit den Auswirkungen der COVID-19-Pandemie in Verbindung gebracht werden kann, wird in diesem Bericht nicht berücksichtigt. Der Rückgang der Emissionen des Sektors seit 2021 ist, wie in den meisten Sektoren, auf Produktionsrückgänge infolge der Auswirkungen des russischen Angriffskrieges gegen die Ukraine zurückzuführen. Die damit verbundenen Unsicherheiten, die zu einem Anstieg der Energiepreise, insbesondere für Erdgas und Strom, zu Kostensteigerungen und damit zu einem Nachfragerückgang führten, werden in diesem Bericht ebenfalls nicht behandelt. Ebenso wenig können die Veränderungen der makroökonomischen Rahmenbedingungen, die Entwicklungen auf den Energiemärkten sowie die möglichen Auswirkungen des „Fit for 55“-Paketes berücksichtigt werden, das 2023 gesetzlich verankert wurde. Darüber hinaus sind die Preise für Emissionsberechtigungen seit 2018 erheblich gestiegen (siehe z. B. DEHSt 2024 für eine grafische Darstellung der beobachteten Preisentwicklung).

Table 2: Ausgewählte Mitgliedstaaten: Kennzahlen zur Zementklinkerproduktion im Jahr 2017

Kennzahlen der Zementklinkerindustrie	Unit	DE	ES	FR	UK	IT	PL	GR	Source
THG-Emissionen	Mt CO_2eq	20	15	10	7	12	10	6	EEA 2019
Klinkerproduktion	Mt	25	18	11	8	13	13	7	UNFCCC 2019/ GCCA 2020
Intensität der THG-Emissionen	t CO_2eq/t clinker	0,81	0,82	0,83	0,84	0,84	0,79	0,84	GCCA 2020
Energieverbrauch	PJ	95	40	46	25	43	48	ND	GCCA 2020
Energieintensität	GJ/t clinker	3,8	3,0	3,9	3,8	3,2	3,7	ND	GCCA 2020, EEA 2019, UNFCCC 2019
Anzahl der Produktionsanlagen für Zementklinker	-	36	31	33	12	32	10	6	EEA 2019

Kennzahlen der Zementklinkerproduktion im Jahr 2017 in den untersuchten Ländern. ND steht für keine Daten.
Quelle: Eigene Berechnung basierend auf verschiedenen Datenquellen. UNFCCC 2019 beinhaltet die folgenden Quellen: Germany (2019); Spain (2019); France (2019); United Kingdom (2019); Italy (2019); Poland (2019); Greece (2019).

Figure 2: Ausgewählte Mitgliedstaaten: Veränderung der Kennzahlen der Zementklinker-produktion 2013-2017



Veränderung der Kennzahlen der Zementklinkerproduktion zwischen 2013 und 2017 in den untersuchten Ländern.
Quellen: EEA 2019, Germany (2019); Spain (2019); France (2019); United Kingdom (2019); Italy (2019); Poland (2019); Greece (2019), GCCA 2020

1 Introduction

1.1 Motivation

Cement clinker production is one of the most important sources of greenhouse gas (GHG) emissions in the industrial sector, since GHG emissions originate not only from combustion of fossil fuels, but also from the calcination of limestone. To be in line with the Paris Agreement, GHG emissions from cement clinker production need to be reduced substantially.

The emissions trading scheme of the EU (EU ETS[3]) is a key policy instrument for reducing GHG emissions from energy intensive industrial sectors in Europe. However, emissions from industrial installations were more driven by economic activity and production levels in the past than by the price for an emission allowance (Nissen et al. 2020). The price of an emission allowance was also low (< 10 €) for a long time period before it started to rise substantially and continuously since the end of 2017. A deeper understanding of the development of the cement clinker production sector, and the drivers of emissions development in the past is necessary in order to assess the potential impact of the EU ETS in the future, i.e. when the price of emission allowances is substantially higher.

The present study provides a data base for further research on the drivers of GHG emissions development from cement clinker production in the past. This is supposed to help gain a better understanding on the possible impact of the EU ETS in the future. To this end, we identified countries that play an important role in the cement clinker production of the EU. For the selected countries we compiled country factsheets on the most important drivers of GHG emissions from cement clinker production. These factsheets summarize trends in terms of GHG emissions, amount of cement clinker production, production technologies as well as market evolution and the regulative framework at the country level. Furthermore, they show the evolution of emissions at the facility level in each country.

The present report summarizes the main trends and drivers of the cement sector in the EU28[4] (see chapter 2) and provides a compilation of country fact sheets for selected countries (see chapter 3 - 9).

1.2 Country selection

We selected countries to be further analysed in the country fact sheets based on a set of predefined screening criteria.

The compilation of the final country list is based on the country's contribution to total GHG emissions of cement clinker production, on data availability and quality, a broad representation of technologies as well as trends in GHG emissions and GHG emission intensity.

The screening finally led to the selection of the following countries: Germany, Spain, France, United Kingdom, Italy and Poland. In addition, a shorter factsheet is provided for Greece[5]. Figure 3 shows the share of these countries' GHG emissions from cement clinker production in total

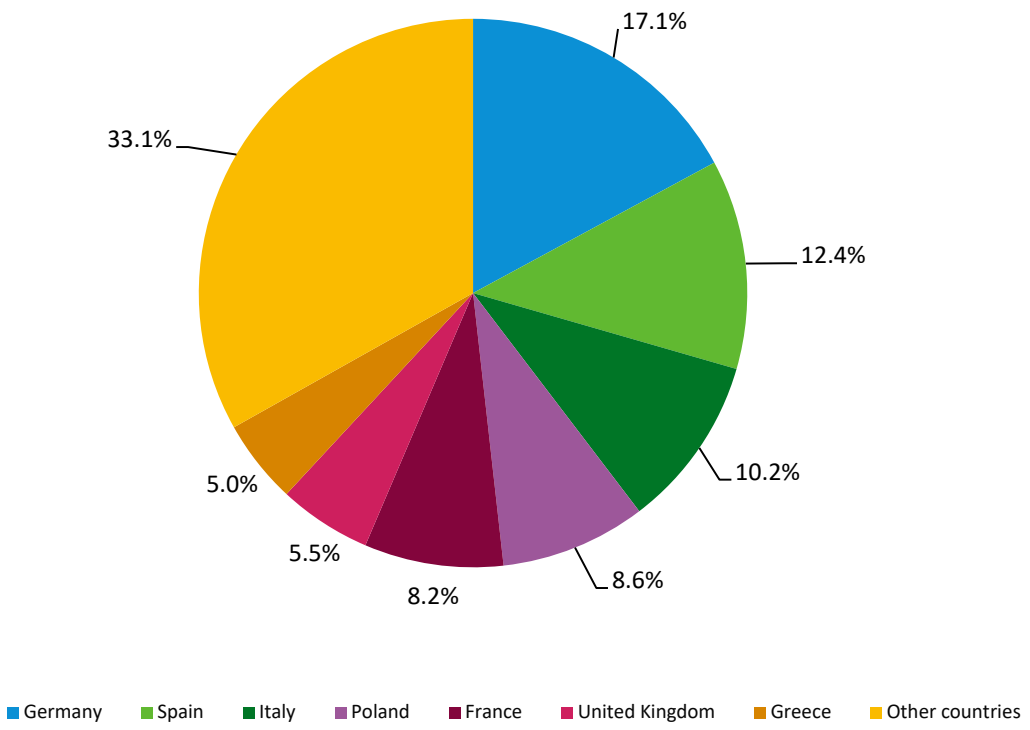
[3] Whenever the term EU ETS is used, it refers to the EU ETS 1 covering operators of large energy installations and energy-intensive industrial plants as well as aircraft and ship operators.

[4] During the reference period investigated in this report (2013-2017), UK was still part of the EU28. UK is therefore included in the present report and data is provided for EU28. The UK has left the EU28 and the EU ETS and runs its own ETS since the beginning of 2021.

[5] For Greece a shorter factsheet is provided due to limited data availability. Therefore, the tables and figures of the factsheet for Greece are not as comprehensive as the information provided in the other factsheets.

EU28 in 2017. The countries investigated for this industry dossier account for 67 % of GHG emissions from cement clinker production in the EU28 in 2017.

Figure 3: Share of selected countries in total EU28 GHG emissions from cement clinker production in 2017



Source: EEA 2019

For each of these countries we compiled trends in terms of GHG emissions, amount of cement clinker production, production technologies as well as market evolution and the regulative framework. In addition, a shorter fact sheet is provided for Greece, which focuses mainly on emission and production trends as well as the import and export situation.

The screening criteria used to assess data availability and quality are derived from the following data sources:

- Annual time series of GHG emissions: Data are taken from the EU Transaction Log (EEA 2019), code 29 "Production of cement clinker". Annual data are available for each country and installation for the entire time period.
- Annual time series of cement clinker production: Data are taken from the cement sustainability initiative "Getting the numbers right"[6]. When the present report was prepared, data were available up to 2017 (GCCA 2020). More recent versions of the dataset are available but could not be considered in the present report. For Spain and the UK, cement clinker data are taken from the National Inventory Report, NIR (UNFCCC 2019)[7], due to

[6] As the GNR dataset published by GCCA is based on voluntary reporting, the coverage is incomplete for some countries and is therefore affected by uncertainties, which could not be assessed in the present report.

[7] The common reporting formats referred to by UNFCCC 2019 are the following references: Spain (2019); United Kingdom (2019).

insufficient coverage of the GNR dataset published by GCCA. Annual data are available for each country for the entire time period.

- Annual time series of the share of biomass fuels and clinker to cement ratio: Data are taken from cement sustainability initiative "Getting the numbers right" (GCCA 2020). Annual data are available for each country for the entire time period.

The ETS operates in trading phases (2005-2007, 2008-2012, 2013-2020, 2021-2030). Between the trading phases, the framework of the EU ETS has undergone several revisions affecting the scope in terms of emissions and type of installations covered by the EU ETS. Therefore, the emission data from the EUTL are affected by changes in the scope between the different trading phases (which was not the case in the cement clinker industry, though). Therefore, in the present report we focus on the short-term trend in the time period of 2013-2017. This time period is not affected by any changes in the scope of the EU ETS and corresponds to the latest available data basis at the time the present study was prepared.

However, the fact sheets cover the time period since the beginning of the EU ETS in 2005 until 2017. For some of the criteria also the long-term trend since 2005 is described.

2 The cement sector in EU28

The following sections provide a short overview of the cement manufacturing process, characterize the cement sector in the EU28[8] and summarize mitigation measures and key factors influencing the evolution of emissions from the cement production sector.

2.1 Cement manufacturing process

Cement clinker is produced from limestone, clay and other minerals. These raw materials are crushed and milled into fine powders (raw meal). The powder is preheated to around 900°C using the hot gases from the kiln. In this process step, the limestone is decarbonized thereby releasing geogenic CO_2 emissions. The raw meal is then fed into rotary kilns, in which the limestone is heated to around 1450°C. At this temperature clinker is formed, which is then cooled down, ground to a fine powder in a cement mill and mixed with gypsum and other mineral components to create cement.

Depending on the composition there are different types of cement, the most commonly used type is Portland and Portland-composite cement. The different types of cement contain different shares of clinker (Cembureau 2021):

- CEM I Portland cement (>95 % clinker)
- CEM II Portland-composite cement (65-94 % clinker)
- CEM III Blast furnace cement (5-64 % clinker)
- CEM IV Pozzolanic cement (45-89 % clinker)
- CEM V Composite cement (20-64 % clinker)

CEM I and CEM II constitute more than 75 % of total cement sold in Europe in 2015 (Favier et al. 2018).

2.2 Production value, value added and number of employees in the selected countries

This section provides an overview of the production value, value added at factor cost and number of employees in the manufacturing of cement (EUROSTAT 2020c, 2020d).

Production value

The production value of the cement industry shows a strong decreasing trend since 2008 for the countries analysed in the present report, except for Germany. In Spain, UK, Italy and Poland, the share of total production value (in EUR) of the industrial sector is below 0.5 % in 2017. For Germany and France, no data was available, either due to a missing production value of the total industry (Germany) or of the cement industry (France) in 2017 (EUROSTAT 2020d).

Value added at factor cost

Regarding the value added at factor cost, the cement industry's share in 2017 is roughly at the same level as the production value's share of the countries. Poland has the highest share with

[8] During the reference period investigated in this report (2013-2017), UK was still part of the EU28. UK is therefore included in the present report and data is provided for EU28. The UK has left the EU28 and the EU-ETS and runs its own ETS since the beginning of 2021.

0.5 % in 2017 and the cement industry of Germany and Italy accounts for only 0.2 %. For France, no data is available for 2017. In Germany, the value added at factor cost shows an increasing trend between 2008 and 2017. The contrary is observed in Italy, Poland and Spain (EUROSTAT 2020d).

Employees

The number of employees includes besides cement manufacturing also other activities such as glass, ceramics and lime production because the only available data is of the NACE sector C.23 "Manufacture of other non-metallic mineral products". Therefore, these figures are not directly comparable to the shares in terms of production value and value added at factor cost, which are confined to the cement manufacturing sector. The share of employees in 2017 in relation to total employees in the industrial sector ranges from 2.8 % to 6.3 %. Poland has the highest and Germany the lowest share. Over time, the number of employees among countries is fluctuating less than the production value and value added at factor cost. Coinciding with the observations made for the production value and value added at factor cost in the cement industry, the number of employees slightly increased in Germany between 2008 and 2017, whereas in all other countries, the number of employees decreased. The strongest reduction is observed in Spain (EUROSTAT 2020c).

Table 3: Selected Member States: Economic indicators of the cement industry

	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	Share of industry 2017
Production value [million EUR]											
Germany	2,716	2,534	2,480	2,672	2,643	2,624	2,733	2,627	2,678	2,814	ND
Spain	4,471	2,668	2,335	2,081	1,664	1,531	1,521	1,582	1,473	1,562	0.3 %
France	2,731	2,388	2,307	2,441	2,528	2,467	2,623	2,483	2,458	ND	ND
UK	784	702	724	ND	ND	493	ND	ND	104	92	0.0 %
Italy	3,409	2,561	2,350	2,747	2,174	1,879	1,711	1,583	1,502	1,885	0.2 %
Poland	1,711	1,212	1,297	1,577	1,298	1,152	1,206	1,174	1,137	1,259	0.4 %
Value added at factor cost [million EUR]											
Germany	948	919	868	872	814	843	930	874	1,027	1,050	0.2 %
Spain	2,189	1,265	1,090	961	731	516	539	494	499	479	0.3 %
France	1,076	981	953	978	892	864	881	840	874	ND	ND
UK	331	263	235	ND	204	70	ND	ND	23	ND	ND
Italy	956	768	564	596	597	506	450	379	372	515	0.2 %
Poland	875	607	569	694	471	453	473	437	412	458	0.5 %
Employees in NACE sector C.23 [Thousands]											
Germany	210	209	202	208	205	204	213	203	223	217	2.8 %
Spain	212	161	131	124	107	96	95	96	97	97	4.8 %
France	124	126	138	132	136	116	115	117	120	120	3.5 %

	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	Share of industry 2017
UK	105	92	85	96	93	92	103	98	96	89	3.1 %
Italy	252	219	222	221	202	194	193	175	167	179	5.0 %
Poland	193	183	167	164	166	173	166	169	170	179	6.3 %

Information on production value and value added at factor cost is provided by the annual detailed enterprise statistics for industry (C.23.51 Manufacture of cement) (EUROSTAT 2020d). The number of employees indicates the number of employees in the NACE sector C.23 "Manufacture of other non-metallic mineral products", thus including besides cement manufacturing also other activities such as glass, ceramics and lime production (EUROSTAT 2020c).

2.3 Emissions of the cement clinker production

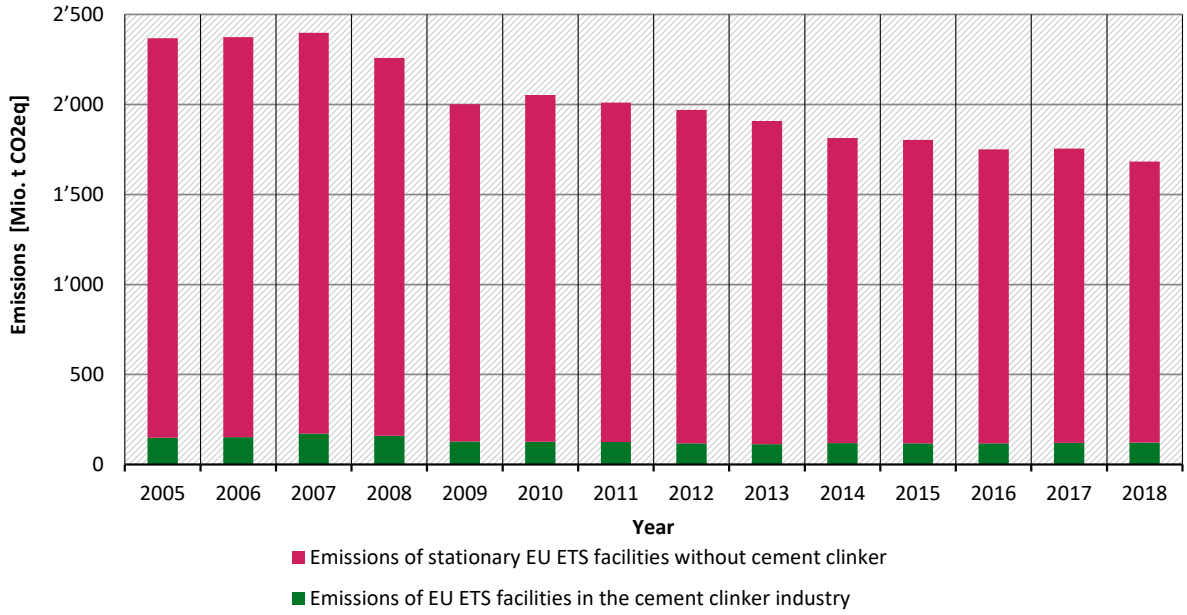
Greenhouse gas emissions from cement clinker production result from the calcination of limestone and from the combustion of fossil fuels that produces thermal energy required for the calcination process. Emissions related to transportation of products and raw materials as well as electricity consumption are not covered by the EU ETS and are therefore not accounted for in the present report. The same applies to emissions from quarrying of raw materials and fuels, as well as emissions that occur after the cooling of clinker (e.g. power consumption of the cement grinding process). Emissions from biomass fuels and fuels with a biomass share are reported by the EU ETS installations, but they mostly do not need to be covered by allowances.[9] Only the part of emissions from biomass fuels with surrendering obligations is included in the EU ETS emissions data on which the present report is based.

The following figure shows the GHG emissions[10] of the stationary installations reporting under the EU ETS. Emissions from the cement clinker industry account for around 6 to 7 % of the total EU ETS emissions from stationary installations. Between 2013 and 2017 they increased by 6 % (with the increase being larger than the increase in production, see chapter 2.4), while the emissions in other industries decreased by roughly 9 %, mainly driven by a decrease in emissions in electricity generation. From 2008 to 2009, there is a relatively sharp drop in emissions, both in the cement clinker industry and the stationary EU ETS sectors. This can be traced back to the economic and financial crisis, which provoked a break in the construction activity, especially in Spain, resulting in a notable reduction of emissions and production levels in the cement clinker industry in the following years. Since 2013, emissions have increased in Spain, Poland, the UK and Germany, whereas they decreased only in France and Italy. In Greece, emissions stayed roughly constant between 2013 and 2017.

[9] If no proof of sustainability is provided for liquid biomass, emission allowances must be surrendered for the corresponding emissions.

[10] The emissions include verified emissions under the EU ETS as well as an estimate of emissions for 2005-2012 reflecting the current scope of the EU-ETS.

Figure 4: EU28: Total GHG emissions in stationary EU ETS sectors and emissions from cement clinker industry



Evolution of total GHG emissions from stationary installations reporting under the EU ETS (sum of verified emissions and an estimate to reflect current ETS scope for allowances and emissions) and GHG emissions from cement clinker industry in EU28 countries.
Source: EEA 2019

The following table shows the GHG emissions from cement clinker production, GHG emission intensity as well as the share of biomass fuels and the clinker to cement ratio in the countries analysed in the present report in 2017. The analysed countries' GHG emission intensity in 2017 was very similar to the EU28 average of 0.81 t CO_2eq/t cement clinker. The share of biomass fuels, however, was in four out of six countries higher than the EU28 average (16 %), with Poland and UK having the largest share (23 % and 21 %) compared to only 3 % in Italy. With regard to the clinker to cement ratio, only the UK and Spain clearly exceed the EU28 average (77 %) while the other countries have approximately the same share in 2017.

Table 4: Selected Member States: Overview of key data of the clinker industry in 2017

Country	GHG emissions from cement clinker production	GHG emission intensity	Share of alternative fuels and mixed wastes / biomass[11] fuels	Clinker to cement ratio
Unit	**Million t CO_2eq**	**t CO_2eq/t grey cement clinker**	**%**	**%**
Germany	20	0.81	46 / 21 %	73 %
Spain	15	0.82*	21 / 12 %	81 %
France	10	0.83	26 / 20 %	75 %
United Kingdom	7	0.84*	25 / 21 %	88 %

[11] Definition biomass fuels according to WBCSD (2016): Products from biogenic origin used as a source of thermal energy, including from animal or plant origin. This is mainly waste from agriculture, forestry, biological waste water treatment and agro-industry.

Country	GHG emissions from cement clinker production	GHG emission intensity	Share of alternative fuels and mixed wastes / biomass[11] fuels	Clinker to cement ratio
Italy	12	0.84	12 / 3 %	77 %
Poland	10	0.78	39 / 23 %	75 %
Greece	6	0.84	ND	ND
EU28	**120**	**0.81**	**30 / 16 %**	**77 %**

*GNR data on the clinker production of the UK and Spain are incomplete. For Spain, the GHG intensity is therefore calculated directly from emissions according to EEA 2019 and clinker production according to Spain 2019. For the UK, the GHG intensity is taken from GCCA 2020, despite the incomplete coverage, since the emissions according to EEA 2019 are insufficient to calculate an average GHG intensity. The robustness of the value for GHG emission intensity according to GCCA 2020 could not be validated in this project and should be subject to further assessments.
Source: EEA 2019, GCCA 2020.

2.4 Evolution of cement clinker production

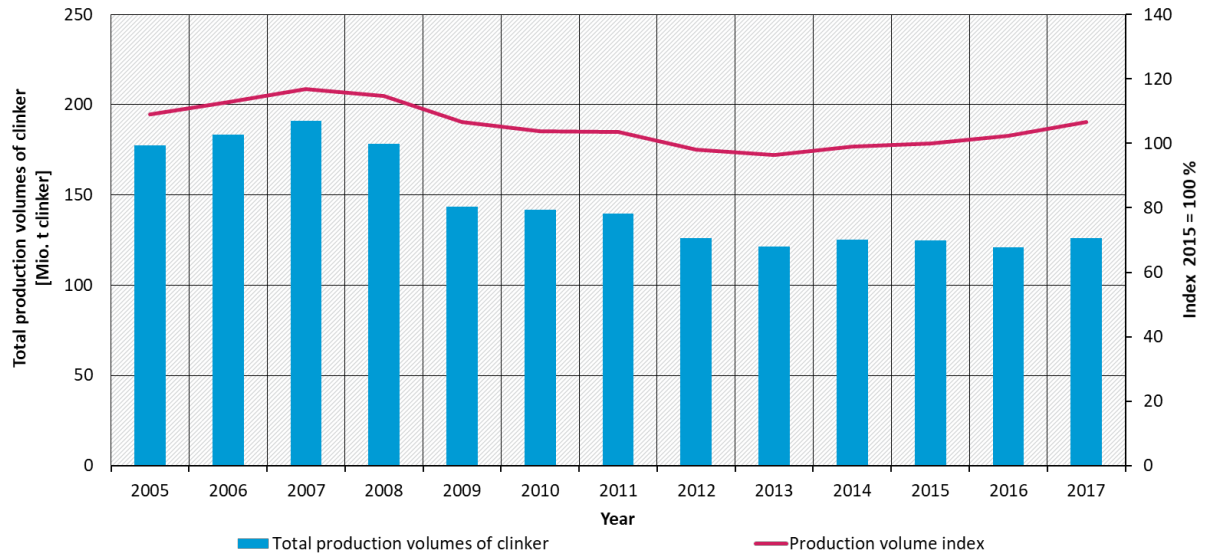
Clinker production (and emissions) data reported by GNR focus on grey cement clinker[12]. As the GNR dataset is based on voluntary reporting, the coverage is incomplete for some countries and is therefore affected by uncertainties, which could not be assessed in this report. Total clinker production volumes have strongly decreased between 2007 and 2013. Between 2013 and 2017, the production increased only slightly (+3 %), reaching around 126 million tonnes in 2017. There is a positive correlation of cement clinker production with the production volume index[13] for the construction industry in the EU28 (correlation coefficient[14]: 0.91). The production volume index is an indicator of cement demand from the construction sector, which is the most important driver of the production of cement clinker and related GHG emissions. While the production volume index decreased between 2007 and 2013, it has increased constantly since then. The cement clinker production, however, increased only slightly in 2014 and remained roughly constant since then.

[12] Clinker consists of grey and white cement clinker, which exhibit different properties and differ in terms of the production process and in terms of raw materials used. Grey clinker is the most frequent type of clinker used, e.g. in Spain less than 5 % of total clinker production consists of white cement clinker (Sanjuán et al. 2020). Therefore, the production and emission intensity data provided by GCCA focus on grey cement clinker.

[13] The production volume index for construction is an indicator which measures monthly changes in the price adjusted output of the construction sector.

[14] Throughout the present document the term correlation coefficient refers to the Pearson correlation coefficient.

Figure 5: EU28: Production of grey cement clinker



Evolution of total grey cement clinker production volume in EU28 (2005-2017) estimated based on data reported by GNR.
Source: GCCA 2020, EUROSTAT 2020b

2.5 Evolution of GHG emission intensity, energy intensity and clinker to cement ratio

The following sections show emission and energy intensity of grey cement clinker production, including shares of alternative fuels and biomass fuels. In addition, the evolution of the cement clinker ratio is described and the substitution of clinker in cement by mineral components. Besides thermal energy, the production of cement also requires electricity. Power consumption is however negligible compared to the thermal energy intensity. It is therefore not considered in the present report. Compared to the total CO_2eq emissions per ton of cement, electricity consumption only accounts for around 5% (Cembureau 2018).

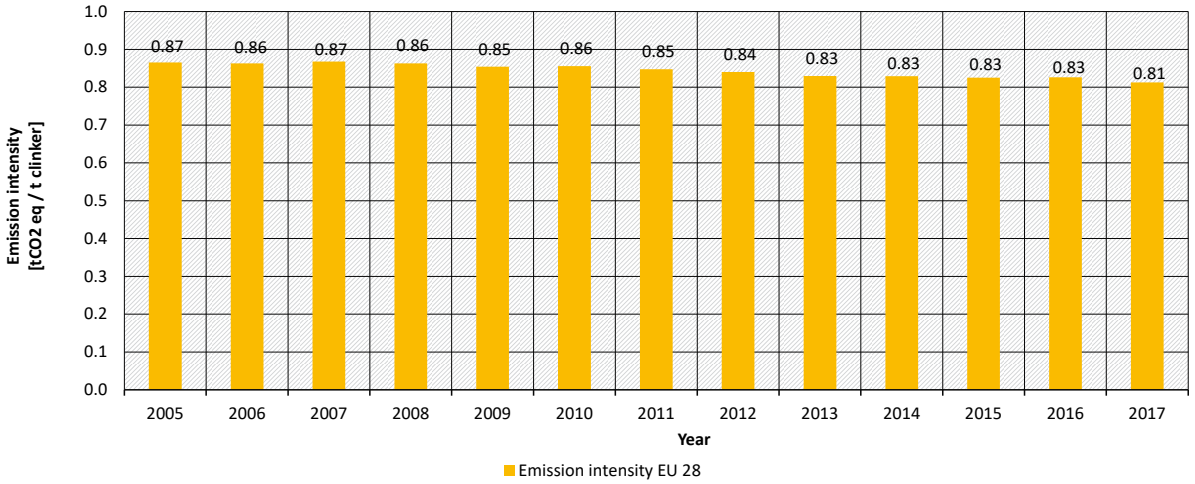
Emission intensity

The emission intensity of grey cement clinker production is calculated by dividing the emissions from the grey cement clinker industry by the production volumes of grey cement clinker in the EU28. These data are taken from GNR (2020)[15], with the exception of Spain (see chapter 2.4). Since the data reported by GNR refer to grey cement clinker only, the emissions differ from the ones reported in the EUTL.

Between 2005 and 2017, the average emission intensity of grey cement clinker production in the EU28 decreased from 0.87 to 0.81 t CO_2eq/t clinker, due to a substitution of fossil fuels with biomass fuels and changes in clinker production technology. This corresponds to a relative decrease of 6 % compared to 2005. The deviations from the EU28 average emission intensity in the analysed countries are rather small: the lowest emission intensity can be observed in Poland (0.79 t CO_2eq/t clinker), the highest emission intensity can be observed in the UK, Italy and Greece (each roughly 0.84 t CO_2eq/t clinker).

[15] Due to the different coverage, the emission intensity calculated according to GNR does not correspond to the ratio of emissions according to EEA 2019 and clinker production according to GCCA 2020 or UNFCCC 2019. However, GCCA is the only consistent data source for calculating intensity and therefore the best available data basis.

Figure 6: EU28: Emission intensity of grey cement clinker production



Evolution of GHG emission intensity of grey cement clinker production in the EU28.
Source: GCCA 2020

Energy intensity and share of biomass/alternative fuels

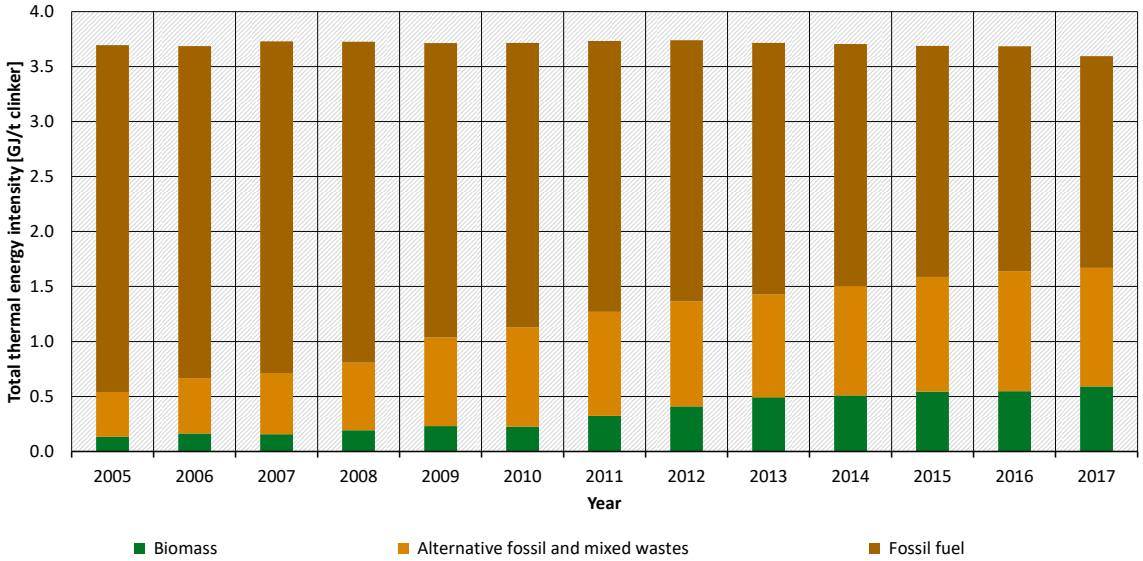
Thermal energy is produced from either regular fossil fuels, such as lignite, hard coal, oil or natural gas, alternative fossil fuels[16] (such as waste oils, solvents and plastics) and biomass fuels (such as waste wood, organic waste, agricultural residues). The share of alternative fossil fuels and biomass in thermal energy is increasing in the EU28 since 2005. In 2005, the share of alternative fossil fuels and biomass amounted to 11 % and 4 % respectively and until 2017, the share increased to 30 % and 16 % respectively. The share of regular fossil fuels still is 54 % in 2017 (GCCA 2020). There is a wide span in the remaining share of fossil fuels among the analysed countries with the highest share in Italy (86 %) and the lowest shares in Germany (34 %) and Poland (38 %).

Total thermal energy consumption intensity per tonne of grey cement clinker produced in the EU28 reaches 3.7 GJ/t clinker in 2005 and decreases marginally to 3.6 GJ/t clinker in 2017 (GCCA 2020).

There is still room for improvement for reaching a larger share of alternative fossil fuels and biomass fuels. However, there are certain limitations such as the country-specific legislation on the incineration of waste materials, the local waste collection system, a more complex management and processing of the waste as well as the low calorific value of some organic materials (Favier et al. 2018).

[16] Definition of "Alternative fossil fuels" according to WBCSD (2016): Products of fossil origin used as a source of thermal energy and not classified as traditional fossil fuel. This is mainly fossil waste such as plastics, solvents, waste oil, end-of-life tires, etc.

Figure 7: EU28: Total thermal energy consumption intensity and share of different energy carriers



Evolution of thermal energy input for grey cement clinker production in the EU28, where the share of alternative fossil and mixed wastes, biomass and fossil fuels are shown.
Source: GCCA 2020

The production of cement clinker has a high energy intensity. For this reason, a look at the development of energy prices might be helpful for understanding the trends in cement clinker production in the EU28. However, based on the factsheets in this report, it appears that energy prices are a much less important driving factor for the emissions from cement clinker production compared to e.g. the demand of cement form the construction sector. In most of the analysed countries, grey cement clinker production decreased despite of constant or even decreasing energy prices (see Appendix: Energy prices). See Emele et al. (2022), for an analysis of the drivers of CO_2-emissions from the European cement industry.

Clinker to cement ratio and mineral components in cement

In cement production, clinker is the main ingredient (especially for CEM I), but up to a defined degree clinker can also be substituted by other, less energy intensive products such as waste or by-products of other industries (slag and fly ash) or other components occurring naturally such as pozzolana depending on the cement type (Favier et al. 2018).

The share of cement clinker in cement depends on the type of cement and cement products that each are characterized by a specific composition and exhibit certain properties. The average clinker to cement ratio and the share of mineral components therefore depend on the demand of different types of cement. Availability of substitutes is therefore less relevant, than the demand of cement products with specific properties.

Between 2005 and 2012 the grey cement clinker share decreased from 77 % to 74 %. Since then, it slightly increased again to almost 77 %. This slight increasing tendency since 2012 causes an increase in emissions per tonne of cement (Lytton 2016). The grey cement clinker share in the analysed countries varies between 73 % (Germany) and more than 80 % (Spain: 81 % and 88 % in UK).

The total share of mineral components (other than grey cement clinker) used in the production of Portland cements in the EU28 fluctuates between 23 % and 26 %: while it increased between

2005 and 2012, there is a slight decreasing tendency since then. In 2017, the share of mineral components reached again 23 % (GCCA 2020).

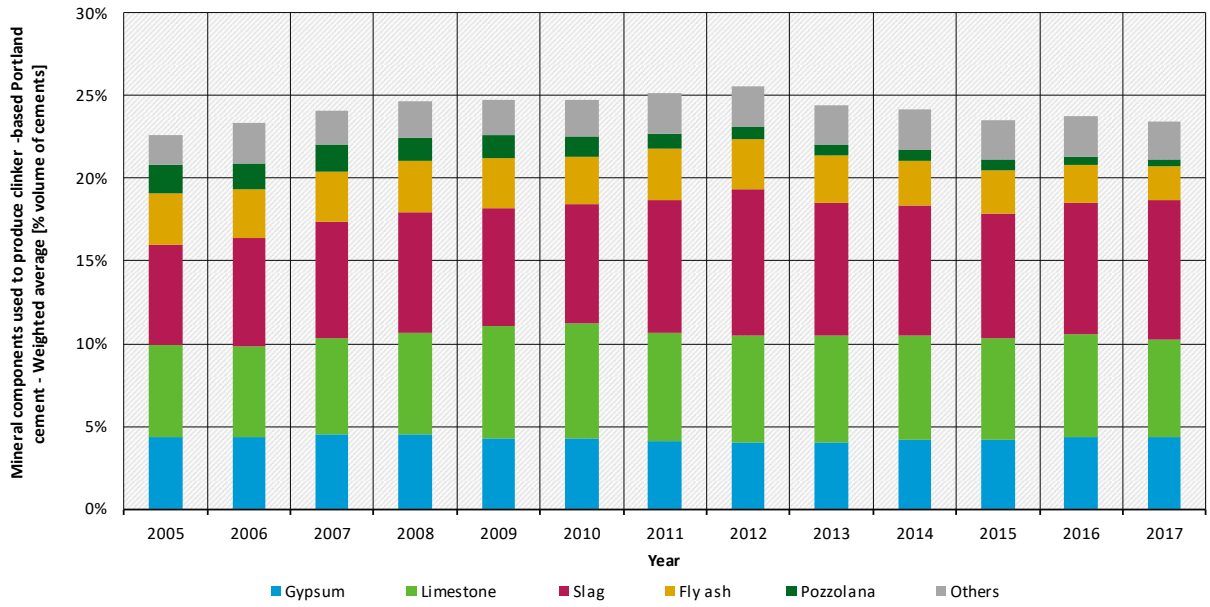
Mineral components used in the production of Portland cements in the EU28 are mainly slag, limestone and gypsum as well as some fly ash and pozzolana (GCCA 2020). The use of slag increased over time from a share of 6 % in 2005 to over 8 % in 2017 whereas the shares of gypsum and limestone stayed roughly constant at 4-6 % (GCCA 2020).

Although the use of limestone is very common in Europe, the clinker substitution potential is limited because limestone requires alumina to react. Also, the use of slag, a by-product from the steel industry, is already quite exhausted and already today it is dependent on imports from outside the EU28 because the amount of slag produced in Europe is not sufficient and this situation is expected to be exacerbated in the near future (Favier et al. 2018).

The use of fly ash slightly decreased over time, accounting for only 2 % in 2017 (GCCA 2020). Fly ash is a by-product of coal-fired power plants and is expected to decrease in availability due to the closure of those plants. By 2050 at the latest, the production of fly ash from the coal industry will be insufficient to act as a substitution of clinker since coal-fired power plants will by then no longer exist if climate neutrality is to be achieved (Favier et al. 2018).

Finally, the use of pozzolana, volcanic ashes naturally occurring mainly in southern European regions, plays a minor role as a substitution of clinker accounting for only 0.4 % in 2017. Its share continuously decreased from 1.7 % in 2005 (GCCA 2020). The decreasing tendency and small share of pozzolana use can be traced back to the fact that mainly countries in southern Europe such as Spain, France and Italy make significant use of this material in the cement production and production in these countries dropped in recent years. The exact reserves of pozzolana in Europe are unknown, but a strong increase of supply is not expected. Due to its geographic feature, an increased use would also imply longer transport distances (Favier et al. 2018).

Figure 8: EU28: Share of mineral components used in production of Portland cement



Evolution of the share of mineral components used in production of Portland cement besides grey cement clinker in the EU28 since 2005.

Source: GCCA 2020

2.6 Market evolution, imports and exports

Imports of cement clinker from countries outside the EU28 to the EU28 increased until 2007, followed by a sharp drop after the economic and financial crisis in 2008/2009 until 2012 and remain at a low level with some annual fluctuations since then (EUROSTAT 2020e). Import volumes compared to domestic clinker production in 2017 vary among the selected member states from the lowest share of 0.4 % in Poland and Germany to a share of 11 % in France and almost 30% in Spain.

Exports of cement clinker from EU28 to countries outside the EU28 show only little fluctuation until 2008, then first increase during the financial crisis in 2008/2009 and subsequently decrease again until 2011. After 2011 they increased until 2014, reaching the highest level over the analysed time period. Since 2014, exports are decreasing again (EUROSTAT 2020e). Export volumes compared to domestic clinker production in 2017 vary strongly in the selected member states from the lowest share of 0.3 % in the UK to the highest share of 28 % in Spain.

The EU28 has turned from a net-importer (2005 to 2008) to a net-exporter of cement clinker from 2009 on. Net-exporting countries to countries outside EU28 are Spain and Greece. Net-importing countries from countries outside EU28 are France and Italy. UK is also a net-importer of cement clinker but imports almost entirely from other EU28 countries.

Figure 9: EU28: Import and export of cement clinker to and from countries outside the EU28

Evolution of the EU28 countries' import and export of cement clinker to and from countries outside the EU28.
Source: EUROSTAT 2020e

2.7 Clinker production technology

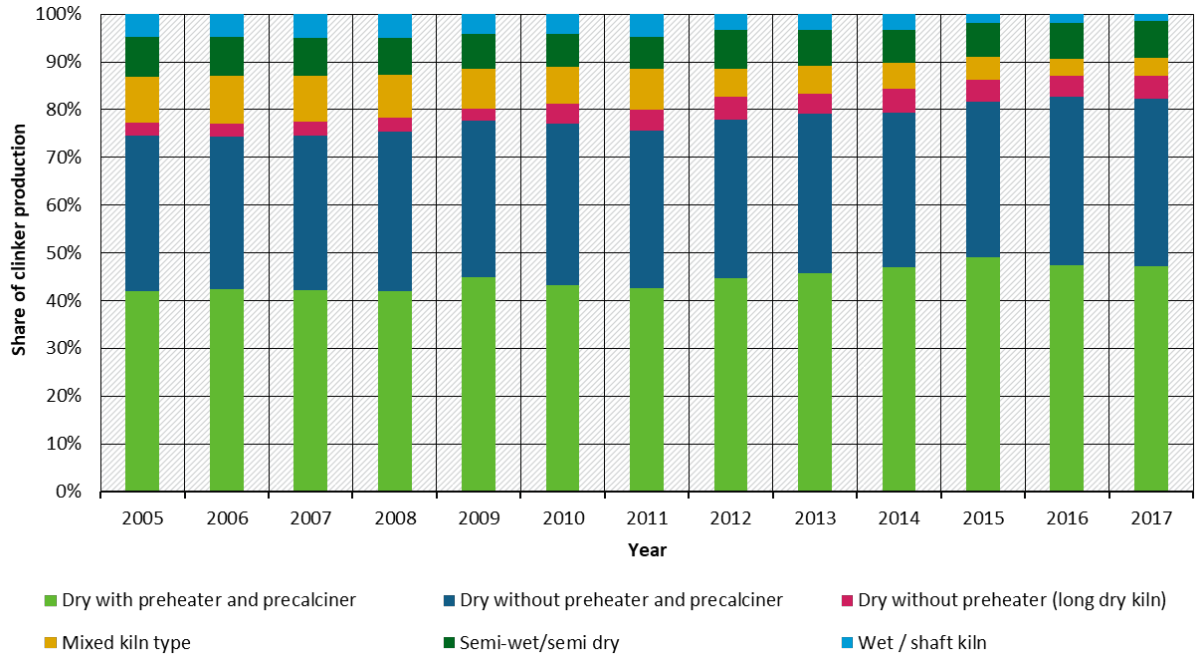
In the cement clinker production of the EU28 mostly dry kilns are used. The share of dry kilns (with and without preheater and precalciner) continuously increased from 75 % in 2005 to 79 % in 2013 up to above 80 % in 2017. Clinker production in mixed kilns and wet kilns decreased since 2005, accounting for only roughly 4 % and 1 % in 2017 respectively (GCCA 2020).

This is a welcomed trend since the wet kiln technology is the one with the highest emission intensity, whereas the dry kiln with preheater and precalciner technology has the lowest emission intensity, given that the installation is operated under optimal conditions.

The share of cement clinker production in long dry kilns and semi-wet/semi dry kilns stayed roughly constant over time (5 % and 8 % in 2017 respectively) (GCCA 2020).

For most countries, data on kiln technology are incomplete (see Appendix: Evolution of cement clinker production technology). The technologies are therefore not further investigated in the country factsheets.

Figure 10: EU28: Share of cement clinker production by kiln type



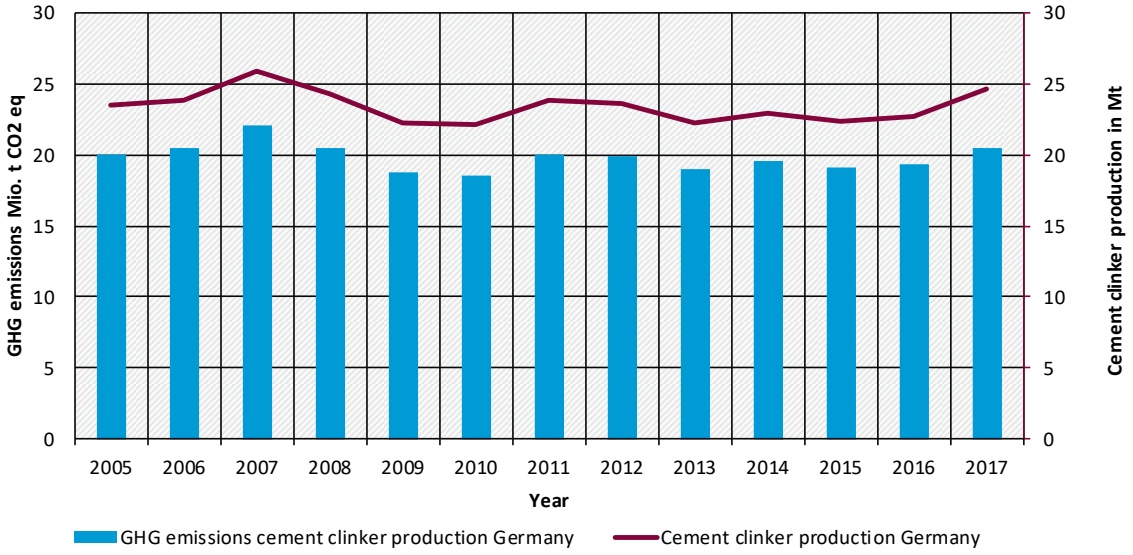
Evolution of the kiln technology applied in the cement clinker production in the EU28. Technologies are listed in the order of emission intensity: "wet kiln" technology has the highest emission intensity, "dry with preheater and precalciner" technology has the lowest emission intensity, given that the installation is operated under optimal conditions. Mixed kiln type accounts for various types of technologies, it is a broad term without a narrow definition.
Source: GCCA 2020

3 Germany

3.1 Key messages

- GHG emissions from the cement clinker production in Germany amounted to roughly 20 million tonnes of CO_2eq in 2017. Since 2013, they increased slightly by 8 %. Over the entire time period from 2005 to 2017, the cement clinker production accounts for roughly 4 % of total EU ETS emissions from Germany.
- Germany contributes a share of 17 % to total EU28 emissions of cement clinker production in 2017 and has the highest share of emissions from the cement industry in the EU28.
- Cement clinker production in Germany increased by 11 % between 2013 and 2017 and shows a similar development over time as GHG emissions (see Figure 11). German cement clinker production accounts for roughly 20 % of the total cement clinker production sector in the EU28 in 2017. This share slightly increased since 2013.
- The similar trend of GHG emissions and clinker production of the cement industry in Germany indicates that the GHG emission intensity per tonne of clinker did not change substantially. Between 2013 and 2017, the emission intensity stayed constant at 0.81 t CO_2eq/t clinker. The emission intensity in 2017 is the same as the EU28 average of 0.81 t CO_2eq/t clinker (see Table 4).

Figure 11: Germany: Total GHG emissions from the cement clinker production



Evolution of total GHG emissions from the cement clinker production and evolution of cement clinker production between 2005 and 2017 in Germany.
Source: GCCA 2020, EEA 2019

- The emission intensity is affected by the fuel composition and quality (i.e. share of fossil fuels vs. biomass fuels) and the efficiency of production technology applied[17]:
  - In Germany, there exists a high level of recycling and no landfilling of municipal solid waste (MSW) such that the use of alternative fossil and mixed wastes as well as biomass for energy generation is above EU28 average. Alternative and biomass fuels contribute a share of 66 % of energy consumption in the cement clinker production sector in Germany in 2017 (EU28 average 46 %, see Figure 7), which is the highest share of alternative and biomass fuels among the countries analysed in the present report.
- The energy intensity per tonne of clinker stayed roughly constant over the entire time period of 2005 to 2017 (fluctuating between 3.7 and 3.8 GJ/t clinker). Compared to fossil fuels, alternative fuels such as biomass have a lower calorific value and may increase the energy consumption of the plant.
- The clinker to cement ratio is 73 % in 2017 (EU28 average 77 %, see Table 4). It shows small fluctuations since 2013. Due to Germany's important metal industry, waste products such as slag are available to be used to substitute clinker.
- The production volume index for the construction industry, an important indicator of cement demand from the construction sector, is increasing since 2005. However, in contrast to the EU and other countries, the development of clinker production in Germany is largely independent of the development of the production volume index. Therefore, it shows no correlation with cement clinker production in Germany (correlation coefficient: -0.02).
- Germany is a net-exporter of cement clinker, but exports remain at a low level since 2012, accounting for 1.5 to 3 % of total domestic cement clinker production. The majority is exported to other countries in the EU28.
- The number of cement clinker production plants remained roughly constant between 2005 and 2019 with only one plant closing in 2012. The three largest facilities in terms of their emissions in 2019 are owned by CEMEX Zement GmbH, Holcim (Deutschland) GmbH and Dyckerhoff GmbH (see Table 5). Average emissions per plant, increased between 2005 and 2019, in line with the increased cement clinker production in this time period.
- The three largest cement clinker production companies, HeidelbergCement AG, Dyckerhoff GmbH and SCHWENK Zement KG clearly dominate the cement clinker production market with more than half of the total emissions stemming from these three companies, which comprise a total of 18 plants.

[17] The condition, operating mode and kiln capacity of a plant as well as moisture and combustibility of the raw material are additional factors affecting the emission intensity. In this factsheet, individual plants were not analysed such that the focus lies on the fuel composition and production technology.

Table 5: Germany: Key figures on the cement clinker industry

Cement clinker industry characteristics	Unit	Year 2017	% change 2017 compared to 2013	Share of cement clinker production sector EU28 in 2017	Source
GHG emissions	Mt CO_2eq	20.5	8 %	17 %	EEA 2019
Clinker production	Mt	24.7	11 %	20 %	GCCA 2020
GHG emission intensity	t CO_2eq/t clinker	0.81[18]	0 %	100 %[19]	GCCA 2020
Energy consumption	PJ	95	12 %	20 %	GCCA 2020
Energy intensity	GJ/t clinker	3.8	1 %	104 %[20]	GCCA 2020
Number of cement clinker production plants		35	0 %	16 %	EEA 2019
Cement clinker plants with highest emissions					
Plant name (Company)	**Share of total capacity of cement clinker prod. facilities***	**Emissions in 2019 [Mt CO_2eq]****	**% change 2019 compared to 2013****	**Share of emissions from cement clinker prod. in Germany in 2019****	
Zementwerk Rüdersdorf (CEMEX Zement GmbH)	5.3 %	1.21	-5 %	6.0 %	
Werk Lägerdorf (Holcim (Deutschland) GmbH)	4.8 %	1.08	-2 %	5.4 %	
Drehöfen Deuna (Dyckerhoff GmbH)	5.3 %	1.03	4 %	5.2 %	

Key figures on the cement clinker production in Germany and on its largest cement clinker plants.
Source: Own table based on various sources. * Own calculations based on Cemnet 2020. **EEA 2019

[18] The GHG emission intensity is calculated based on data from GCCA 2020 and therefore differs from the calculation of emissions from EEA 2019 divided by clinker production.

[19] This value indicates that the emission intensity in Germany is 100 % of the EU28's emission intensity in 2017.

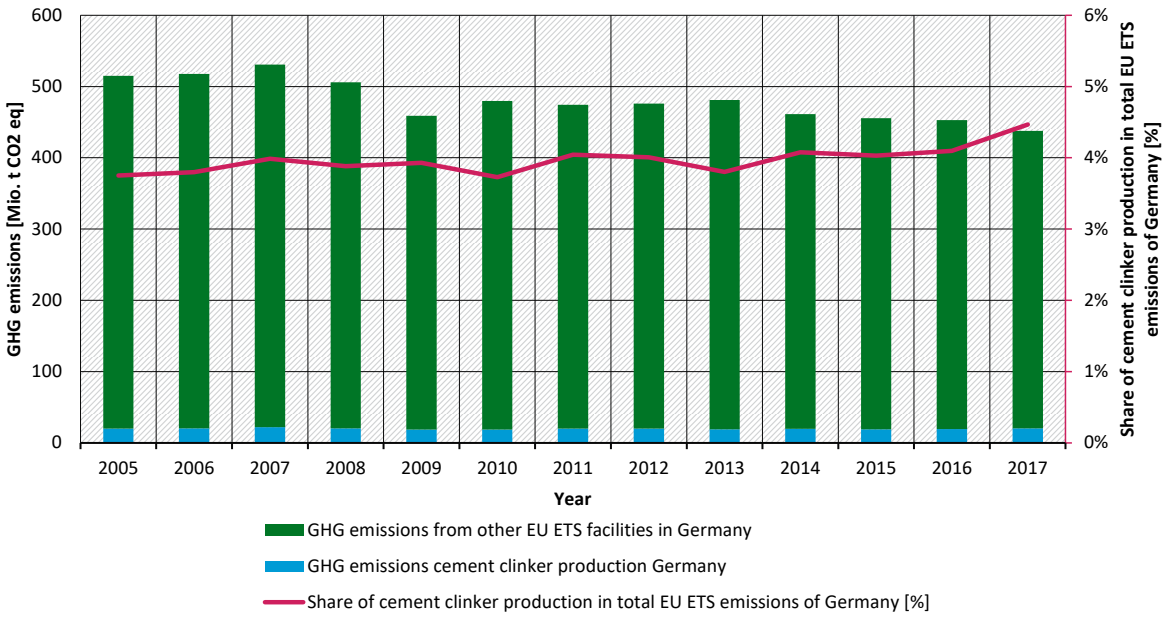
[20] This value indicates that the energy intensity in Germany is 104 % of the EU28's energy intensity in 2017.

3.2 Evolution of GHG emissions

The following trends can be observed for the emissions from the EU ETS facilities in Germany:

- In 2005 the emissions of stationary facilities participating in the EU ETS in Germany[21] amount to 500 million tonnes of CO_2eq and decreased by about 15 % between 2005 and 2017. In 2017, the cement clinker production contributes a share of about 4 % (around 20 million tonnes of CO_2eq). This share is relatively stable between 2005 and 2017 with an increasing trend. Whereas emissions from cement clinker production increased slightly in that time period (+2 %), emissions in other EU ETS facilities decreased (-16 %) between 2005 and 2017 (EEA 2019), mostly due to a decrease of coal power generation.
- The increase of GHG emissions from cement clinker production since 2013 (+ 8 %) is mainly due to the increase in clinker production volumes.

Figure 12: Germany: Total GHG emissions from EU ETS facilities and share of emissions from cement clinker industry



Evolution of total GHG emissions from EU ETS facilities between 2005 and 2017 in Germany (left axis). The bars show the emissions from cement clinker production and other facilities of the EU ETS. The red line (right axis) indicates the relative share of GHG emissions from cement clinker production in total emissions from EU ETS facilities in Germany.
Source: EEA 2019, own calculations

- Total GHG emissions[22] in Germany amounted to over 993 million tonnes of CO_2eq in 2005 (Germany 2019). They decrease to 906 million tonnes of CO_2eq in 2017. Emissions from EU ETS facilities accounted for 48 % of Germany's total GHG emissions in 2017 (EEA 2019).

[21] Total emissions from the EU ETS facilities include verified emissions under the EU ETS as well as an estimate of emissions for 2005-2012 reflecting the current scope of the EU ETS.

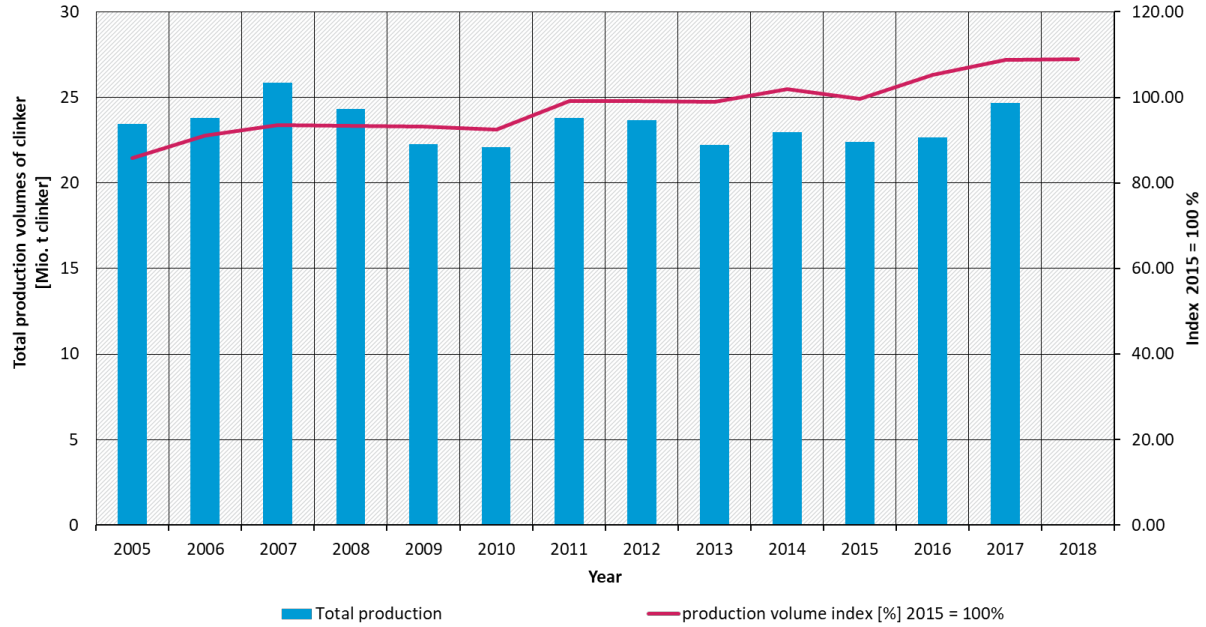
[22] Total GHG emissions reported here exclude emissions from land use, land use change and forestry. Indirect GHG emissions are excluded as well.

3.3 Evolution of cement clinker production

Production of grey cement clinker

The production of grey cement clinker is the most important driver of emissions from cement production. The production volume increased from about 24 million tonnes in 2005 to almost 26 million tonnes in 2007 (+10 %). Between 2007 and 2010 production volumes drop to about 22 million tonnes of grey cement clinker. Since then, the annual production fluctuated between 22 and 25 million tonnes of clinker. The production volume index for the construction industry relative to 2015 increased since 2005. However, in contrast to the EU and other countries, the development of clinker production in Germany is largely independent of the development of the production volume index. Therefore, it shows no correlation to the amount of clinker produced (correlation coefficient: -0.02).

Figure 13: Germany: Production of grey cement clinker and evolution of production volume index of the construction sector



Evolution of total grey cement clinker production volume in Germany (2005-2017) estimated based on data reported by GNR (left axis). The red line (right axis) indicates the evolution of production volume index of the construction sector in Germany since 2005. 2015 corresponds to 100 %.
Source: GCCA 2020, EUROSTAT 2020b (Calendar adjusted data, non-seasonally adjusted data)

3.4 Evolution of GHG emission, energy intensity and clinker to cement ratio

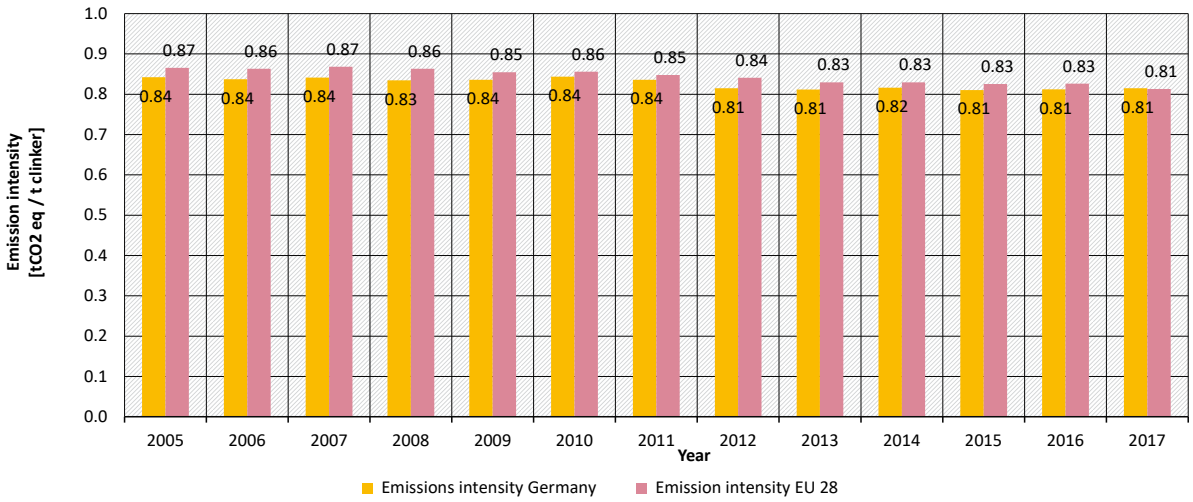
Evolution of GHG emission intensity

The GHG emission intensity per tonne of clinker is mainly affected by the fuel composition (i.e. share of fossil fuels vs. biomass fuels) and the efficiency of production technology applied. In 2017, emissions per tonne of clinker produced amount to about 0.81 t CO_2eq/t clinker[23] in Germany, while the EU28 average is also at around 0.81 t CO_2eq/t clinker. Since 2005, emission intensity shows a slight decreasing trend, from 0.84 t CO_2eq/t clinker in 2005 to 0.81 t CO_2eq/t clinker in 2017. This corresponds to a relative reduction of 3 % compared to 2005, similar to the

[23] More accurate data for the emission intensity are available for Germany (DEHSt 2021). In DEHSt 2021 an emission intensity of 0.803 t CO_2eq/t clinker is reported, however, to ensure compatibility across all countries analysed, for Germany the same data basis as for the other countries (GCCA 2020) is used.

general decreasing trend in EU28 (decrease of average emission intensity between 2005 and 2017 by 6 %, see Figure 6).

Figure 14: Germany and EU28: Emission intensity of clinker production



Evolution of GHG emission intensity of clinker production in Germany and EU28.
Source: GCCA 2020

Evolution of energy intensity

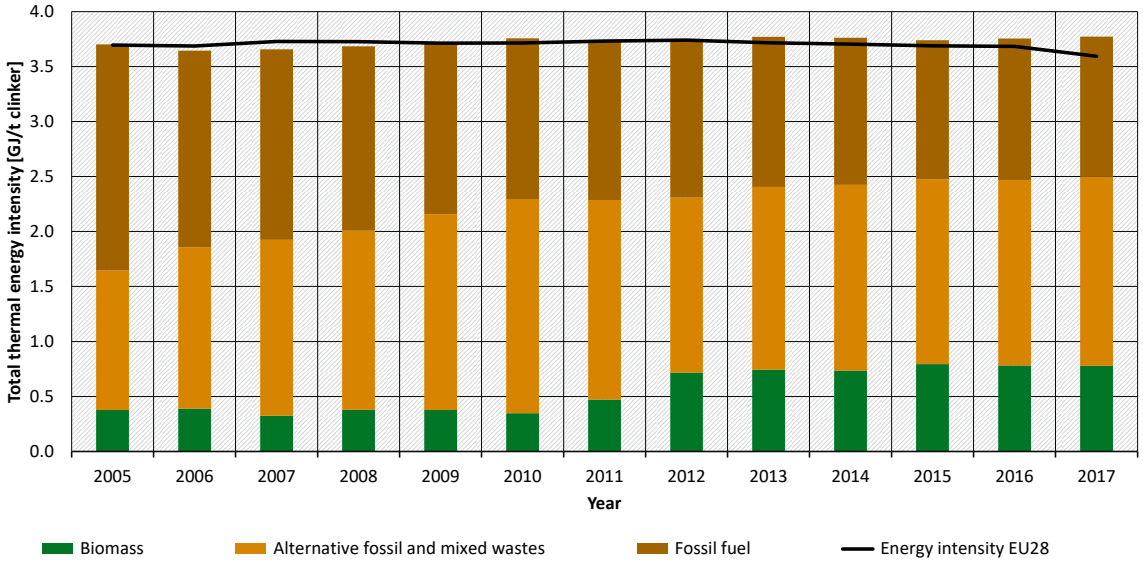
In Germany, total thermal energy consumption intensity[24] per tonne of grey cement clinker produced amounts to about 3.70 GJ/t clinker in 2005 with a slight increasing trend over time reaching 3.77 GJ/t clinker in 2017. In the EU28, total thermal energy consumption intensity per tonne of grey cement clinker is at a similar level and shows a very slight decreasing trend (GCCA 2020).

Thermal energy is produced from either regular fossil fuels, such as coal or oil, alternative fossil fuels[25] (such as waste solvents, plastics or tires) and biomass fuels. The share of alternative fossil fuels and biomass in thermal energy is increasing since 2005 and has been higher compared to the EU28 average over the entire time period (Figure 7). In 2005, the share of alternative fossil fuels and biomass amounted to 34 % and 10 % respectively and until 2017, the share increased to 46 % and 21 % respectively. Therefore, in 2017 the share of fossil fuels is only at 34 % (compared to 54 % in the EU28 average). Germany is the country with the highest share of alternative fuels in the European cement sector (GCCA 2020). This is in line with Germany's high level of recycling and the successful use of waste as alternative fuel for the cement clinker production (see chapter 3.6).

[24] Besides thermal energy, the production of cement also requires electricity. Power consumption is however negligible compared to the thermal energy intensity. It is therefore not considered in the present report.

[25] Definition of "alternative fuels" according to WBCSD (2016): Products of fossil origin used as a source of thermal energy and not classified as traditional fossil fuel. This is mainly fossil waste such as plastics, solvents, waste oil, end-of-life tires, etc.

Figure 15: Germany: Total thermal energy consumption intensity and share of different energy carriers



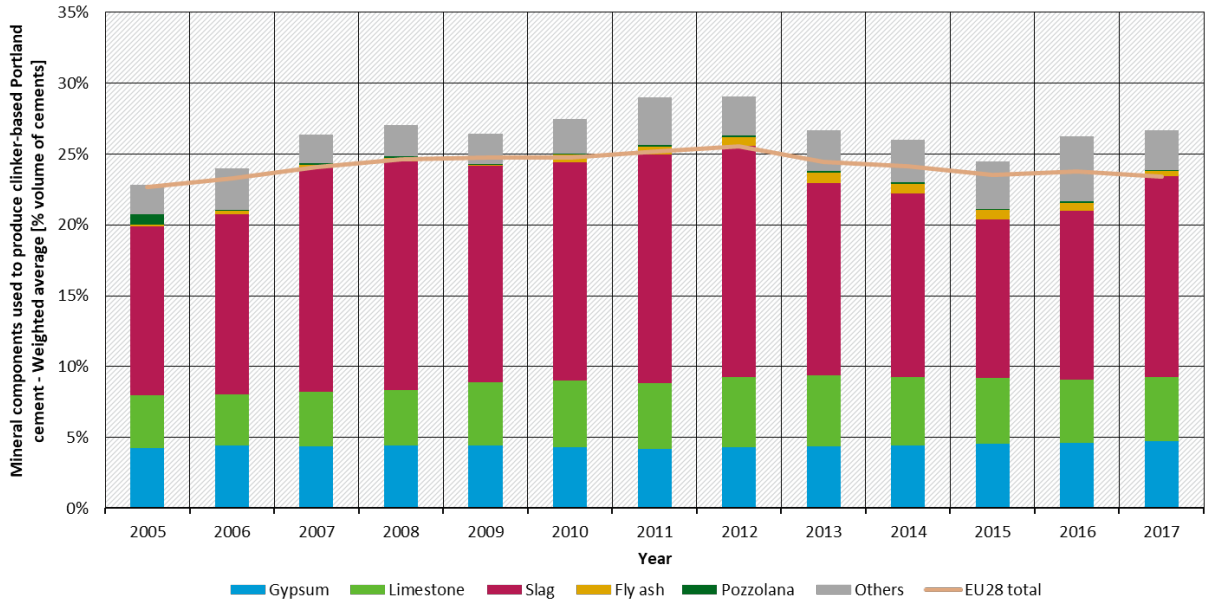
Evolution of thermal energy input for grey cement clinker production in Germany and EU28. For Germany, the share of alternative fossil and mixed wastes, biomass and fossil fuels are shown.
Source: GCCA 2020

Clinker to cement ratio and mineral components in cement

In the production of Portland cements besides cement clinker mainly slag, gypsum and limestone are used in Germany (GCCA 2020). Germany has an important metal industry, which produces wastes (slag), which can be reused in the cement industry. The share of mineral components used in production of Portland cement besides grey cement clinker is therefore slightly higher in Germany than in the EU28 corresponding to a lower clinker to cement ratio in 2017 (73 %[26] vs. 77 % EU28 average). Between 2005 and 2012 the share of mineral components increased from 23 % to 29 % exceeding the EU28 average. Since 2012, a slight decreasing trend can be observed, while still lying above the EU28 total. In 2016 and 2017, the share of mineral components in Germany has increased again reaching 27 % in 2017.

[26] More accurate data for the clinker to cement ratio are available for Germany (VDZ 2021), however, to ensure compatibility across all countries analysed, for Germany the same data basis as for the other countries (GCCA 2020) is used.

Figure 16: Germany: Share of mineral components used in production of Portland cement besides grey cement clinker



Evolution of the share of mineral components used in production of Portland cement besides grey cement clinker in Germany and in the EU28 since 2005.
Source: GCCA 2020

3.5 Market evolution, imports and exports

Import and export of Portland cement

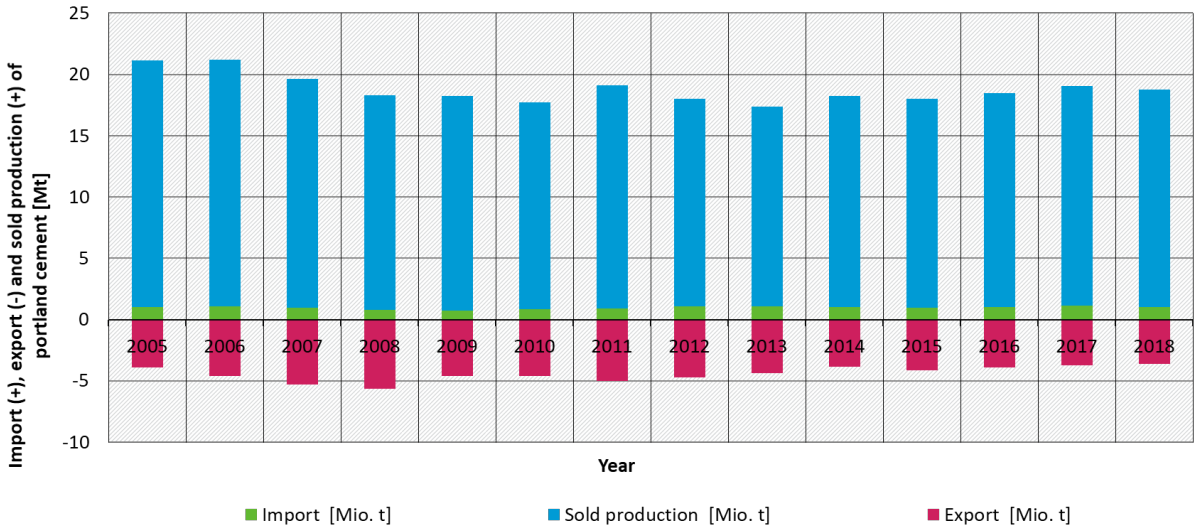
Import and export of cement products were analysed for Portland cement, which is the most widely used type of cement[27]. For Portland cement, import and export remain at a low level compared to total sold production[28]. Sold production of Portland cement decreased from 20 million tonnes in 2005 to about 18 million tonnes in 2018 (EUROSTAT 2020a).

Import of cement stayed roughly constant at about 1 million tonnes between 2005 and 2018. Export increased from about 4 million tonnes in 2005 to nearly 6 million tonnes in 2008. Since then exports are decreasing to again roughly 4 million tonnes in 2018.

[27] Portland cement (CEM I, II) constitutes more than 75 % of total cement sold in Europe in 2015.

[28] Sold production corresponds to the value and volume of the product sold by the enterprise, it differs from total production (the volume of all production of the product, including both the proportion that is sold and the proportion that is retained by the enterprise for adding to stocks, using in further processing etc.).

Figure 17: Germany: Development of the Portland cement market



Evolution of import, export and sold production of Portland cement in Germany between 2005 and 2018.
Source: EUROSTAT 2020a

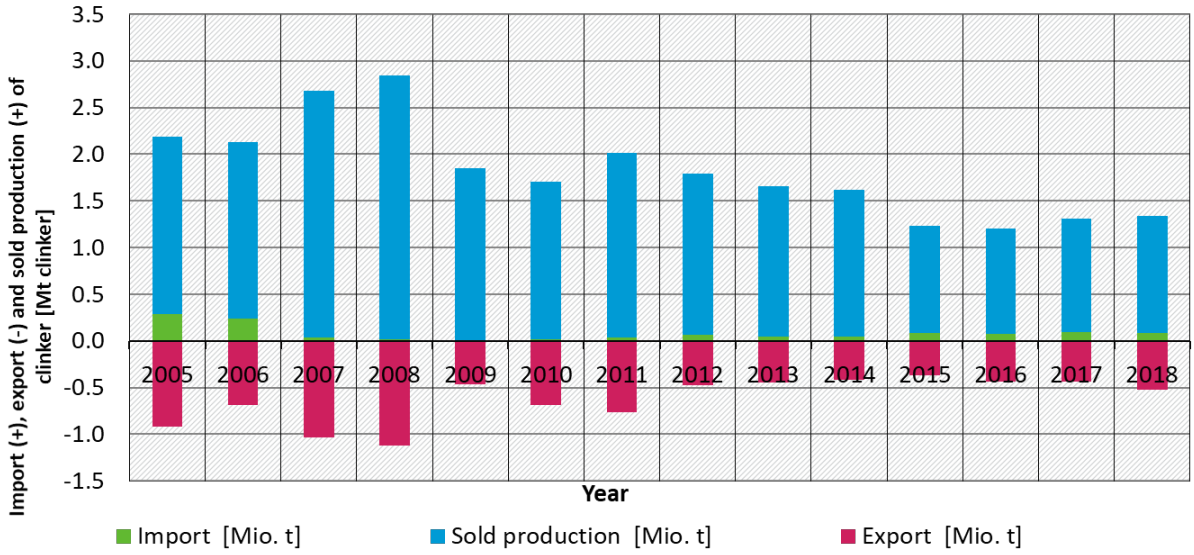
Import and export of cement clinker

In Germany, the share of import and export volumes compared to domestic clinker production (see chapter 3.3) is rather small compared to the other analysed countries.

Until 2008, the amount of clinker that was exported, increased to more than 1 million tonnes (see Figure 198), which is 5 % of total cement clinker production (see chapter 3.3). Since then, export volumes fluctuated between 0.4 and almost 0.8 million tonnes. Germany is a net-exporter of cement clinker, but the exports remained constant at a low level since 2012, accounting for 1.5 to 3 % of total domestic cement clinker production (EUROSTAT 2020a).

An opposite trend is observed for imports of cement clinker. Germany imported 0.3 million tonnes in 2005, corresponding to roughly 1 % of total cement clinker production. Then, imports decreased constantly until 2007, where no cement clinker was imported. Since 2011, only very little cement clinker is imported (EUROSTAT 2020a). Therefore, the share of import and export volumes compared to domestic clinker production (see chapter 3.3) is rather small compared to the other analysed countries.

Figure 18: Germany: Development of the cement clinker market



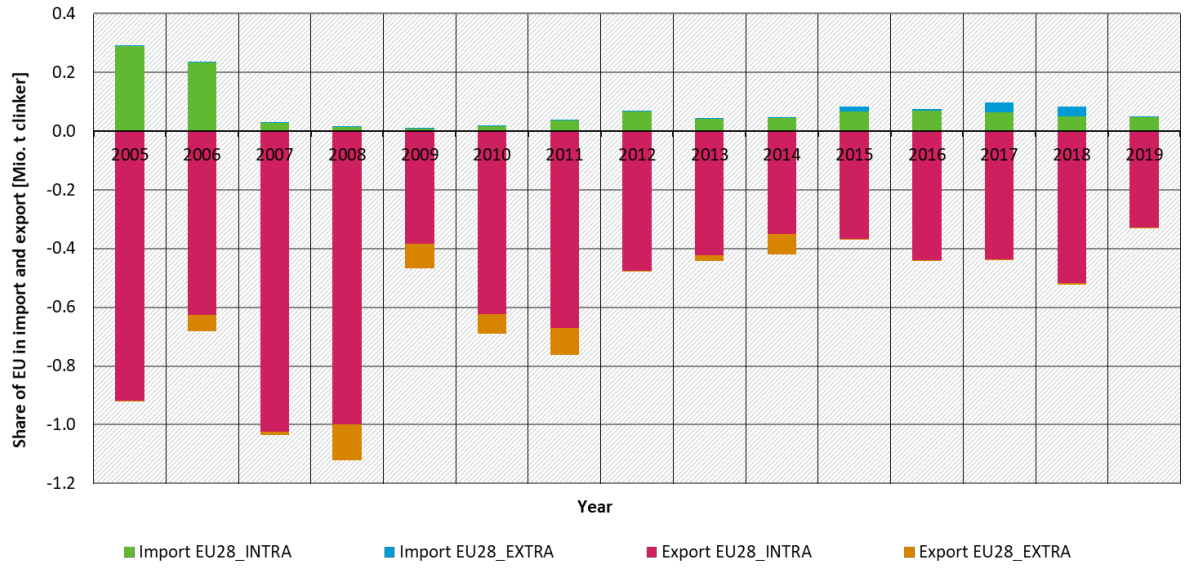
Evolution of import, export and sold production of cement clinker in Germany between 2005 and 2018. The blue bars only show the sold production of clinker, this does not include the cement clinker production that is directly processed to cement by the same company.
Source: EUROSTAT 2020a

Import and export of cement clinker within the EU28 and outside the EU28

Imports of cement clinker from other EU28 countries are more important than imports from countries outside the EU28. No clinker was imported from countries outside the EU28 in 2019 (EUROSTAT 2020e).

Exports of cement clinker from Germany to EU28 countries are higher than exports to non-EU28 countries. Since 2015 no cement clinker was exported to countries outside the EU28 (EUROSTAT 2020e).

Figure 19: Germany: Import and export of cement clinker to and from other EU28 countries/countries outside the EU28



Evolution of Germany's import of cement clinker from other EU28 countries (Import EU28_INTRA) and from countries outside the EU28 (Import EU28_EXTRA) and evolution of Germany's export of clinker to other EU28 countries (Export EU28_INTRA) and to countries outside the EU28 (Export EU28_EXTRA).
Source: EUROSTAT 2020e

3.6 Regulative, economic and political framework

The following sections summarize the regulative, economic and political framework affecting the cement sector in Germany. This includes the use of waste as alternative fuels and state aid.

Use of waste fuels in the cement industry

In Germany, the waste sector has reached a high level of recycling (53 % of treated wastes are recycled), there is no landfilling of municipal solid waste (MSW), and there is a high level of energy recovery (De Beer et al. 2017).

In Germany, there is a competition for available waste particularly with waste incinerators. The generation of power and heat from biomass is privileged under the Renewable Energy Act and the Renewable Heating Act. This poses a disadvantage for the cement industry in terms of use of biomass based alternative fuels. Although the landfilling of untreated biodegradable materials and municipal solid waste containing organic matter ceased on 1 June 2005, about 22 % of waste is still disposed of (De Beer et al. 2017).

There are regulations for NOx emissions beyond EU legislation, which poses a barrier for further exploitation of the co-processing potential (De Beer et al. 2017).

State Aid

In the State Aid Transparency database of the European commission over 150 instruments are listed for the cement sector (C.23.51 Production of cement) in Germany. They include mainly "Tax advantage or tax exemption" (EC 2020).

3.7 Facility data – the largest emitters and their location

GHG emissions and production capacity

In 2019, 35 cement clinker production plants were subject to the EU ETS in Germany (activity code 29). The following table provides an overview on GHG emission and cement production capacity of the three largest cement clinker facilities in terms of emissions in Germany.

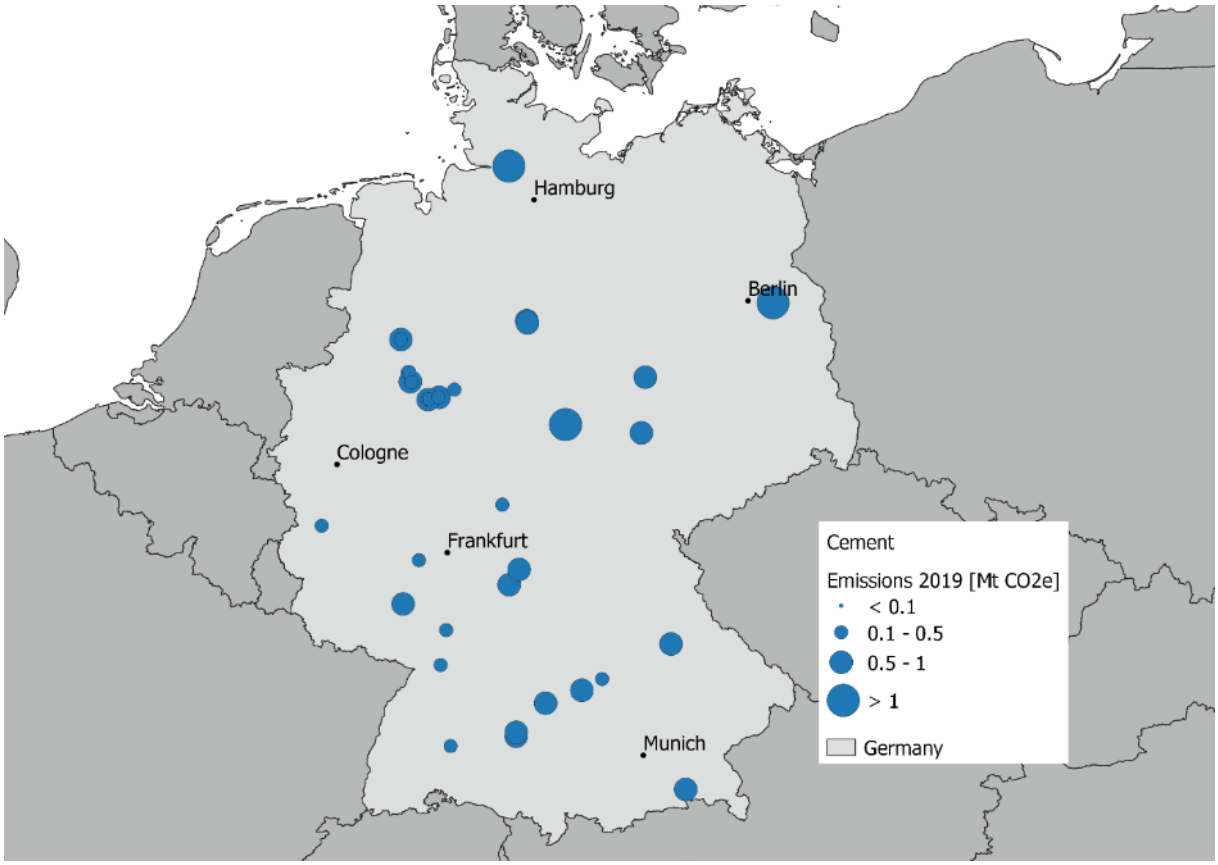
Table 6: Germany: Emissions and production capacity of the three largest cement clinker plants in terms of emissions

ID	Installation	Company	City	Emissions (Mt CO_2eq)					Share of total verified emissions	Share of total capacity
				2005	2009	2010	2015	2019	2019	2019
81	Zementwerk Rüdersdorf	CEMEX Zement GmbH	Rüders-dorf	1.3	1.2	1.3	1.3	1.2	6.0%	5.3%
74	Werk Lägerdorf	Holcim (Deutsch-land) GmbH	Läger-dorf	1.1	1.1	1.2	1.2	1.1	5.4%	4.8%
116	Drehöfen Deuna	Dyckerhoff GmbH	Deuna	0.9	1.1	1.1	0.9	1.0	5.2%	5.3%

Emissions and production capacity of the largest cement clinker facilities in terms of emissions in Germany.
Source: EEA 2019, Own calculations based on Cemnet 2020.

The following map shows the location of the cement clinker production facilities participating in the EU ETS in 2019 in Germany. Three facilities emitted over 1 million tonnes of CO_2eq, 17 facilities emitted between 500,000 and 1 million tonnes of CO_2eq and 15 facilities had emissions below 500,000 tonnes of CO_2eq in 2019.

Figure 20: Germany: Location of cement clinker production plants



Location of cement clinker production plants in Germany (2019), the size of the dots indicates the amount of verified emissions in 2019.
Source: EEA 2019

Cement clinker production companies

The largest cement clinker production company "HeidelbergCement AG" in terms of emissions emitted 4.68 million tonnes of CO_2eq in 2019. It encompasses 8 different production plants subject to EU ETS.

The second largest cement clinker production company "Dyckerhoff GmbH", consisting of 6 plants, emitted 3.27 million tonnes of CO_2eq in 2019.

The third largest company "SCHWENK Zement KG" including 4 plants emitted 2.58 million tonnes of CO_2eq in 2019.

Together, these three companies account for 54 % of total verified emission from cement clinker production in 2019.

3.8 Facility data – examples of recent investments

Exemplary list of investments in the cement production sector based on company's data:

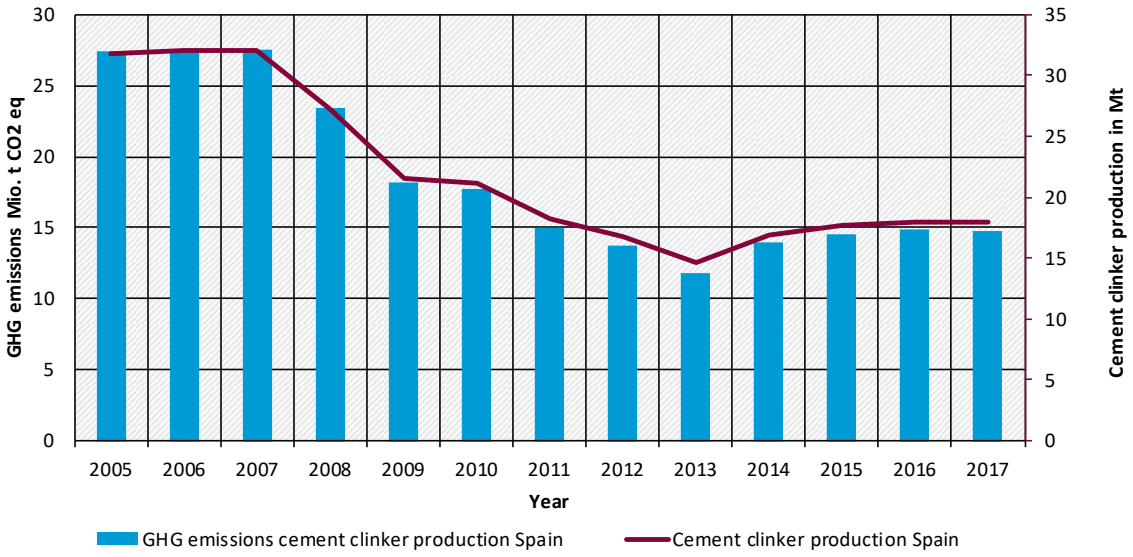
- Germany's largest cement clinker production company "HeidelbergCement AG", whose "Zementwerk Burglengenfeld" plant accounted for the fourth highest emissions in 2019, had started an investment programme in 2014 with the aim to modernise and increase the efficiency of their cement plants and environmental protection in Germany. The programme was completed with the commissioning of a new kiln line in their "Zementwerk Schelklingen" in 2019. HeidelbergCement continues to focus their investment activities on the improvement of environmental protection. This includes investments in the reduction of dust, nitrogen oxide and sulphur oxide emissions as well as increasing the use of alternative fuels and raw materials (HeidelbergCement AG 2020).
- The cement clinker production company "OPTERRA Zement GmbH" announced a 23 million EUR investment in May 2018 for their "Zementwerk Karsdorf" plant in order to improve environmental performance and provide secure jobs. Two plants with special filters were built at the Karsdorf plant, which primarily serve emission control in order to comply with the new limit values applied in Germany since the beginning of 2019 for dust, ammonia and nitrogen oxides, among other things (OPTERRA GmbH 2018).
- "Dyckerhoff GmbH", which is part of the Italian cement clinker production company "Buzzi Unicem", spent 6.8 million EUR in 2019 on the installation of selective catalytic reduction (SCR) technology for NOx emissions reduction at their "Drehöfen Deuna" and "Drehöfen Göllheim" plants. The Deuna plant, which was Germany's third largest facility with regard to emissions in 2019, is further undergoing modernization and efficiency improvements of electrical installations as is the Lengerich plant, which amounts to a total of 2.1 million EUR. Another 0.8 million EUR went into the completion of NOx, CO and total organic carbon (TOC) reduction equipment at "Werk Geseke" (Buzzi Unicem 2020).

4 Spain

4.1 Key messages

- GHG emissions from cement clinker production in Spain amounted to roughly 15 million tonnes of CO_2eq in 2017. Since 2013 they increased by 25 %. Compared to 2005, however, emissions decreased by almost 50 %, mainly driven by a sharp decrease in construction activity due to the economic and financial crisis in 2008. In 2017, cement clinker production accounts for roughly 11 % of total EU ETS emissions in Spain. This share slightly decreased over time from 14 % in 2005.
- With 12 %, Spain contributes the second highest share of total emissions from the cement clinker production in the EU28 in the year 2017.
- Cement clinker production in Spain shows a very similar development over time as emissions with an increase of 22 % between 2013 and 2017 but a drop of 43 % compared to 2005 (see Figure 21). Spanish cement production accounts for roughly 15 % of the total cement clinker production sector in the EU28 in 2017. This share slightly increased since 2013.
- The similar trend of emissions and production of the cement industry in Spain indicates that the emissions intensity per tonne of clinker did not change substantially. Between 2013 and 2017, the emission intensity increased marginally from 0.81 t CO_2eq/t clinker to 0.82 t CO_2eq/t clinker. The emission intensity in 2017 is slightly higher than the EU28 average of 0.81 t CO_2eq/t clinker (see Table 4).

Figure 21: Spain: Total GHG emissions from the cement clinker production



Evolution of total GHG emissions from the cement clinker production and evolution of cement clinker production between 2005 and 2017 in Spain.
Source: Spain 2019, EEA 2019

- The emission intensity is affected by the fuel composition (i.e. share of fossil fuels vs. biomass fuels) and the efficiency of production technology applied[29]:
  - Waste regulation in Spain is very limited and not well developed with almost half of the generated waste being disposed of in landfills. Therefore, the use of alternative fossil and mixed wastes as well as biomass for energy consumption lies below the EU28 average (33 % Spain vs. 46 % EU28 average in 2017, see Figure 7). Nevertheless, the share of alternative fuels increased substantially since 2005 (+ 24 percentage points between 2005 and 2013) and stayed roughly constant since 2013. In 2017, fossil fuels still dominate the thermal energy input in Spain (Figure 25).
- The energy intensity per tonne of clinker did not change substantially over the time period of 2005 to 2017 (fluctuating between 3.5 and 3.6 GJ/t clinker).
- The use of mineral components as a substitution of clinker is rather low in Spain compared to other European countries. The use of pozzolana is quite common and constant over time due to the natural occurrence of this material in Southern European regions. The clinker to cement ratio lies at around 81 % in 2017 (EU28 average 77 %, see Table 4), has been fluctuating around 80 % in recent years and is higher than the EU28 average.
- The production volume index for the construction industry, an important indicator of cement demand from the construction sector, correlates strongly positively with cement production in Spain (correlation coefficient: 0.98). The production volume index shows a strong decrease between 2005 and 2012 and since then a slight increase is observed.
- Since 2010, Spain has turned from a net-importer to a net-exporter of cement clinker. Imports of cement clinker have seen a sharp decrease since 2005 with almost no imports since 2011, while exports of cement clinker have an increasing trend since 2008. With 28 % of total production being exported in 2017, export volumes compared to domestic clinker production are also much higher than in the other analysed countries. The majority is exported to countries outside the EU28.
- At the beginning of 2005, 37 cement clinker production plants were in operation. One plant ceased production already in 2009 and five more in 2013. Since then, the number of cement clinker production plants stayed constant at 31 plants in 2017 as well as 2019. The largest cement clinker production plant "Morata de Tajuña" emitted 0.95 million tonnes of CO_2eq in 2019.

[29] The condition, operating mode and kiln capacity of a plant as well as moisture and combustibility of the raw material are additional factors affecting the emission intensity. In this factsheet, individual plants were not analysed such that the focus lies on the fuel composition and production technology.

Table 7: Spain: Key figures on the cement clinker industry

Cement clinker industry characteristics	Unit	Year 2017	% change 2017 compared to 2013	Share of cement clinker prod-uction sector EU28 in 2017	Source
GHG emissions	Mt CO_2eq	14.8	25 %	12 %	EEA 2019
Clinker production	Mt	17.9	22 %	15 %	Spain 2019
GHG emission intensity	t CO_2eq/t clinker	0.82	2 %	101 %[30]	EEA 2019, Spain 2019
Energy consumption	PJ	40	2 %	9 %	GCCA 2020[31]
Energy intensity	GJ/t clinker	3.0	-15 %	84 %[32]	GCCA 2020
Number of cement clinker production plants		31	0 %	14 %	EEA 2019
Cement clinker plants with highest emissions					
Plant name (Company)	**Share of total capacity of cement clinker prod. facilities***	**Emissions in 2019 [Mt CO_2eq]****	**% change 2019 compared to 2013****	**Share of emissions from cement clinker prod. in Spain in 2019****	
Cementos Portland Valderrivas - Morata de Tajuña (Cementos Portland Valderrivas, S.A.)	7.4 %	0.95	134 %	6.7 %	
Cementos Molins Industrial S.A. (Cementos Molins Industrial, S.A.)	4.2 %	0.89	-8 %	6.3 %	
Cemex España Operaciones, S.L.U. - Alcanar (Cemex España Operaciones, S.L.U.)	4.9 %	0.70	307 %	5.0 %	

Key figures on the cement clinker production in Spain and on its largest cement clinker plants.
Source: Own table based on various sources. * Own calculations based on Cemnet 2020. **EEA 2019

[30] This value indicates that the emission intensity in Spain is 101 % of the EU28's emission intensity in 2017.

[31] Due to the low coverage of the GCCA dataset for Spain, the data are not directly comparable to the observed evolution of cement clinker production and GHG emissions.

[32] This value indicates that the energy intensity in Spain is 84 % of the EU28's energy intensity in 2017.

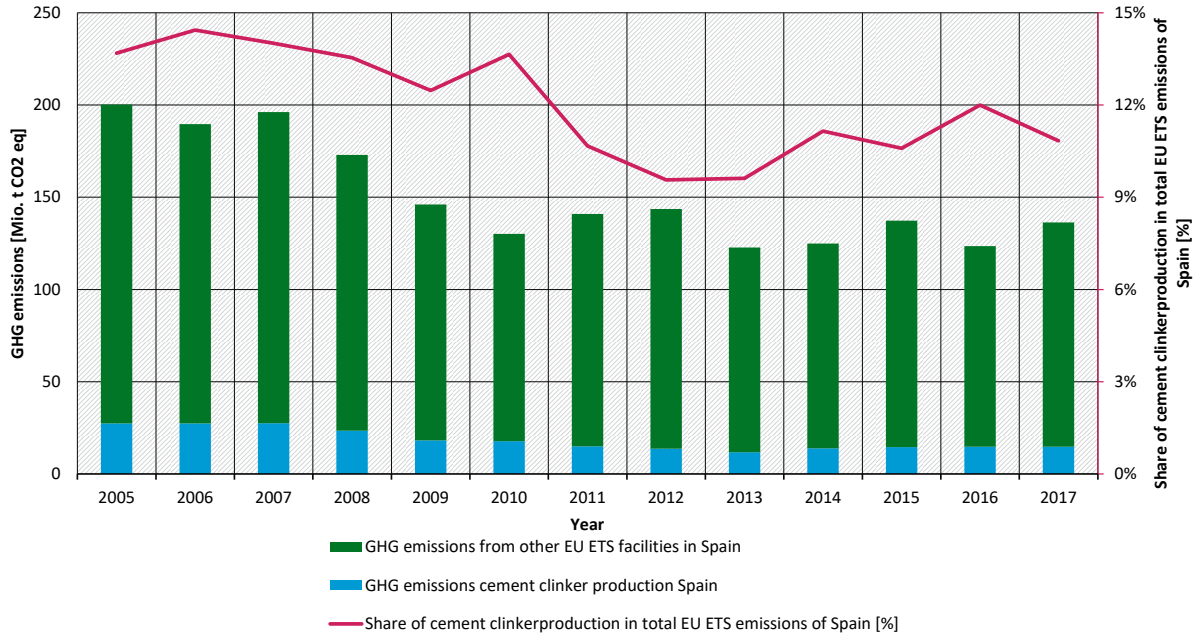
4.2 Evolution of GHG emissions

The following trends can be observed for the emissions from the EU ETS facilities in Spain:

- In 2005 the emissions of stationary facilities participating in the EU ETS in Spain[33] amount to 200 million tonnes of CO_2eq. In 2017, the cement clinker production contributes a share of about 11 % (15 million tonnes of CO_2eq). This share declines between 2006 and 2012. After 2013 there is again a slight increase in the share of the cement clinker production in Spain's EU ETS emissions. Emissions from cement clinker production have decreased more strongly (-46 %) than in other EU ETS facilities in Spain (-30 %) between 2005 and 2017 (EEA 2019).
- A sharp drop in emissions from Spain's EU ETS facilities is observed during the economic and financial crisis (-35 % in 2010 compared to 2007), with a reduction of about 70 million tonnes of CO_2eq for the entire EU ETS facilities and a reduction of about 10 million tonnes of CO_2eq for the cement clinker production sector. After 2010 the emissions from the cement clinker production sector continue to drop until 2013 and since then they increased slightly to a level of about 15 million tonnes of CO_2eq. Total emissions of all EU ETS facilities in Spain fluctuate between 110 and 130 million tonnes of CO_2eq since 2010 (EEA 2019).
- The observed increase of GHG emissions from cement clinker production since 2013 is mainly due to the increase in clinker production volumes, which is partially compensated by an increase in the share of biomass fuels and alternative fuels.

[33] Total emissions from the EU ETS facilities include verified emissions under the EU ETS as well as an estimate of emissions for 2005-2012 reflecting the current scope of the EU ETS.

Figure 22: Spain: Total GHG emissions from EU ETS facilities and share of emissions from cement clinker industry



Evolution of total GHG emissions from EU ETS facilities between 2005 and 2017 in Spain (left axis). The bars show the emissions from cement clinker production and other facilities of the EU ETS. The red line (right axis) indicates the relative share of GHG emissions from cement clinker production in total emissions from EU ETS facilities in Spain.
Source: EEA 2019, own calculations

- Total GHG emissions[34] in Spain amounted to about 441 million tonnes of CO_2eq in 2005 (Spain 2019). They decrease until 2017 to 340 million tonnes of CO_2eq. Emissions from EU ETS facilities accounted for 40 % of Spain's total GHG emissions in 2017 (EEA 2019).

4.3 Evolution of cement clinker production

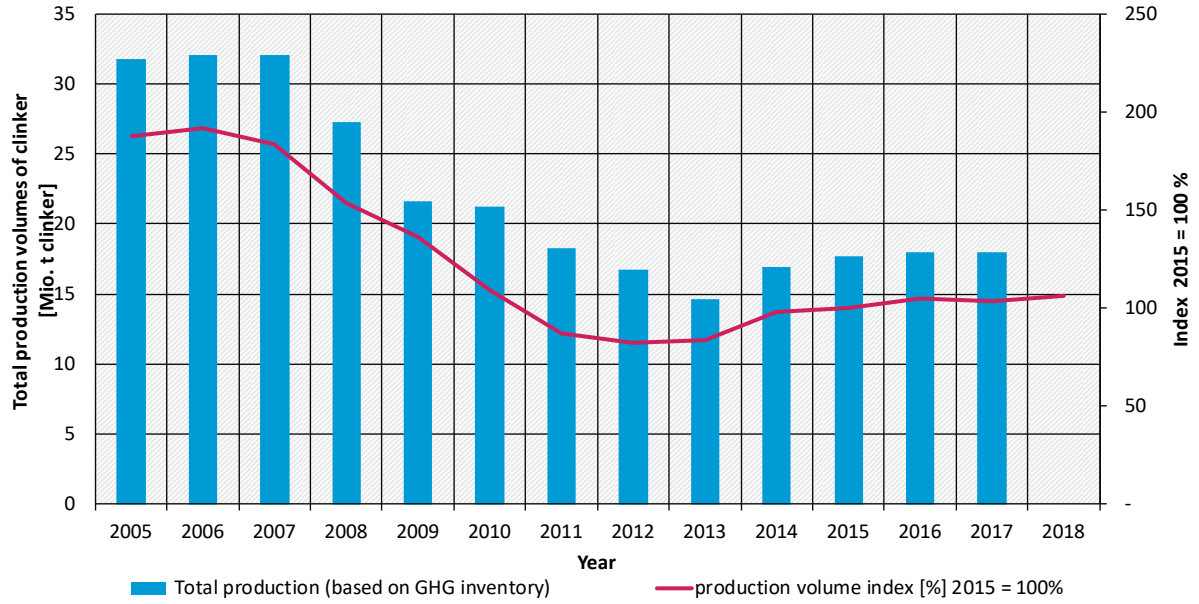
Production of grey cement clinker

The production of grey cement clinker is the most important driver of emissions from cement production. Production volumes[35] stay rather constant between 2005 and 2007 at slightly more than 30 million tonnes. Between 2007 and 2013 production volumes drop by 50 % to about 15 million tonnes of grey cement clinker. Since then, there is a slight increase in production volumes. However, they still remain below the level of 2005 (Spain 2019). There is a strong positive correlation to the production volume index for the construction industry (correlation coefficient: 0.98). The production volume index for the construction industry relative to 2015 shows a strong decline between 2005 and 2012, increases slightly in the following years and remains at a constant level since 2016.

[34] Total GHG emissions reported here exclude emissions from land use, land use change and forestry. Indirect GHG emissions are excluded as well.

[35] For Spain, clinker production data according to GCCA 2020 show insufficient coverage. Therefore, the data from the NIR are used (UNFCCC 2019).

Figure 23: Spain: Production of grey cement clinker and evolution of production volume index of the construction sector



Evolution of total grey cement clinker production volume in Spain (2005-2017) estimated based on data reported by Spain (left axis). The red line (right axis) indicates the evolution of production volume index of the construction sector in Spain since 2005. 2015 corresponds to 100 %.

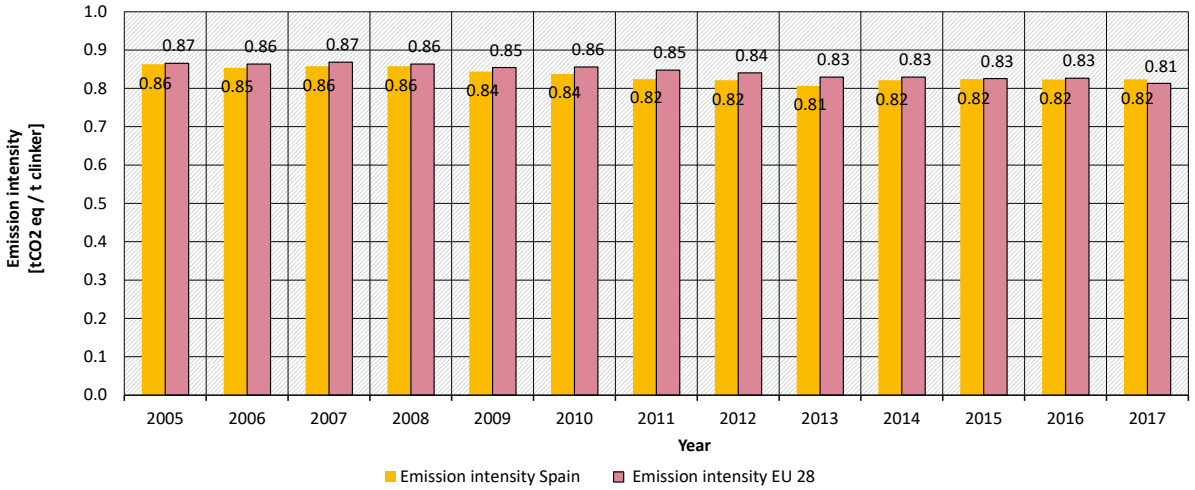
Source: Spain 2019, EUROSTAT 2020b (Calendar adjusted data, non-seasonally adjusted data)

4.4 Evolution of GHG emission, energy intensity and clinker to cement ratio

Evolution of GHG emission intensity

The emission intensity per tonne of clinker is mainly affected by the fuel composition (i.e. share of fossil fuels vs. biomass fuels) and the efficiency of production technology applied. In 2017, emissions per tonne of clinker produced amount to about 0.82t CO_2eq/t clinker in Spain, higher than the EU28 average of around 0.81 t CO_2eq/t clinker which could possibly be due to the comparatively high share of fossil fuels. Since 2005, emission intensity shows a slight decreasing trend, from 0.86 t CO_2eq/t clinker in 2005 to 0.82 t CO_2eq/t clinker in 2017. This corresponds to a relative reduction of 4 % compared to 2005.

Figure 24: Spain and EU28: Emission intensity of clinker production



Evolution of GHG emission intensity of clinker production in Spain and EU28. The emission intensity of Spain is based on clinker production data from the GHG inventory (Spain 2019) and emission data from EEA 2019. The emission intensity for the EU28 is provided by GCCA 2020.
Source: Spain 2019, EEA 2019, GCCA 2020

Evolution of energy intensity

In Spain, total thermal energy consumption intensity[36] per tonne of grey cement clinker produced amounts to about 3.58 GJ/t clinker in 2005 and around 3.03 GJ/t clinker in 2017 with few annual fluctuations but roughly staying the same over time (except from 2016 to 2017, see below). In the EU28, total thermal energy consumption intensity per tonne of grey cement clinker is at a similar level and shows a very slight decreasing trend (GCCA 2020).

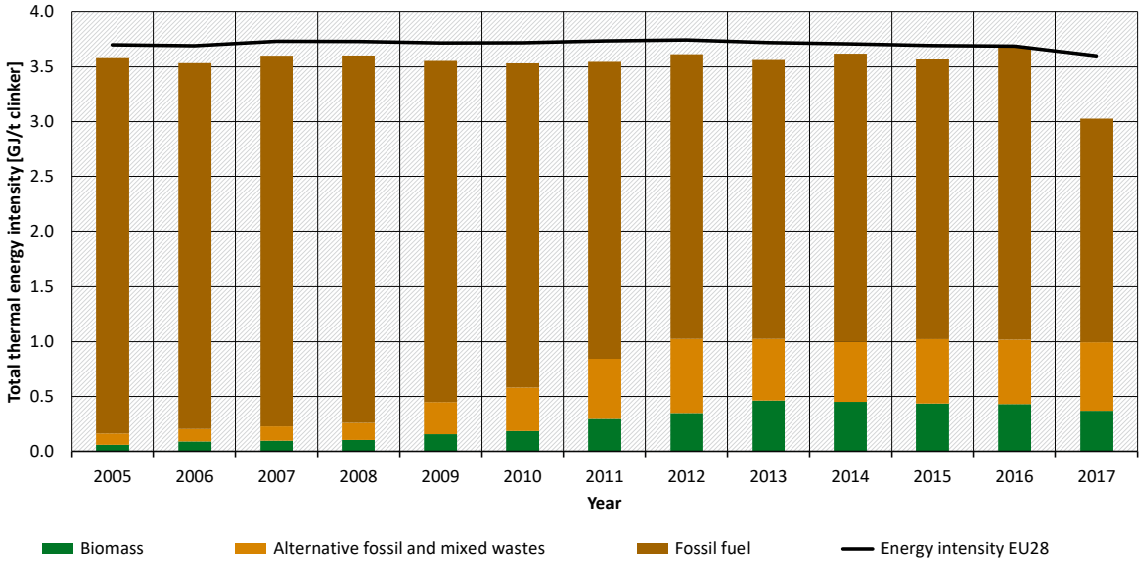
In Spain, a substantially lower thermal energy consumption is observed in 2017, which however does not correspond well to the trend observed in the emission intensity (Figure 24), which shows no reduction in these years (GCCA 2020). We suspect that this reduction in energy intensity is due to an erroneous data basis and does not reflect the actual development.

Thermal energy is produced from either regular fossil fuels, such as coal or oil, alternative fossil fuels[37] (such as waste solvents, plastics or tires) and biomass fuels. The share of alternative fossil fuels and biomass in thermal energy is increasing since 2005. In 2005, the share of "alternative fossil fuels and mixed wastes" and biomass amounted to 3 % and 2 % (EU28 average 11 % and 4 %) respectively and until 2017, the share increased to 21 % and 12 % (EU28 average 30 % and 16 %) respectively. Thus, in 2017 the share of regular fossil fuels is at 67 % (EU28 average 54 %) (GCCA 2020). Though the use of waste as alternative fuel for the cement clinker production has increased substantially in this time period, there is still a lot of room for improvement in the Spanish waste processing industry (see chapter 4.6). Over the entire time period, the share of alternative fossil fuels and biomass in Spain is substantially lower as compared to the EU28 average (Figure 7).

[36] Besides thermal energy, the production of cement also requires electricity. Power consumption is however negligible compared to the thermal energy intensity. It is therefore not considered in the present report.

[37] Definition of "alternative fuels" according to WBCSD (2016): Products of fossil origin used as a source of thermal energy and not classified as traditional fossil fuel. This is mainly fossil waste such as plastics, solvents, waste oil, end-of-life tires, etc.

Figure 25: Spain: Total thermal energy consumption intensity and share of different energy carriers



Evolution of thermal energy input for grey cement clinker production in Spain and EU28. For Spain, the share of alternative fossil and mixed wastes, biomass and fossil fuels are shown.
Source: GCCA 2020

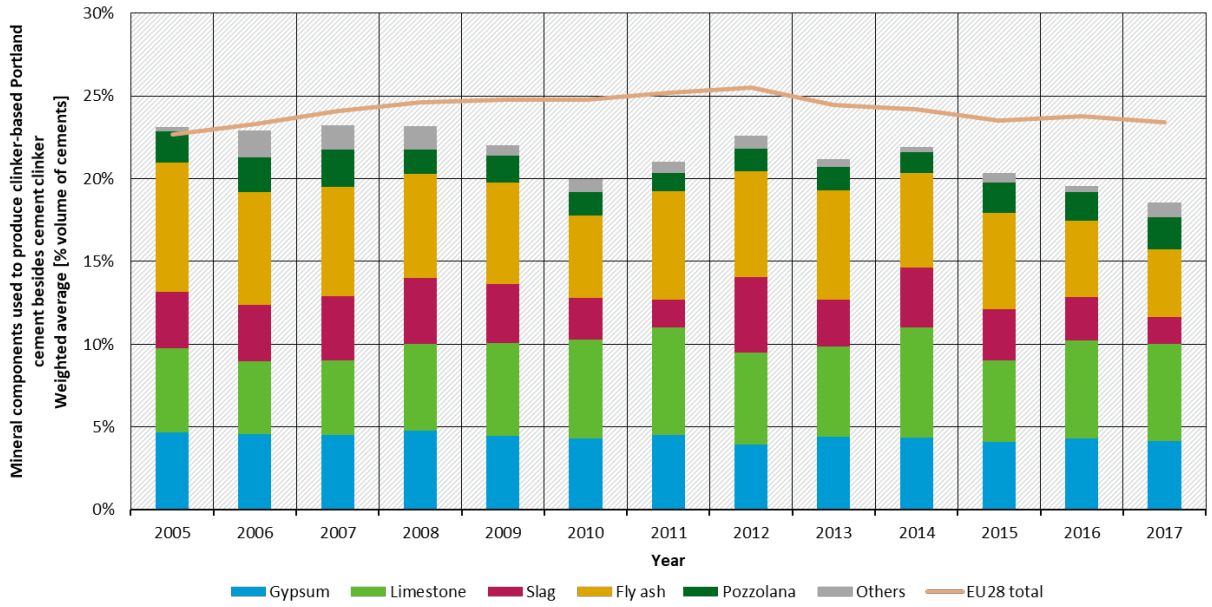
Clinker to cement ratio and mineral components in cement

In the production of Portland cements besides grey cement clinker mainly limestone, gypsum and fly ash are used in Spain (GCCA 2020). In some years, slag accounts for a substantial amount as well. The share of mineral components in Spain is lower than in the EU28 corresponding to a higher clinker to cement ratio in 2017 (81 % vs. 77 % EU28 average). Between 2005 and 2010 the share of mineral components decreased from 23 % to 20 % falling below the EU28 average. After 2010, a slight increasing trend can be observed before the share decreases again in 2014 reaching 19 % in 2017, which is well below the EU28 average.

Spain has the second highest grey cement clinker share of all countries analysed in the present report[38]. Both the trend of the clinker to cement ratio in Spain and in the EU28 show a slight increasing tendency since 2012 causing an increase in emissions per tonne of cement in Spain.

[38] The construction boom before 2008 stimulated cement clinker production such that, as a consequence of the financial crisis in 2009, Spain had an excess of clinker output, which lead to an increased clinker share and clinker exports reducing the carbon efficiency of cement production (Branger et al. 2015).

Figure 26: Spain: Share of mineral components used in production of Portland cement besides grey cement clinker



Evolution of the share of mineral components used in production of Portland cement besides grey cement clinker in Spain and in the EU28 since 2005.
Source: GCCA 2020

4.5 Market evolution, imports and exports

Import and export of Portland cement

Import and export of cement products were analysed for Portland cement, which is the most widely used type of cement[39]. For Portland cement, import and export remain at a low level compared to total sold production[40]. Sold production of Portland cement increased slightly from roughly 47 million tonnes in 2005 to about 50 million tonnes in 2007. Between 2007 and 2013, sold production shows a sharp decline to about 13 million tonnes. Since then, the sold production remains almost constant, with a slight increase reaching 16 million tonnes in 2018 (EUROSTAT 2020a).

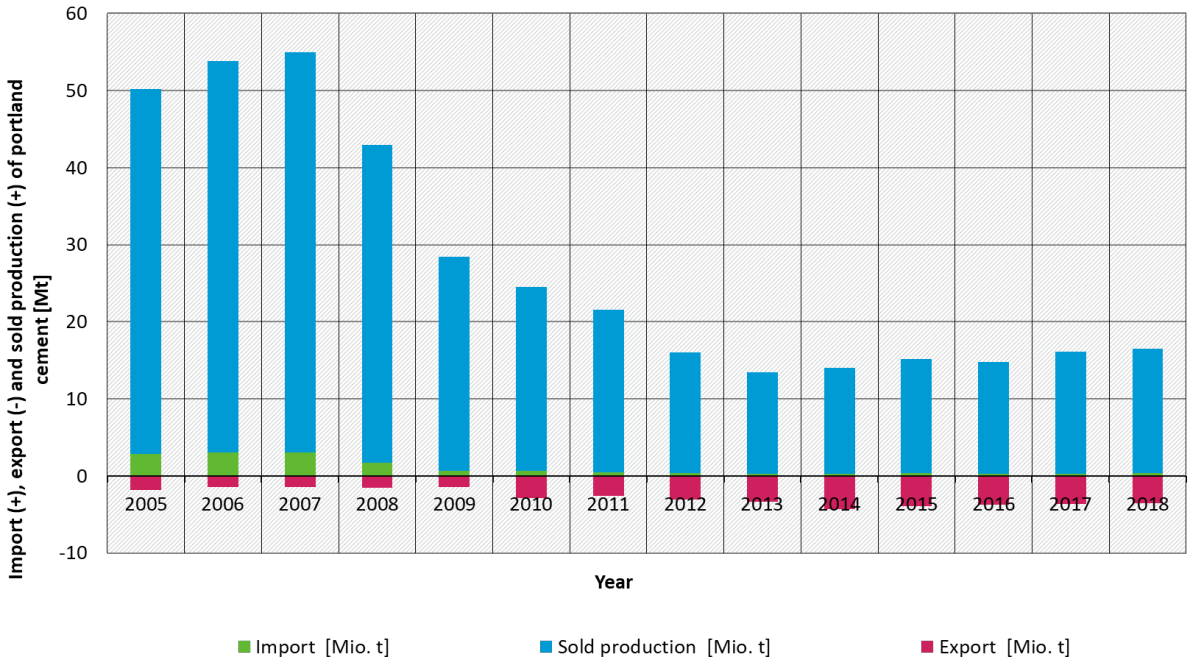
Import of cement increased from about 2.8 million tonnes in 2005 to about 3 million tonnes in 2007. Until 2010 the imports drop sharply and are negligible since then.

These trends can be explained with the construction boom before 2008 and the subsequent massive downturn of construction activities starting in 2008/2009 (Fernández Muñoz et al. 2017). Since 2013, there is a slightly increasing volume of sold production and exports though on a much lower level than before 2008.

[39] Portland cement (CEM I, II) constitutes more than 75 % of total cement sold in Europe in 2015.

[40] Sold production corresponds to the value and volume of the product sold by the enterprise it differs from total production (the volume of all production of the product, including both the proportion that is sold and the proportion that is retained by the enterprise for adding to stocks, using in further processing etc.).

Figure 27: Spain: Development of the Portland cement market



Evolution of import, export and sold production of Portland cement in Spain between 2005 and 2018.
Source: EUROSTAT 2020a

Import and export of cement clinker

The market for cement clinker in Spain since 2005 shows different trends in import, export and sold production[41]. Until 2009, Spain was a net-importer of cement clinker. Since 2010, Spain exports more than it imports. One of the main influencing factors was the construction boom before 2008 that stimulated cement clinker consumption (domestic production and imports). A drop in construction activity after the economic and financial crisis lead to over-capacities (Branger et al. 2015). Excess production was partly sold to other domestic companies or exported to other countries mainly outside the EU28 (see below).

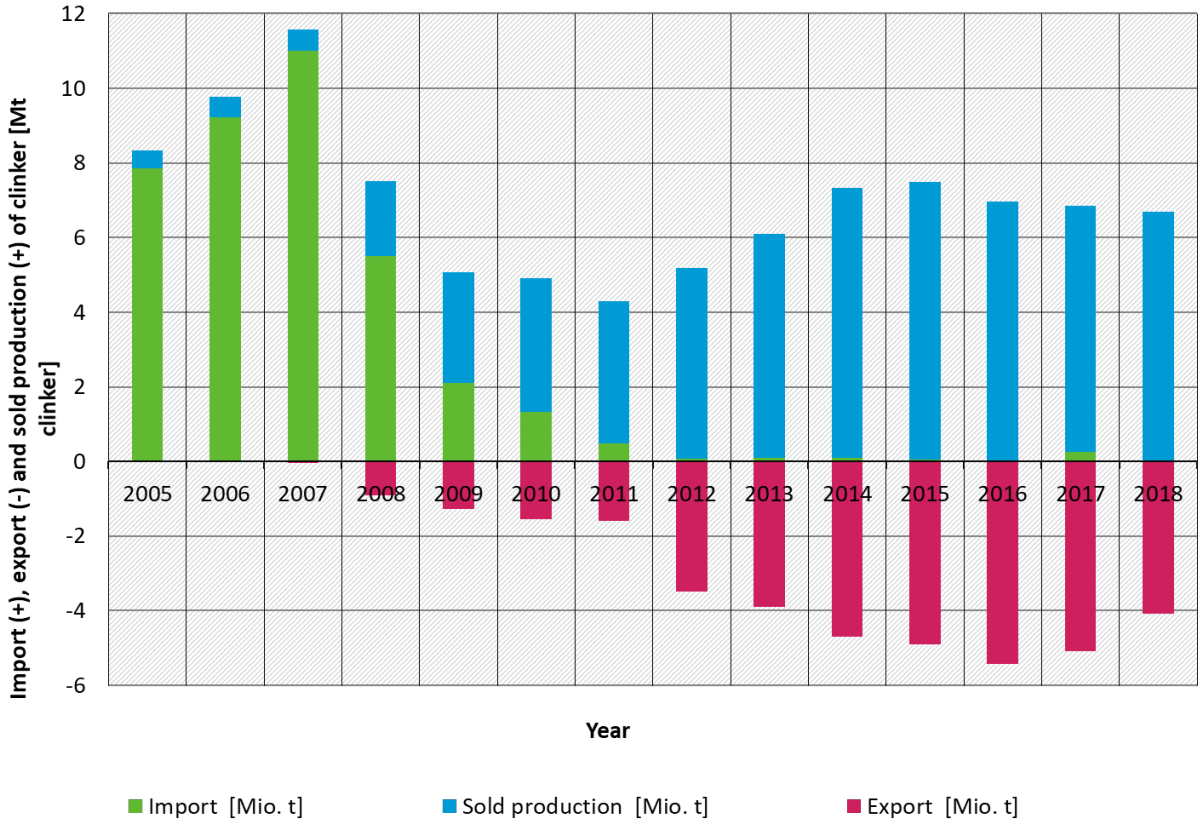
Almost no cement clinker was exported until 2008. Between 2008 and 2016, exports increased substantially to over 5 million tonnes in 2016 and decreased again to about 5 million tonnes of cement clinker in 2017. Generally, export volumes compared to domestic clinker production (see chapter 4.3) are much higher than in the other analysed countries increasing from 3 % in 2008 to more than 30 % in 2016 and 28 % in 2017.

The trend of sold production is similar to the trend in exported amounts of clinker with slightly higher absolute amounts (EUROSTAT 2020a).

An opposite trend is observed for imports of cement clinker. Between 2005 and 2007 imports first increased from almost 8 million tonnes to a level of about 11 million tonnes in 2007, which corresponds to a share of 34 % of total cement clinker production in 2007 (EUROSTAT 2020a). Since then, imported amounts dropped substantially. After 2011, almost no cement clinker is imported anymore. This again can be traced back to the financial crisis of 2008/2009. Due to overcapacities in the cement clinker production imports ceased and exports increased.

[41] Sold production is smaller than total clinker production, since the amount of clinker that is directly processed to cement by the same company is not accounted for in the sold production.

Figure 28: Spain: Development of the cement clinker market



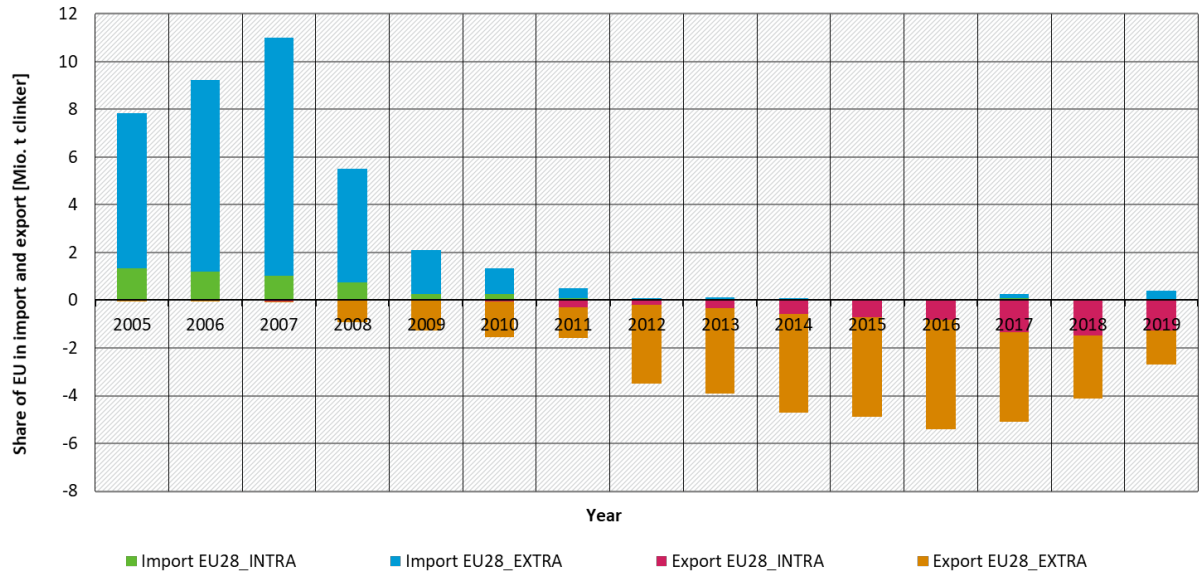
Evolution of import, export and sold production of cement clinker in Spain between 2005 and 2018. The blue bars only show the sold production of clinker, this does not include the cement clinker production that is directly processed to cement by the same company.
Source: EUROSTAT 2020a

Import and export of cement clinker within the EU28 and outside the EU28

Imports of cement clinker from other EU28 countries are less important than imports from countries outside the EU28, probably because of Spain's geographical location with access to the sea and the proximity to Morocco. About 17 % of imports originated from other EU28 countries in 2005. This share dropped to about 10 % in 2007 (EUROSTAT 2020e).

Exports of cement clinker from Spain to countries outside the EU28 are also higher than exports to EU28 countries. Between 2008 and 2016, more than 80 % of the exported cement clinker was exported to countries outside the EU28. As exports to non-EU28 countries decrease since 2016, the share of exports to the EU28 countries shows an increasing trend and reached almost 50 % in 2019 (EUROSTAT 2020e).

Figure 29: Spain: Import and export of cement clinker to and from other EU28 countries/countries outside the EU28



Evolution of Spain's import of cement clinker from other EU28 countries (Import EU28_INTRA) and from countries outside the EU28 (Import EU28_EXTRA) and evolution of Spain's export of clinker to other EU28 countries (Export EU28_INTRA) and to countries outside the EU28 (Export EU28_EXTRA).
Source: EUROSTAT 2020e

4.6 Regulative, economic and political framework

The following sections summarize the regulative, economic and political framework affecting the cement sector in Spain. This includes the use of waste as alternative fuels and state aid.

Use of waste fuels in the cement industry

In Spain, the waste processing industry is not well developed, since in 2014 still around 43 % of generated waste were landfilled. The Spanish co-processing rate is well below the EU28 average, with about 23 % of thermal energy originating from alternative fuels. The potential for the co-processing rate in the Spanish cement industry is estimated at 35 % (De Beer et al. 2017).

The lack of investment in the waste management industry, low landfilling taxes and low public acceptance of co-processing of waste pose high barriers to use of waste fuels in the cement industry. In addition, poor law enforcement in waste management - in particular at local and regional level - and lack of cooperation between different regions within Spain are considered as barriers. Furthermore, subsidies for power and heat generation for biomass make biomass co-processing costly (De Beer et al. 2017).

Also, regional differences for taxes and fees of waste treatment led to a trade of waste across regions within Spain or across the border. Waste is transported to locations with lower treatment costs, even though local treatment options might exist (De Beer et al. 2017).

State Aid

In the State Aid Transparency database of the European commission no information is provided on any case of state aid for the cement sector (C.23.51 Production of cement) in Spain (EC 2020).

4.7 Facility data – the largest emitters and their location

GHG emissions and production capacity

In 2019, 31 cement clinker production plants were subject to the EU ETS in Spain. The following table provides an overview on GHG emission and cement production capacity of the three largest cement clinker facilities in terms of emissions in Spain.

Table 8: Spain: Emissions and production capacity of the three largest cement clinker plants in terms of emissions

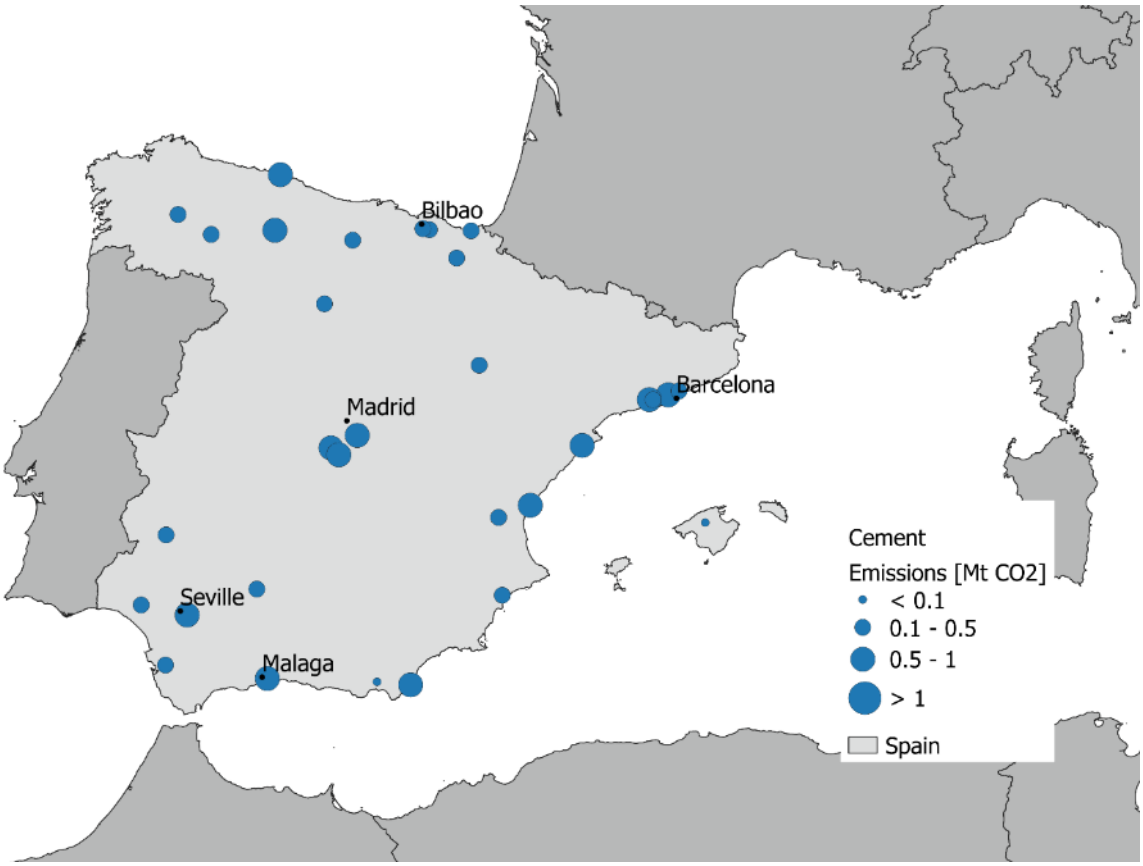
ID	Installation	Company	City	Emissions (Mt CO_2eq)					Share of total verified emis-sions	Share of total capa-city
				2005	2009	2010	2015	2019	2019	2019
699	Cementos Portland Valderrivas - Morata de Tajuña	Cementos Portland Valderrivas, S.A.	Morata de Tajuña	2.1	1.0	0.9	0.5	0.9	6.7%	7.4%
390	Cementos Molins Industrial S.A.	Cementos Molins Industrial, S.A.	Sant Vicenç Dels Horts (Barcelona)	1.2	1.0	1.0	1.0	0.9	6.3%	4.2%
391	Cemex España Operaciones, S.L.U. - Alcanar	Cemex España Operaciones, S.L.U.	Alcanar (Tarragona)	1.6	1.0	1.1	0.8	0.7	5.0%	4.9%

Emissions and production capacity of the largest cement clinker facilities in terms of emissions in Spain.

Source: EEA 2019, Own calculations based on Cemnet 2020.

The following maps shows the location of the cement clinker production facilities participating in the EU ETS in 2019 in Spain. 12 facilities emitted over 500,000 tonnes of CO_2eq, 17 facilities emitted between 100,000 and 500,000 of CO_2eq and two facilities had emissions below 100,000 tonnes of CO_2eq in 2019.

Figure 30: Spain: Location of cement clinker production plants



Location of cement clinker production plants in Spain (2019), the size of the dots indicates the amount of verified emissions in 2019.
Source: EEA 2019

Cement clinker production companies

The largest cement clinker production company "Cementos Portland Valderrivas, S.A." in terms of emissions emitted 3.3 million tonnes of CO_2eq in 2019. It encompasses 6 different production plants subject to EU ETS.

The second largest cement clinker production company "LafargeHolcim España, S.A.U.", consisting of 5 plants, emitted 2.7 million tonnes of CO_2eq. The third largest company "Cemex España Operaciones, S.L.U." including 7 plants emitted 2.5 million tonnes of CO_2eq.

Together, these three companies account for 60 % of total verified emission from cement clinker production in 2019.

4.8 Facility data – examples of recent investments

Exemplary list of investments in the cement production sector based on company's data:

- The cement clinker production company "Grupo Cementos Portland Valderrivas", whose "Morata de Tajuña" plant accounted for the highest emissions in 2019, has been pursuing a strategy of resizing the concrete, mortar and aggregate businesses since 2013, which has entailed the transfer or closure of the unprofitable plants of these businesses in the Spanish market. In 2015, the company consolidated substitution of fossil fuels by alternative fuels in its clinker kilns, reaching an average value of 13 % of alternative fuels for all its factories.

Climate change mitigation has become one of the main environmental challenges for the company. New additions for low CO_2 intensity cements were obtained within the framework of improved process efficiency (Grupo Cementos Portland Valderrivas 2015).

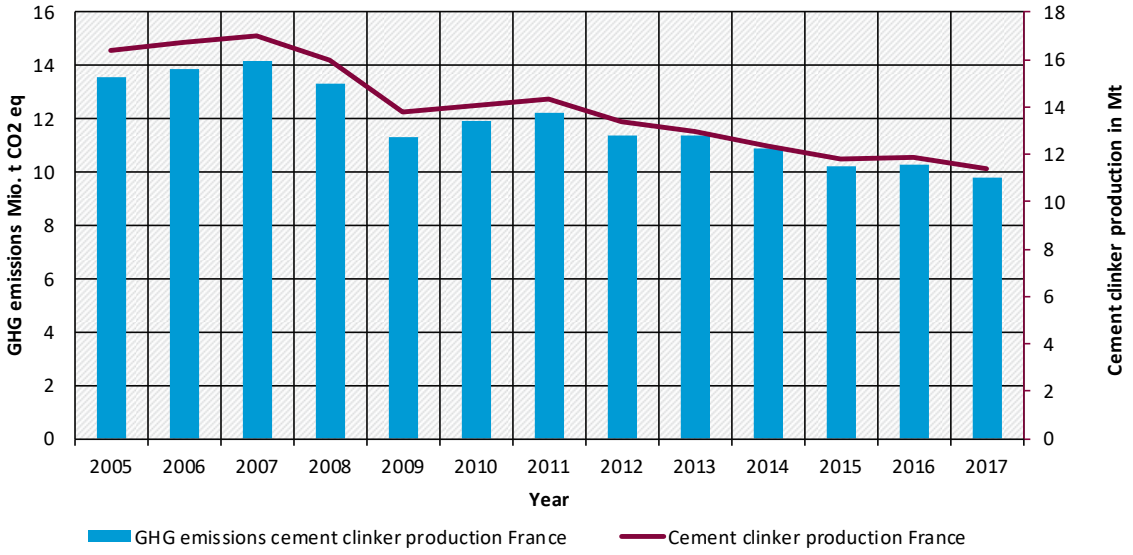
- "Cementos Molins Industrial S.A." owns the second largest cement clinker production plant with regard to emissions in 2019. Also, this company commits to the consumption of alternative fuels, achieving a record percentage of 42.9 % with regard to replacement with alternative fuels. For the company, the identification and direct contributions to the Sustainable Development Goals (SDGs) in their value chain is important as is apparent from their Annual Report 2019. Further, in 2019, they recorded investments of 3.1 million EUR in Spain for dismantling works of the former cement lines, a new bagging machine for Portland cement, the improvement in the cooling water and the softened water circuit facilities, the acquisition of a loader and a new dumper for the quarry (Cementos Molins 2019).

5 France

5.1 Key messages

- GHG emissions from cement clinker production in France amounted to roughly 10 million tonnes of CO_2eq in 2017. Since 2013 emissions decreased by 14 %. In 2017, the cement clinker production accounts for roughly 8 % of total EU ETS emissions from France. This share stayed roughly constant over time with a slight decrease since 2013.
- France contributes a share of 8 % to total EU28 emissions of cement clinker production in 2017. Cement clinker production in France shows a very similar development to GHG emissions with a decrease of 12 % between 2013 and 2017 (see Figure 31). Cement clinker production in France accounts for roughly 9 % of the total cement clinker production sector in the EU28 in 2017. This share slightly decreased since 2013.
- The similar trend of emissions and production of cement clinker indicates that the emissions intensity per tonne of clinker did not change substantially. Between 2013 and 2017, the emission intensity decreased only marginally from 0.85 t CO_2eq/t clinker to 0.83 t CO_2eq/t clinker. The emission intensity is slightly higher than the EU28 average of 0.81 t CO_2eq/t clinker in 2017 (see Table 4).

Figure 31: France: Total GHG emissions from the cement clinker production



Evolution of total GHG emissions from the cement clinker production and evolution of cement clinker production between 2005 and 2017 in France.
Source: GCCA 2020, EEA 2019

- The emission intensity is affected by the fuel composition (i.e. share of fossil fuels vs. biomass fuels) and the efficiency of production technology applied[42]:

[42] The condition, operating mode and kiln capacity of a plant as well as moisture and combustibility of the raw material are additional factors affecting the emission intensity. In this factsheet, individual plants were not analysed such that the focus lies on the fuel composition and production technology.

  - The use of alternative fossil and mixed wastes as well as biomass for energy consumption is equal to the EU28 average (46 % France vs. 46 % EU28 average in 2017, see Figure 7). The share of alternative fuels in France increased substantially since 2005 with a stronger increase since 2013. In 2017, fossil fuels still slightly dominate the thermal energy input in France.

- The energy intensity per tonne of clinker shows a slight increase over the time period of 2005 to 2017 (from 3.7 GJ/t clinker in 2005 to 3.9 GJ/t clinker in 2017).
- The use of mineral components as a substitution of clinker is quite important in France with slag being the most often used substitut for clinker. The clinker to cement ratio lies at roughly 76 % in 2017 (EU28 average 77 %, see Table 4) and shows some fluctuations since 2013.
- The production volume index for the construction industry, an important indicator of cement demand from the construction sector, shows a strong positive correlation to cement clinker production in France (correlation coefficient: 0.88). Since 2015, however, a slight increase in the production volume index is observed while cement clinker production shows a slight decrease.
- France is a net-importer of cement clinker, and imports volumes compared to domestic clinker production are much higher than in the other analysed countries (11 % in 2017). Imports of cement clinker in France fluctuate over time and originate both from countries inside as well as outside the EU28. Exports of cement clinker are on a much lower level and rather constant over time.
- The number of cement clinker production plants slightly decreased between 2005 and 2019 with four plants closing during this time period. The three largest facilities in terms of their emissions in 2019 are owned by Lafarge Holcim, Vicat and Ciments Calcia. The production is distributed quite evenly among the plants. Average emissions per plant decreased between 2005 and 2019, in line with the decreased cement clinker production in this time period.

Table 9: France: Key figures on the cement clinker industry

Cement clinker industry characteristics	Unit	Year 2017	% change 2017 compared to 2013	Share of cement clinker production sector EU28 in 2017	Source
GHG emissions	Mt CO_2eq	9.8	-14 %	8 %	EEA 2019
Clinker production	Mt	11.4	-12 %	9 %	GCCA 2020
GHG emission intensity	t CO_2eq/t clinker	0.83[43]	-2 %	102 %[44]	GCCA 2020
Energy consumption	PJ	46	-12 %	10 %	GCCA 2020
Energy intensity	GJ/t clinker	3.9	0 %	109 %[45]	GCCA 2020
Number of cement clinker production plants		33	-6 %	15 %	EEA 2019
Cement clinker plants with highest emissions					
Plant name (Company)	**Share of total capacity of cement clinker prod. facilities***	**Emissions in 2019 [Mt CO_2eq]****	**% change 2019 compared to 2013****	**Share of emissions from cement clinker prod. in France in 2019****	
Lafarge Holcim Ciments-Usine de St Pierre La Cour (LAFARGEHOLCIM CIMENTS)	10.3 %	0.87	-2 %	8.4 %	
VICAT Usine de Montalieu (VICAT)	12.9 %	0.78	-3 %	7.5 %	
CIMENTS CALCIA - Usine de Couvrot (CIMENTS CALCIA)	6.5 %	0.75	-9 %	7.2 %	

Key figures on the cement clinker production in France and on its largest cement clinker plants.
Source: Own table based on various sources. * Own calculations based on Cemnet 2020. **EEA 2019

[43] The GHG emission intensity is calculated with data from GCCA 2020 and therefore differs from the calculation of emissions from EEA 2019 divided by the clinker production.

[44] This value indicates that the emission intensity in France is 102 % of the EU28's emission intensity in 2017.

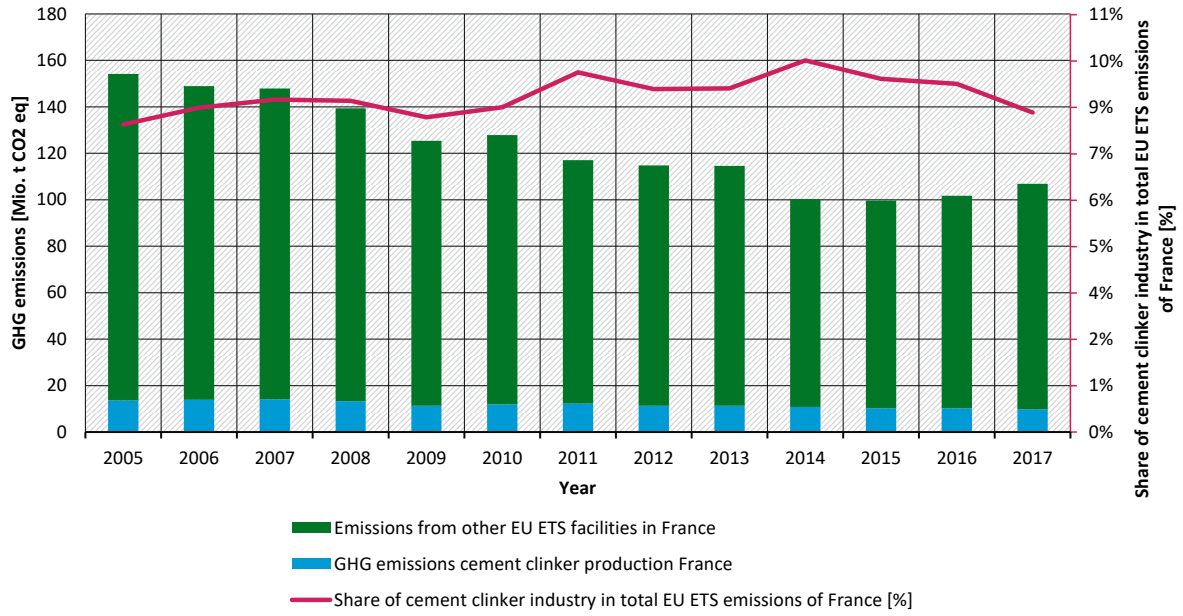
[45] This value indicates that the energy intensity in France is 109 % of the EU28's energy intensity in 2017.

5.2 Evolution of GHG emissions

The following trends can be observed for the emissions from the EU ETS facilities in France:

- In 2005 the emissions of stationary facilities participating in the EU ETS in France[46] amount to 150 million tonnes of CO_2eq. By 2017, emissions decreased by 31 %. In 2017, the cement clinker production contributes a share of about 8 % (10 million tonnes of CO_2eq). This share stayed roughly constant over time with a slight decrease since 2013. Emissions from cement clinker production decreased less (-28 %) compared to other EU ETS facilities (-31 %) between 2005 and 2017 (EEA 2019).
- The observed decrease of GHG emissions from cement clinker production since 2011 is mainly due to the decrease in clinker production volumes and an increase in the share of biomass fuels and alternative fuels.

Figure 32: France: Total GHG emissions from EU ETS facilities and share of emissions from cement clinker industry



Evolution of total GHG emissions from EU ETS facilities between 2005 and 2017 in France (left axis). The bars show the emissions from cement clinker production and other facilities of the EU ETS. The red line (right axis) indicates the relative share of GHG emissions from cement clinker production in total emissions from EU ETS facilities in France.
Source: EEA 2019, GCCA 2020, own calculations

- Total GHG emissions[47] in France amounted to about 559 million tonnes of CO_2eq in 2005 (France 2019). They decrease until 2017 to 471 million tonnes of CO_2eq. Emissions from EU ETS facilities accounted for 23 % of France's total GHG emissions in 2017 (EEA 2019).

[46] Total emissions from the EU-ETS facilities include verified emissions under the EU-ETS as well as an estimate of emissions for 2005-2012 reflecting the current scope of the EU-ETS.

[47] Total GHG emissions reported here exclude emissions from land use, land use change and forestry. Indirect GHG emissions are excluded as well.

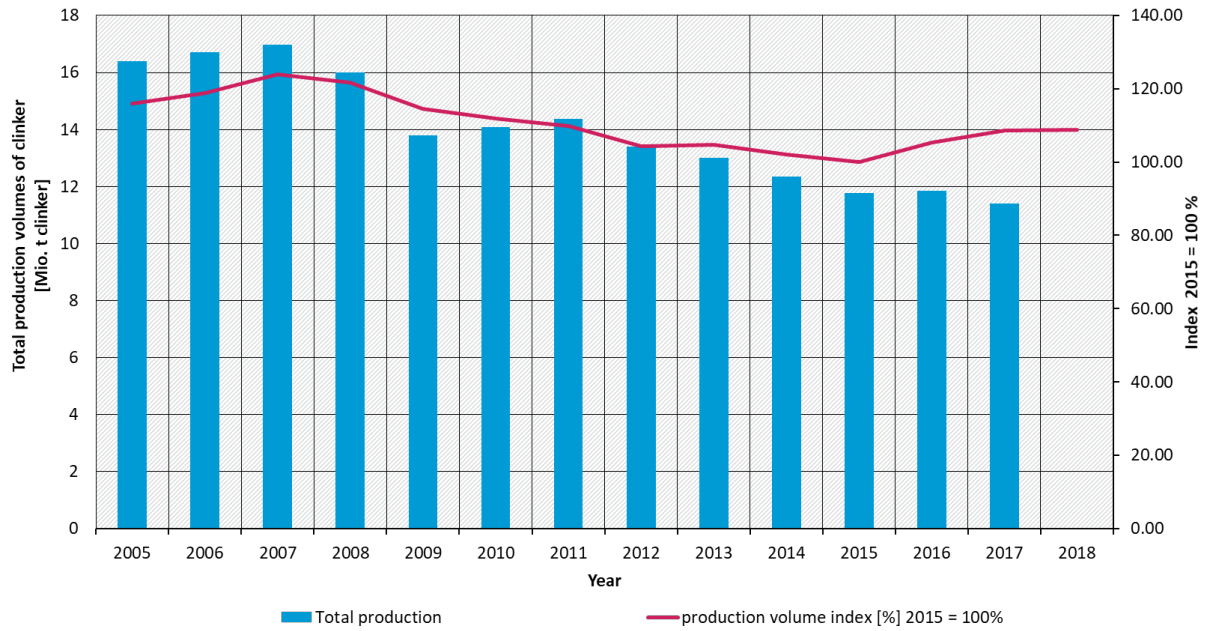
5.3 Evolution of cement clinker production

Production of grey cement clinker

The production of grey cement clinker is the most important driver of emissions from cement production. Between 2005 and 2017 production volumes show a decrease to about 11 million tonnes of grey cement clinker, which corresponds to a decrease of 30 %. In the same period, total GHG emissions of the cement clinker production decreased by 28 % (see Figure 31).

The production volume index for the construction industry relative to 2015 shows an increase between 2005 and 2007 and a decline between 2007 and 2017. The evolution of the production volume index indicates a strong positive correlation with the cement clinker production (correlation coefficient: 0.88). In the most recent years, a slight decoupling of the developments is visible as for the UK with the production volume index showing an increasing trend whilst production of cement clinker is decreasing, partly due to an increase in the amount of imported clinker and cement.

Figure 33: France: Production of grey cement clinker and evolution of production volume index of the construction sector



Evolution of total grey cement clinker production volume in France (2005-2017) estimated based on data reported by GNR (left axis). The red line (right axis) indicates the evolution of production volume index of the construction sector in France since 2005. 2015 corresponds to 100 %.

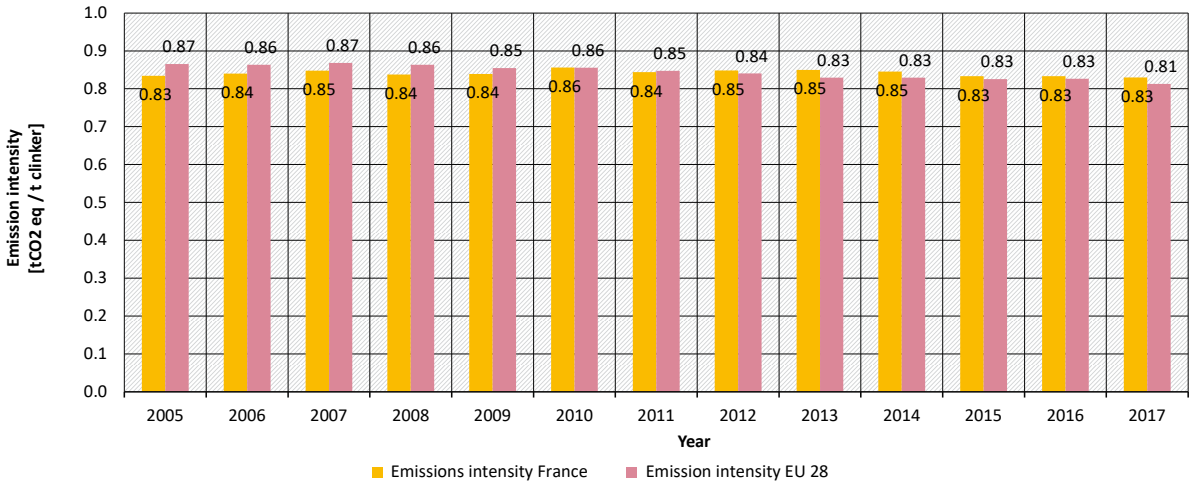
Source: GCCA 2020, EUROSTAT 2020b (Calendar adjusted data, non-seasonally adjusted data)

5.4 Evolution of GHG emission and energy intensity and clinker to cement ratio

Evolution of GHG emission intensity

The emission intensity per tonne of clinker is mainly affected by the fuel composition (i.e. share of fossil fuels vs. biomass fuels) and the efficiency of production technology applied. In 2017, emissions per tonne of clinker produced amount to about 0.83 t CO_2eq/t clinker in France (same level as 2005), while the EU28 average is at around 0.81 t CO_2eq/t clinker in 2017.

Figure 34: France and EU28: Emission intensity of clinker production



Evolution of GHG emission intensity of clinker production in France and EU28.
Source: GCCA 2020

Evolution of energy intensity

In France, total thermal energy consumption intensity[48] per tonne of grey cement clinker produced amounts to about 3.74 GJ/t clinker in 2005 and to about 3.92 GJ/t clinker in 2017 with a slight increasing trend over time. In the EU28, total thermal energy consumption intensity per tonne of grey cement clinker is lower in all years and shows a very slight decreasing trend (GCCA 2020).

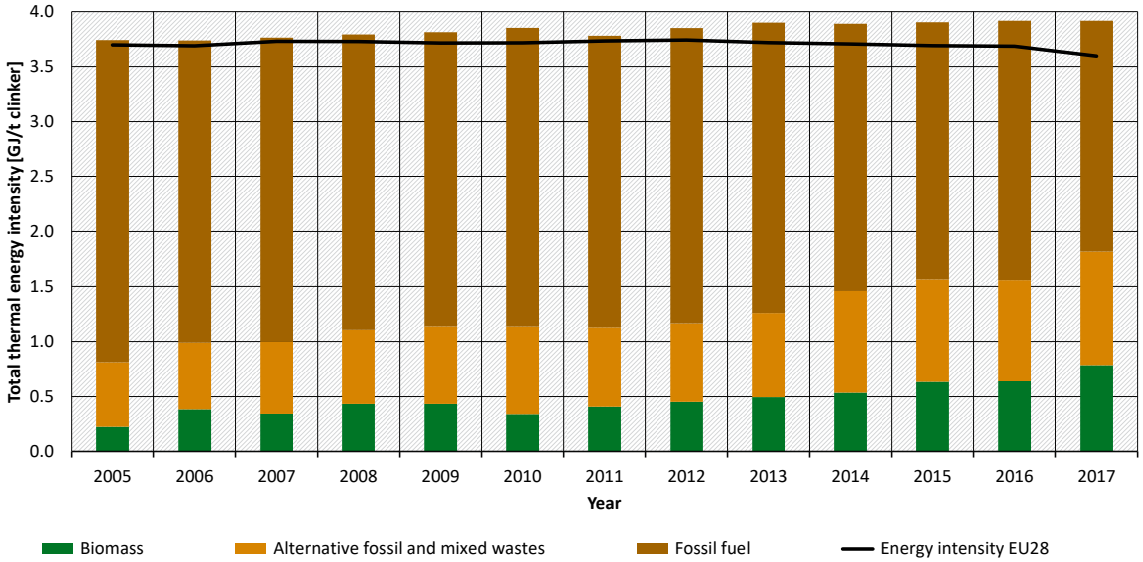
Thermal energy is produced from either regular fossil fuels, such as coal or oil, alternative fossil fuels[49] (such as waste solvents, plastics or tires) and biomass fuels. The share of alternative fossil fuels and biomass in thermal energy is increasing since 2005. In 2005, the share of "alternative fossil fuels and mixed wastes" and biomass amounted to 16 % and 6 % (EU28 averages 11 % and 4 %) respectively and until 2017, the share increased to 26 % and 20 % (EU28 averages 30 % and 16 %) respectively. Thus, in 2017 the share of regular fossil fuels is at 54 % (equal to the EU28 average) (GCCA 2020).

Even though the use of waste as alternative fuel for the cement clinker production has increased substantially in this time period, technological limitations currently pose a barrier further improvement of co-processing of waste fuels (see chapter 5.6).

[48] Besides thermal energy, the production of cement also requires electricity. Power consumption is however negligible compared to the thermal energy intensity. It is therefore not considered in the present report.

[49] Definition of "alternative fuels" according to WBCSD (2016): Products of fossil origin used as a source of thermal energy and not classified as traditional fossil fuel. This is mainly fossil waste such as plastics, solvents, waste oil, end-of-life tires, etc.

Figure 35: France: Total thermal energy consumption intensity and share of different energy carriers

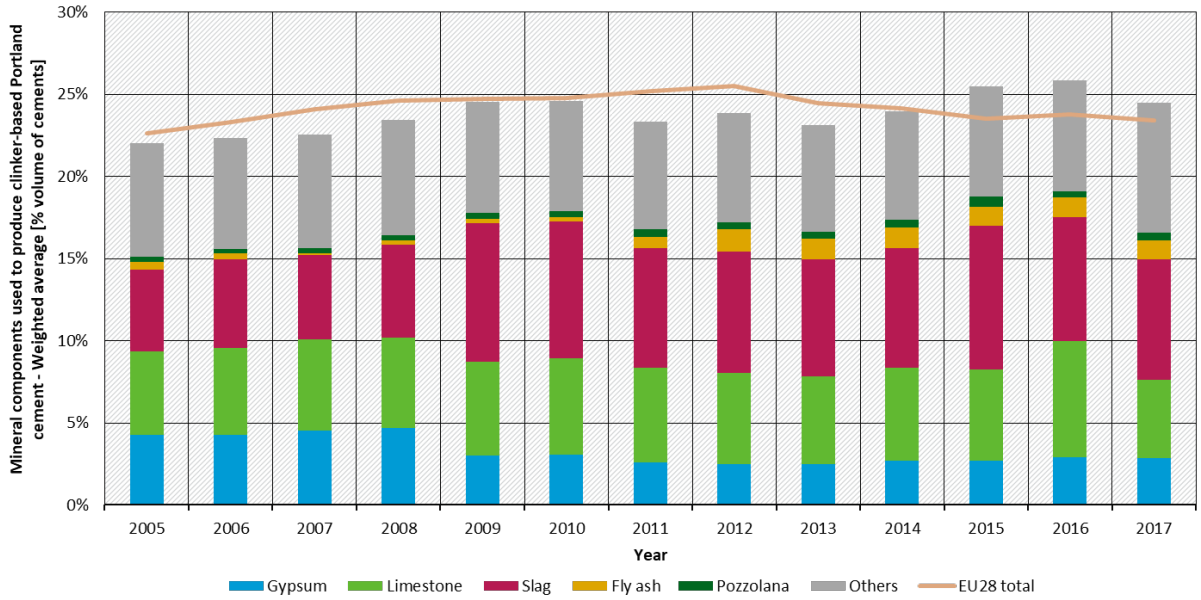


Evolution of thermal energy input for grey cement clinker production in France and EU28. For France, the share of alternative fossil and mixed wastes, biomass and fossil fuels are shown.
Source: GCCA 2020

Clinker to cement ratio and mineral components in cement

In the production of Portland cements besides grey cement clinker mainly limestone, gypsum, slag and fly ash are used in France (GCCA 2020). The share of mineral components in France is roughly equal to the EU28 in most years. In 2017, France's share of mineral components lies slightly above the EU28 average corresponding to a lower clinker to cement ratio (75 % for France vs. 77 % EU28 average). Between 2005 and 2010, the share of mineral components in France increased from 22 % to 25 %. In the following years until 2013, a slight decreasing trend can be observed before the share increases again in 2014 reaching almost 25 % in 2017 thereby exceeding the average of the EU28 countries.

Figure 36: France: Share of mineral components used in production of Portland cement besides grey cement clinker



Evolution of the share of mineral components used in production of Portland cement besides grey cement clinker in France and in the EU28 since 2005.
Source: GCCA 2020

5.5 Market evolution, imports and exports

Import and export of Portland cement

Import and export of cement products were analysed for Portland cement, which is the most widely used type of cement[50]. For Portland cement, import and export remain at a very low level compared to total sold production[51]. Sold production of Portland cement increased to about 22 million tonnes in 2008. Until 2010 the sold production dropped to almost 15 million tonnes. In 2011 the sold production of Portland cement then increased again to around 20 million tonnes and decreased afterward until it was around 15 million tonnes in 2015. Since then, the sold production remains almost constant, with a slight increase reaching 17 million tonnes in 2018 (EUROSTAT 2020a).

Import of cement increased from about less than 1 million tonnes in 2005 to about 2.5 million tonnes in 2011. It remained constant since then. The export of Portland cement is at a very low level (below one million tonnes) constant.

[50] Portland cement (CEM I, II) constitutes more than 75 % of total cement sold in Europe in 2015.

[51] Sold production corresponds to the value and volume of the product sold by the enterprise it differs from total production (the volume of all production of the product, including both the proportion that is sold and the proportion that is retained by the enterprise for adding to stocks, using in further processing etc.).

Figure 37: France: Development of the Portland cement market

Evolution of import, export and sold production of Portland cement in France between 2005 and 2018.
Source: EUROSTAT 2020a

Import and export of cement clinker

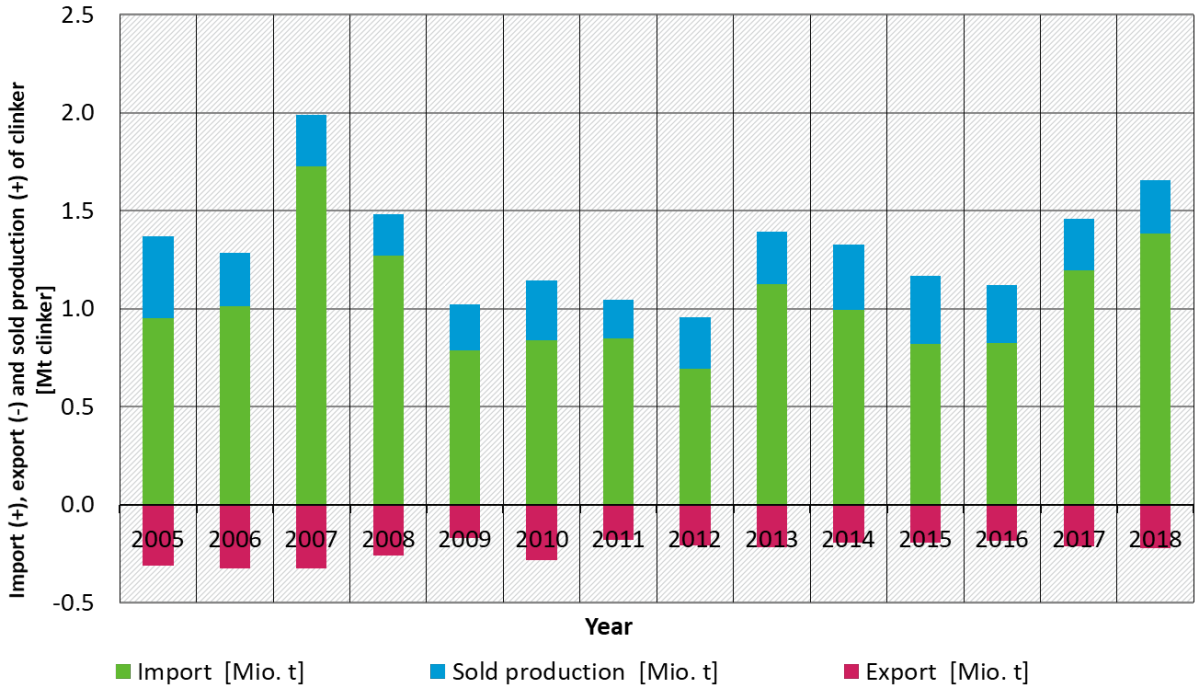
The market for cement clinker in France since 2005 shows different trends in import, export and sold production[52]. France is a net-importer of cement clinker, and import volumes compared to domestic clinker production are higher than in the other analysed countries.

Exports of cement clinker show an overall decreasing trend with a drop from 0.31 million tonnes in 2005 to 0.17 million tonnes in 2009, corresponding to roughly 1 % of total domestic cement clinker production in 2009. Besides an increase in the subsequent year, the amount of exports of cement clinker stayed roughly constant at a similar level of about 0.2 million tonnes from 2011-2018. The trend of sold production is similar to the trend in exported amounts of clinker with slightly higher absolute amounts (EUROSTAT 2020a).

Imports of cement clinker increased to a level of about 1.7 million tonnes in 2007 and then dropped substantially to 0.7 million tonnes in 2012. Since then, cement clinker imports increased again and reached a level of 1.4 million tonnes in 2018. Import volumes account for 11 % of domestic clinker production (see chapter 5.3) in 2017 (EUROSTAT 2020a) and are much higher than in the other analysed countries.

[52] Sold production is smaller than total clinker production, since the amount of clinker that is directly processed to cement by the same company is not accounted for in the sold production.

Figure 38: France: Development of the cement clinker market



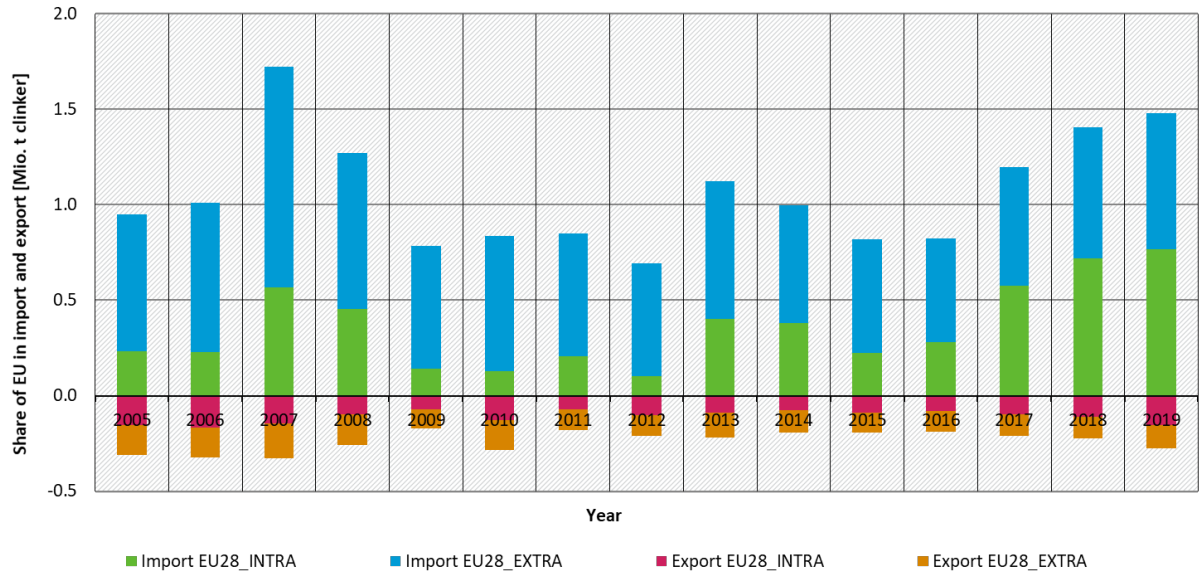
Evolution of import, export and sold production of cement clinker in France between 2005 and 2018. The blue bars only show the sold production of clinker, this does not include the cement clinker production that is directly processed to cement by the same company.
Source: EUROSTAT 2020a

Import and export of cement clinker within the EU28 and outside the EU28

Imports of cement clinker from other EU28 countries became more important over time. Whereas in 2005, about 24 % of imports originated from other EU28 countries, this share increased to more than 50 % in 2019

Exports of cement clinker from France to countries outside the EU28 are also approximately equal to exports to EU28 countries (EUROSTAT 2020e).

Figure 39: France: Import and export of cement clinker to and from other EU28 countries/countries outside the EU28



Evolution of France's import of cement clinker from other EU28 countries (Import EU28_INTRA) and from countries outside the EU28 (Import EU28_EXTRA) and evolution of France's export of clinker to other EU28 countries (Export EU28_INTRA) and to countries outside the EU28 (Export EU28_EXTRA).
Source: EUROSTAT 2020e

5.6 Regulative, economic and political framework

The following sections summarize the regulative, economic and political framework affecting the cement sector in France. This includes the use of waste as alternative fuels and state aid.

Use of waste fuels in the cement industry

In France, the main barrier to increase fuel substitution is a low technical readiness to increase the co-processing rate and a lack of economic incentives to modernize the cement industry. Furthermore, the high-quality waste (e.g. high calorific value, low chlorine content, etc.) is not available for the cement sector in sufficient quantity. The current co-processing rate in France (37.3 %) is slightly below the EU28 average of 40.2 % in 2014 (De Beer et al. 2017).

Further fuel switching is largely limited due to the outdatedness of the technology in the cement sector. A potential average co-processing rate of around 50 % across the industry is seen as an upper limit without technological upgrades (De Beer et al. 2017).

In 2014, about half of the treated wastes were recycled in France, 17 % incinerated with energy recovery and 26 % landfilled. Depending on the type of waste, the landfill taxes range from very low (20 EUR/tonne) to very high (120 EUR/tonne). A new waste management law aims at 50 % reduction of waste landfilled by 2025 (De Beer et al. 2017).

Due to strong public opposition, it is nearly impossible to construct new waste incineration plants, however further development of combined heat and power incinerators is expected. This could motivate the pre-processing industry to develop both high-quality waste for the cement industry and lower quality waste for incinerators. As the competition for waste streams increases however, the price of solid shredded wastes (SSW) could raise. About half of the alternative fuels used in the cement sector originates from other industries; the availability of the wastes will therefore also depend on the market development in these other sectors (De Beer et al. 2017).

State Aid

In the State Aid Transparency database of the European commission five measures are listed for the cement sector (C.23.51 Production of cement) in France (EC 2020). They include Investment aid for waste recovery, experimental development and investment aid for energy efficiency and industrial research.

5.7 Facility data - the largest emitters and their location

GHG emissions and production capacity

In 2019, 33 cement clinker production plants were subject to the EU ETS in France. The following table provides an overview on GHG emission and cement production capacity of the three largest cement clinker facilities in terms of emissions in France.

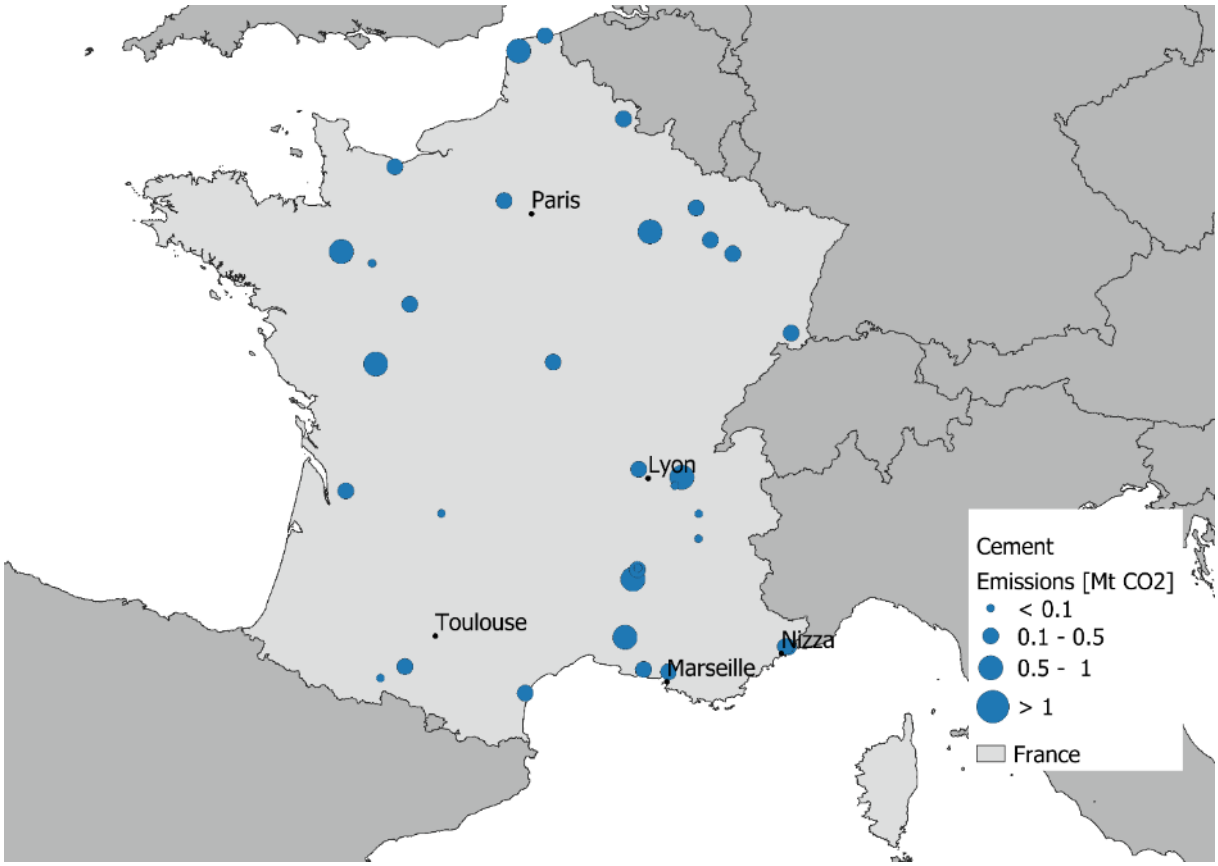
Table 10: France: Emissions and production capacity of the three largest cement clinker plants in terms of emissions

ID	Installation	Company	City	Emissions (Mt CO_2eq)					Share of total verified emis-sions	Share of total capa-city
				2005	2009	2010	2015	2019	2019	2019
534	Lafarge Holcim Ciments- Usine de St Pierre La Cour	LAFARGEHOLCIM CIMENTS	Saint Pierre La Cour	1.0	0.7	0.9	0.9	0.9	8.4%	10.3 %
368	VICAT Usine de Montalieu	VICAT	Montalieu-Vercieu	0.9	0.7	0.8	0.7	0.8	7.5%	12.9 %
218	CIMENTS CALCIA - Usine de Couvrot	CIMENTS CALCIA	Vitry-le-François	0.8	0.8	0.7	0.7	0.8	7.2%	6.5%

Emissions and production capacity of the largest cement clinker facilities in terms of emissions in France.
Source: EEA 2019, Own calculations based on Cemnet 2020.

The following figure shows the location of the cement clinker production facilities participating in the EU ETS in 2019 in France. 7 facilities emitted over 500,000 tonnes of CO_2eq, 19 facilities emitted between 100,000 and 500,000 tonnes of CO_2eq and 7 facilities had emissions below 100,000 tonnes of CO_2eq in 2019.

Figure 40: France: Location of cement clinker production plants



Location of cement clinker production plants in France (2019), the size of the dots indicates the amount of verified emissions in 2019.
Source: EEA 2019

Cement clinker production companies

The largest cement clinker production company "CIMENTS CALCIA" in terms of emissions emitted 3.5 million tonnes of CO_2eq in 2019. It encompasses 9 different production plants subject to EU ETS.

The second largest cement clinker production company "LAFARGEHOLCIM CIMENTS", consisting of 8 plants, emitted 3.33 million tonnes of CO_2eq. The third largest company "VICAT" including 5 plants emitted 1.43 million tonnes of CO_2eq.

Together, these three companies account for 79 % of total verified emission from cement clinker production in 2019.

5.8 Facility data – examples of recent investments

Exemplary list of investments in the cement production sector based on company's data:

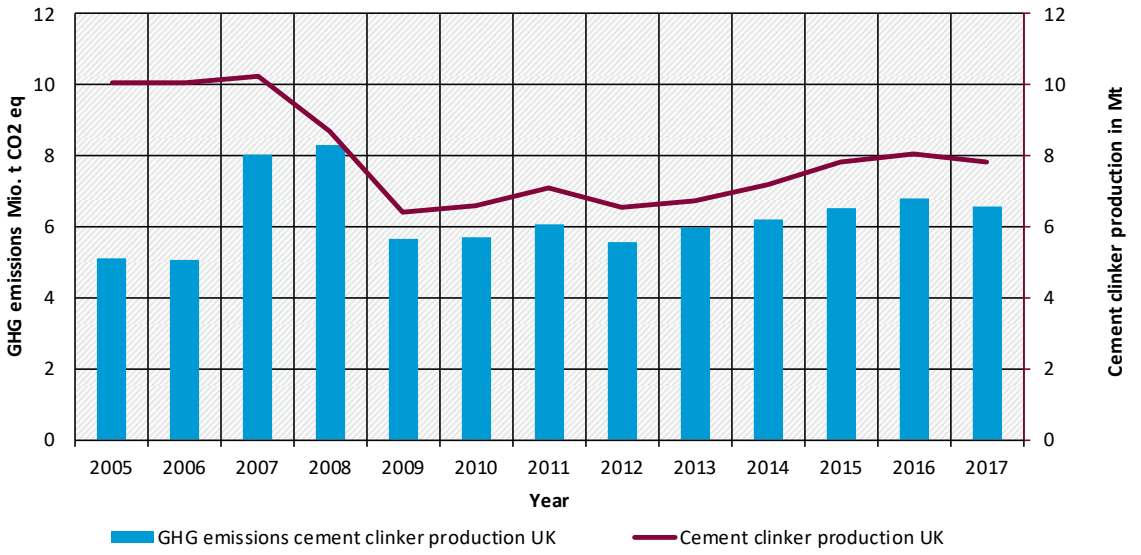
Gross investments regarding cement clinker production companies in France include among other the following technological advancements. The second largest cement clinker production company in France "LafargeHolcim Ciments" invested 160 million CHF (150 million EUR) to reduce their carbon footprint in Europe. The aim is to increase the use of low-carbon fuels and recycled materials in their processes and products. The company launched the project Lafarge360 in France, which includes scoring and carbon footprint modelling (LafargeHolcim 2020).

6 United Kingdom (UK)

6.1 Key messages

- The UK has left the EU28 and the EU ETS and runs its own ETS since the beginning of 2021.
- GHG emissions from cement clinker production in the UK amounted to roughly 7 million tonnes of CO_2eq in 2017. Since 2013 they increased by 10 %. In 2017, the cement clinker production accounts for roughly 5 % of total EU ETS emissions from the UK. This share continuously increased over time because overall ETS emissions have decreased substantially, especially in the energy sector (combustion installations).
- UK contributes a share of 5 % to total EU28 emissions of cement clinker production in 2017. Among the countries analysed in in the present report, the UK has the lowest share of emissions from the cement clinker production of the EU28.
- Cement clinker production in the UK shows an increase of 17 % between 2013 and 2017 (see Figure 41) according to the National Inventory Report (United Kingdom 2019), substantially more than the increase in emissions. UK accounts for roughly 6 % of the total cement clinker production sector in the EU28 in 2017. This share slightly decreased since 2013.

Figure 41: UK: Total GHG emissions from the cement clinker production



Evolution of total GHG emissions from the cement clinker production and evolution of cement clinker production between 2005 and 2017 in the UK. Four plants participated only between 2007 and 2009 and exhibit a strong reduction in emissions already in 2009. The peak in emissions 2007 - 2008 is therefore due to the change in the number of plants that were in operation.
Source: United Kingdom 2019, EEA 2019

- Contrary to the NIR, GNR data show a decline in clinker production between 2013 and 2017. Obviously, the GNR data do not cover all clinker production in recent years. According to GNR, the emission intensity per tonne of clinker decreased substantially between 2005 and 2014, but increased slightly between 2013 and 2017, from 0.82 to 0.84 t CO_2eq/t clinker

(slightly higher than the EU28 average of 0.81 t CO_2eq/t clinker in 2017 (see Table 4)). However, this observed deterioration of emission intensity is not consistent with the development of clinker production and emissions between 2013 and 2017 (emissions: +10 %, production: +17 %).

- The emission intensity is affected by the fuel composition (i.e. share of fossil fuels vs. biomass fuels) and the efficiency of production technology applied[53]:
  - The waste co-processing rate in the UK is higher than the EU28 average. This is reflected in the use of alternative fossil and mixed wastes as well as biomass for energy consumption, which increased rapidly between 2005 and 2012. Since then, especially the share of biomass has increased and lies above the EU28 average in 2017 (21 % UK vs. 16 % EU28 average, see Figure 7). However, in 2017, fossil fuels still slightly dominate the thermal energy input in the UK. Alternative fuels such as biomass have a low calorific value and may increase the energy consumption of the plant.
- The energy intensity per tonne of clinker decreased slightly over the entire time period of 2005 to 2017 (from 4.0 GJ/t clinker in 2005 to 3.8 GJ/t clinker in 2017).
- The share of mineral components used as a substitut of clinker is very low compared to other European countries. The clinker to cement ratio is at around 88 % in 2017 (EU28 average 77 %, see Table 4) and is increasing in recent years. The UK has the highest clinker share among the six countries analysed in in the present report.
- The production volume index for the construction industry, an important indicator of cement demand from the construction sector, shows no correlation with cement clinker production in the UK (correlation coefficient: 0.38). In contrast to the EU and other countries, the development of clinker production in the UK is largely independent of the development of the production volume index. Since 2013, both the production volume index and cement clinker production increased.
- UK is a net-importer of cement clinker. The share of imports in total domestic clinker production amounts to 6.8 % in 2017. Imports in the UK fluctuate strongly over time with a slightly increasing trend since 2013. Cement clinker is almost entirely imported from countries inside the EU28. Exports of cement clinker are negligible.
- At the beginning of 2005, 8 cement clinker production plants were in operation, 8 additional plants participate since 2007/2008 in the EU ETS. Two plants ceased production already in 2008, two in 2009 and one in 2018. In 2019, there were 11 cement clinker production plants in operation. The three largest facilities in terms of their emissions in 2019 are owned by Breedon Cement Limited, Cemex UK Cement Limited and Castle Cement Ltd. The production of these three plants accounts for more than 40 % of total emissions in 2019. Average

[53] The condition, operating mode and kiln capacity of a plant as well as moisture and combustibility of the raw material are additional factors affecting the emission intensity. In this factsheet, individual plants were not analysed such that the focus lies on the fuel composition and production technology.

emissions per plant decreased between 2005 and 2019, in line with the decreased cement clinker production in this time period.

Table 11: UK: Key figures on the cement clinker industry

Cement clinker industry characteristics	Unit	Year 2017	% change 2017 compared to 2013	Share of cement clinker production sector EU28 in 2017	Source
GHG emissions	Mt CO_2eq	6.6	10 %	5 %	EEA 2019
Clinker production	Mt	7.8	17 %	6 %	United Kingdom 2019
GHG emission intensity	t CO_2eq/t clinker	0.84	2 %	103 %[54]	GCCA 2020
Energy consumption	PJ	25	-7 %	5 %	GCCA 2020
Energy intensity	GJ/t clinker	3.8	2 %	102 %[55]	GCCA 2020
Number of cement clinker production plants		12	0 %	5 %	EEA 2019
Cement clinker plants with highest emissions					
Plant name (Company)	**Share of total capacity of cement clinker prod. facilities***	**Emissions in 2019 [Mt CO_2eq]****	**% change 2019 compared to 2013****	**Share of emissions from cement clinker prod. in the UK in 2019****	
Hope Cement (Breedon Cement Limited)	13.6 %	1.08	12 %	16.4 %	
Rugby Works (Cemex UK Cement Limited)	16.3 %	0.98	1 %	14.8 %	
Ketton Works (Castle Cement Ltd)	12.7 %	0.71	4 %	10.8 %	

Key figures on the cement clinker production in the UK and on its largest cement clinker plants.
Source: Own table based on various sources. * Own calculations based on Cemnet 2020. **EEA 2019

6.2 Evolution of GHG emissions

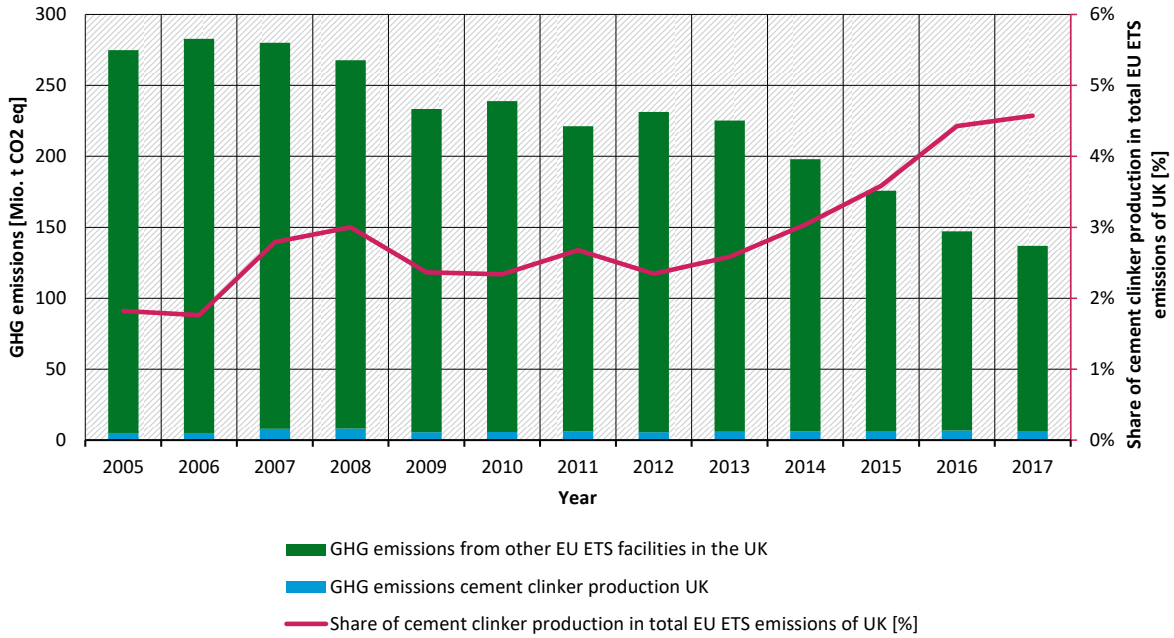
The following trends can be observed for the emissions from the EU ETS facilities in the UK:

[54] This value indicates that the emission intensity in the UK is 103 % of the EU28's emission intensity in 2017.

[55] This value indicates that the energy intensity in the UK is 102 % of the EU28's energy intensity in 2017.

- In 2005 the emissions of stationary facilities participating in the EU ETS in the UK[56] amount to 200 million tonnes of CO_2eq and show a decrease of about 31 % until 2017. The cement clinker production contributes a share of about 3 % (5 million tonnes of CO_2eq) in 2005. This share increases between 2005 and 2017 to 6 %, mostly due to a reduction of emissions from coal fired power plants. Emissions from cement clinker production increased substantially (+29 %) while emissions in other EU ETS facilities declined by more than 50% between 2005 and 2017 (EEA 2019).
- The observed increase of GHG emissions from cement clinker production since 2011 is mainly due to the increase in clinker production volumes, which is partially compensated by an increase in the share of biomass fuels.

Figure 42: UK: Total GHG emissions from EU ETS facilities and share of emissions from cement clinker industry



Evolution of total GHG emissions from EU ETS facilities between 2005 and 2017 in the UK (left axis). The bars show the emissions from cement clinker production and other facilities of the EU ETS. The red line (right axis) indicates the relative share of GHG emissions from cement clinker production in total emissions from EU ETS facilities in the UK.
Source: EEA 2019, GCCA 2020, own calculations

- Total GHG emissions[57] in the UK amounted to about 700 million tonnes of CO_2eq in 2005 (United Kingdom 2019). They decrease until 2017 to 470 million tonnes of CO_2eq. Emissions from EU ETS facilities accounted for 29 % of the UK's total GHG emissions in 2017 (EEA 2019).

[56] Total emissions from the EU ETS facilities include verified emissions under the EU ETS as well as an estimate of emissions for 2005-2012 reflecting the current scope of the EU ETS.

[57] Total GHG emissions reported here exclude emissions from land use, land use change and forestry. Indirect GHG emissions are excluded as well.

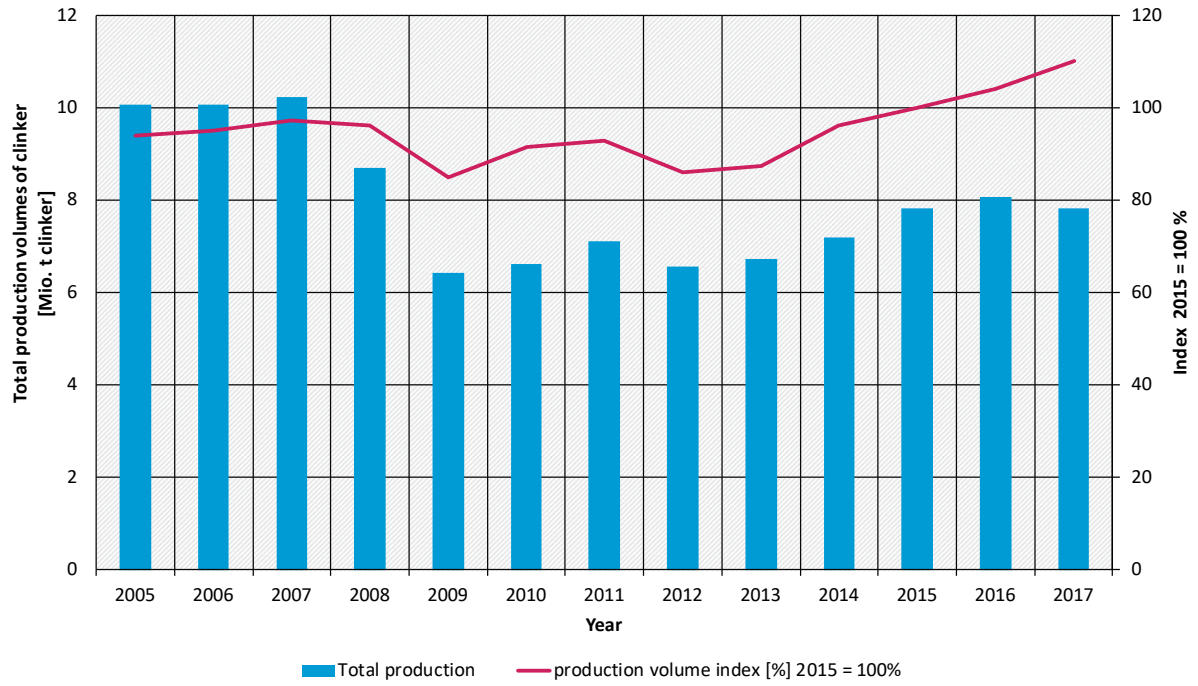
6.3 Evolution of cement clinker production

Production of grey cement clinker

The production of grey cement clinker is the most important driver of emissions from cement production. It shows a slight increase between 2005 and 2007 reaching the highest production volume of more than 10 million tonnes in 2007. Between 2007 and 2009 production volumes[58] dropped by about one third to about 6.4 million tonnes of grey cement clinker. Between 2009 and 2016, there is a slight increase in production volumes, and a decrease between 2016 and 2017. However, they remain substantially below the levels of 2005-2007.

The production volume index for the construction industry relative to 2015 shows an increase between 2005 and 2017, with a temporary decline in 2009 and 2012. In contrast to the EU and other countries, the development of clinker production in the UK is largely independent of the development of the production volume index. Therefore, the evolution of the production volume index shows no correlation with cement clinker production (correlation coefficient: 0.38).

Figure 43: UK: Production of grey cement clinker and evolution of production volume index of the construction sector



Evolution of total grey cement clinker production volume in the UK (2005-2017) estimated based on data reported by United Kingdom (left axis). The red line (right axis) indicates the evolution of production volume index of the construction sector in the UK since 2005. 2015 corresponds to 100 %.
Source: United Kingdom 2019, EUROSTAT 2020b (Calendar adjusted data, non-seasonally adjusted data)

6.4 Evolution of GHG emission, energy intensity and clinker to cement ratio

Evolution of GHG emission intensity

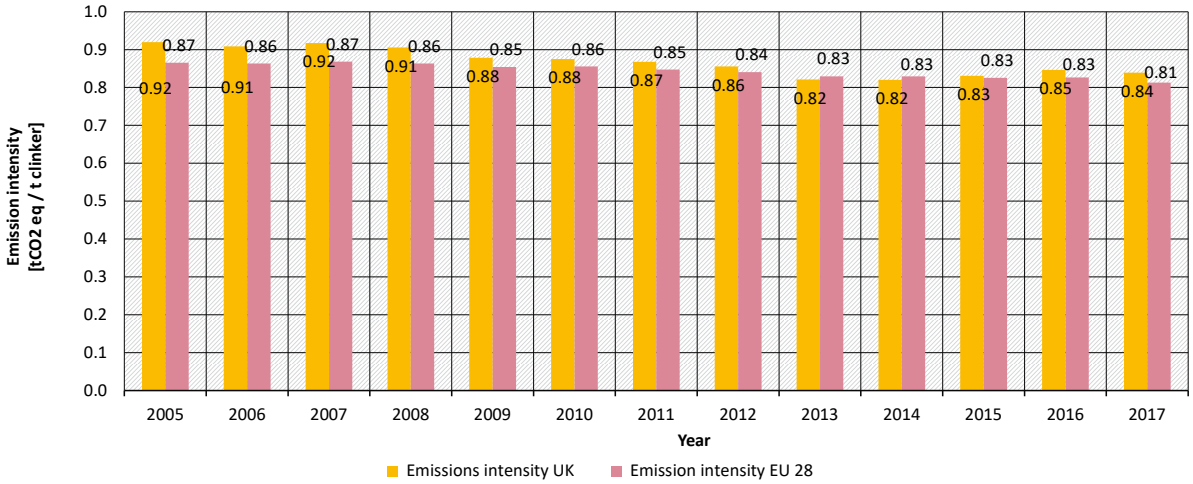
The emission intensity per tonne of clinker is mainly affected by the fuel composition (i.e. share of fossil fuels vs. biomass fuels) and the efficiency of production technology applied Emission

[58] Data of production volumes of clinker are affected by uncertainty, since not all facilities are reporting data in the cement sustainability initiative "Getting the numbers right" (GCCA) dataset.

intensity in UK clinker production decreased from 0.92 t CO_2eq/t clinker in 2005 to 0.82 t CO_2eq/t clinker in 2014. This corresponds to a relative reduction of 11 % compared to 2005. Since 2014, the emission intensity increased again to 0.84 t CO_2eq/t clinker in 2017, which is slightly higher than the EU28 average of 0.81 t CO_2eq/t clinker.

Possible reasons for the observed substantial decrease in emission intensity in the UK between 2005 and 2014 are the increase in the share of alternative and biofuels, improvements in energy efficiency of existing installations or closure of plants with a high emission intensity. The increase since 2014, however, can be traced back to the increase in the share of fossil fuels between 2015 and 2017.

Figure 44: UK and EU28: Emission intensity of clinker production



Evolution of GHG emission intensity of clinker production in the UK and EU28.
Source: GCCA 2020

Evolution of energy intensity

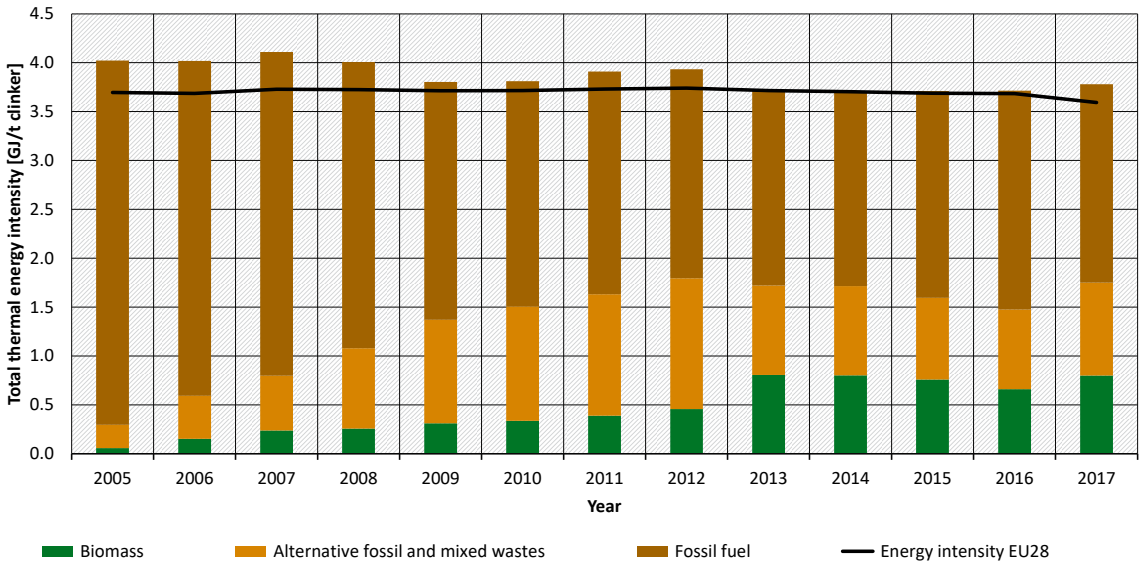
In the UK, total thermal energy consumption intensity[59] per tonne of grey cement clinker produced amounts to about 4 GJ/t clinker in 2005 with a decreasing trend over time reaching 3.8 GJ/t clinker in 2017. In the EU28, total thermal energy consumption intensity per tonne of grey cement clinker is at a similar level, though in 2017 the UK's energy intensity was slightly above the EU28 average (GCCA 2020).

Thermal energy is produced from either regular fossil fuels, such as coal or oil, alternative fossil fuels[60] (such as waste solvents, plastics or tires) and biomass fuels. The share of alternative fossil fuels in thermal energy increased between 2005 and 2012. Since then, it is constant at a lower level. The share of biomass in thermal energy also increased since 2005, with a small drop in 2016. In 2005, the share of "alternative fossil fuels and mixed wastes" and biomass amounted to roughly 6 % and 1 % respectively and until 2017, the share increased to 25 % and 21 % respectively (GCCA 2020). This can be traced back to the above EU28 average co-processing rate in the UK (see chapter 6.6). Over the entire time period, the share of fossil fuels in the UK (54 % in 2017) is similar to the EU28 average (54 % in 2017, see Figure 7).

[59] Besides thermal energy, the production of cement also requires electricity. Power consumption is however negligible compared to the thermal energy intensity. It is therefore not considered in the present report.

[60] Definition of "alternative fuels" according to WBCSD (2016): Products of fossil origin used as a source of thermal energy and not classified as traditional fossil fuel. This is mainly fossil waste such as plastics, solvents, waste oil, end-of-life tires, etc.

Figure 45: UK: Total thermal energy consumption intensity and share of different energy carriers



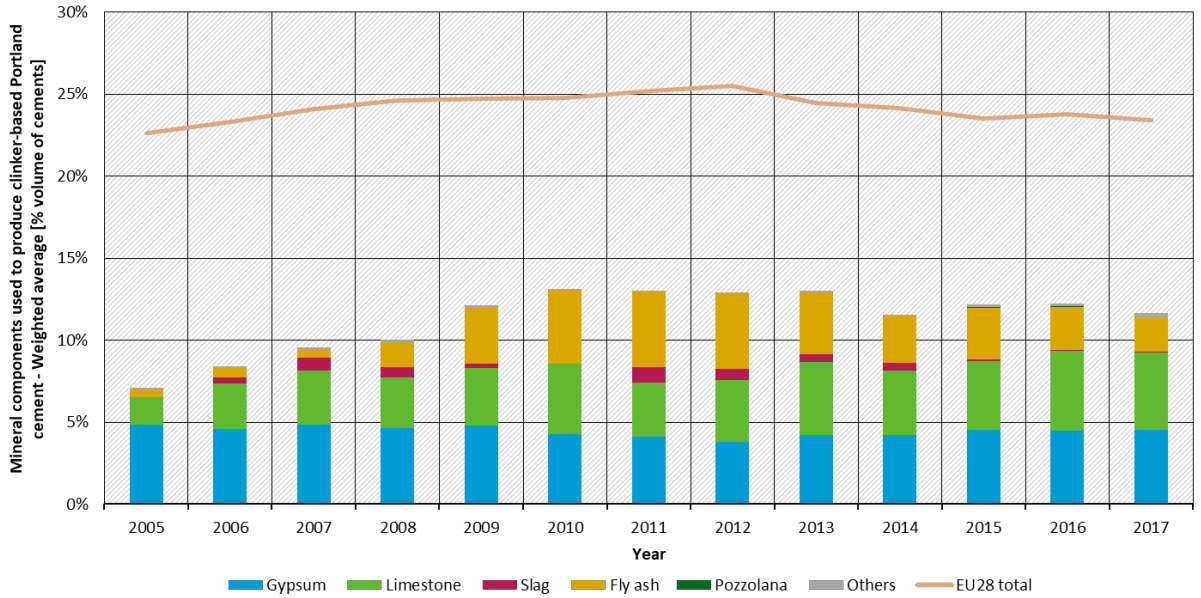
Evolution of thermal energy input for grey cement clinker production in the UK and EU28. For the UK, the share of alternative fossil and mixed wastes, biomass and fossil fuels are shown.
Source: GCCA 2020

Clinker to cement ratio and mineral components in cement

In the production of Portland cements besides grey cement clinker mainly gypsum is used in the UK (GCCA 2020), indicating that - compared to the other countries analysed in this report - UK produces a higher share of CEM I, which exhibits a higher clinker to cement ratio than other types of cement. Since 2005 the share of limestone is increasing constantly. Between 2009 and 2014 fly ash is used to some amount. Since then, it decreased slightly, possibly due to the decrease in coal-fired power generation and steel production.

The share of mineral components in the UK lies well below the EU28 average over the entire time period, corresponding to a much higher clinker to cement ratio (88 % vs. 77 % EU28 average). Between 2005 and 2013 the share of mineral components increased in the UK from 7 % to 13 %. Since then, a slight decreasing trend can be observed reaching 12 % in 2017.

Figure 46: UK: Share of mineral components used in production of Portland cement besides grey cement clinker



Evolution of the share of mineral components used in production of Portland cement besides grey cement clinker in the UK and in the EU28 since 2005.
Source: GCCA 2020

6.5 Market evolution, imports and exports

Import and export of Portland cement

Import and export of cement products were analysed for Portland cement, which is the most widely used type of cement[61]. For Portland cement, import and export remain at a low level compared to total sold production[62].

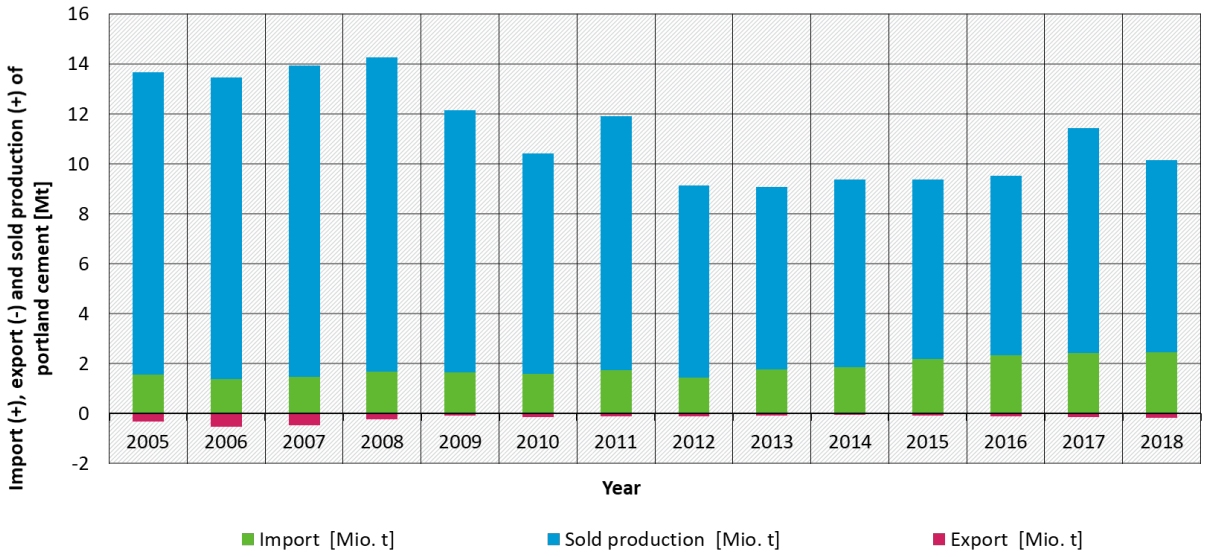
Sold production of Portland cement is rather constant around 14 million tonnes between 2005 and 2008. After 2008 it decreased to 9 million tonnes in 2012. Since then, an increasing tendency is observed (EUROSTAT 2020a).

Import of cement increased from about 1.6 million tonnes in 2005 to about 1.8 million tonnes in 2013 and increased further to almost 2.5 million tonnes in 2018.

[61] Portland cement (CEM I, II) constitutes more than 75 % of total cement sold in Europe in 2015.

[62] Sold production corresponds to the value and volume of the product sold by the enterprise it differs from total production (the volume of all production of the product, including both the proportion that is sold and the proportion that is retained by the enterprise for adding to stocks, using in further processing etc.).

Figure 47: UK: Development of the Portland cement market



Evolution of import, export and sold production of Portland cement in the UK between 2005 and 2018.
Source: EUROSTAT 2020a

Import and export of cement clinker

In the UK there is no data for the sold production[63] between 2005 and 2018.

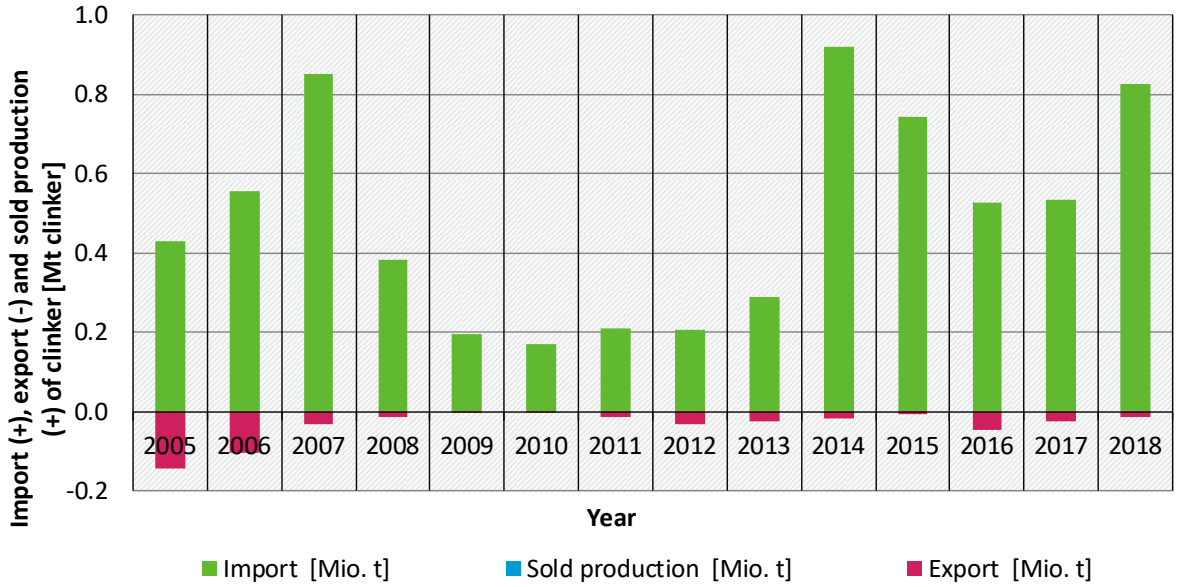
UK is a net-importer of cement clinker. Import volumes compared to domestic clinker production are higher than in Germany, Poland and Greece, and similar to the other analysed countries.

The amount of cement clinker imported increased to about 0.9 million tonnes in 2007 and then dropped to a level of roughly 0.2 million tonnes between 2009 and 2013. In 2014 imports increased again to 0.9 million tonnes and stayed roughly at this level until 2018. The share of imports in total domestic clinker production (see chapter 6.3) amounts to 4.3 % in 2005 and 6.8 % in 2017 (EUROSTAT 2020a).

The amount of cement clinker exported dropped from 0.14 million tonnes to zero in 2010 and since then remained at a very low level with a slight increase until 2016 and a further decrease in 2018. The share of exports in total domestic clinker production (see chapter 6.3) amounts to 1.4 % in 2005 and 0.3 % in 2017 (EUROSTAT 2020a).

[63] Sold production is smaller than total clinker production, since the amount of clinker that is directly processed to cement by the same company is not accounted for in the sold production.

Figure 48: UK: Development of the cement clinker market



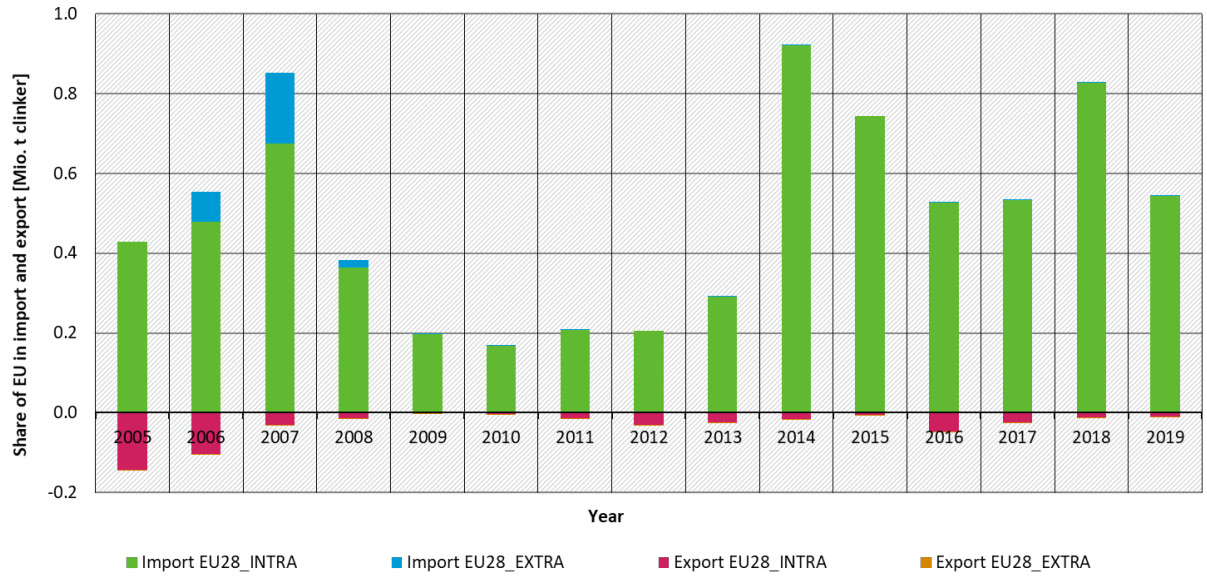
Evolution of import, export and sold production of cement clinker in the UK between 2005 and 2018. No data for sold production in this time period.
Source: EUROSTAT 2020a

Import and export of cement clinker within the EU28 and outside the EU28

Imports of cement clinker from countries outside the EU28 are less important than imports from other EU28 countries. Over 95 % of imports originated from other EU28 countries since 2004. Only in the year 2007 roughly 20 % of imports were from extra EU28 countries (EUROSTAT 2020e).

Exports of cement clinker from the UK are irrelevant compared to the imports. They decreased from 0.1 million tonnes in 2005 to zero in 2010 and since then show slight variations with a decreasing tendency on a very low level (EUROSTAT 2020e).

Figure 49: UK: Import and export of cement clinker to and from other EU28 countries/countries outside the EU28



Evolution of the UK's import of cement clinker from other EU28 countries (Import EU28_INTRA) and from countries outside the EU28 (Import EU28_EXTRA) and evolution of the UK's export of clinker to other EU28 countries (Export EU28_INTRA) and to countries outside the EU28 (Export EU28_EXTRA).
Source: EUROSTAT 2020e

6.6 Regulative, economic and political framework

The following sections summarize the regulative, economic and political framework affecting the cement sector in the UK. This includes the use of waste as alternative fuels and state aid.

Use of waste fuels in the cement industry

In the UK high quality waste is not available to the cement sector in sufficient quantity. Market distortions due to Waste to Energy (WtE) and biomass related government support are a barrier.

The government has a positive attitude towards co-processing and there are no specific legal or regulatory barriers to the use of alternative fuels in cement production.

The current co-processing rate (44 %) is above the EU28 average, co-processing started in the 1990's. It is expected that incremental growth could bring the cement industry to around 50 % fuel substitution by 2020 (De Beer et al. 2017).

State Aid

In the State Aid Transparency database of the European commission 48 state aid measures are for the cement sector (C.23.51 Production of cement) in the UK, mostly categorized as "Other forms of tax advantage" (EC 2020).

6.7 Facility data - the largest emitters and their location

GHG emissions and production capacity

In 2019, 11 cement clinker production plants were subject to the EU ETS in UK. The following table provides an overview on GHG emission and cement production capacity of the three largest cement clinker facilities in terms of emissions in the UK.

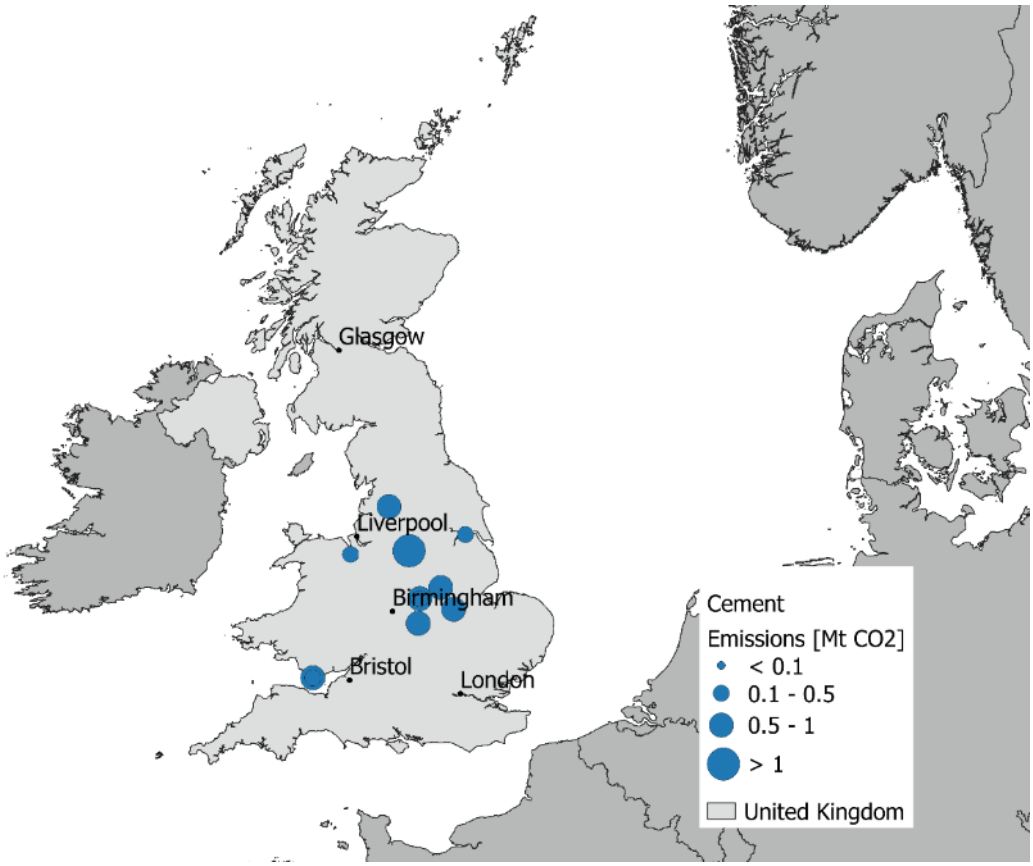
Table 12: UK: Emissions and production capacity of the three largest cement clinker plants in terms of emissions

ID	Installation	Company	City	Emissions (Mt CO_2eq)					Share of total verified emissions	Share of total capacity
				2005	2009	2010	2015	2019	2019	2019
735	Hope Cement	Breedon Cement Limited	Derbyshire	-	0.9	0.9	1.0	1.1	16.4%	13.6%
91	Rugby Works	Cemex UK Cement Limited	Rugby	1.0	1.1	1.0	1.0	1.0	14.8%	16.3%
672	Ketton Works	Castle Cement Ltd	Birmingham	1.0	0.7	0.7	0.6	0.7	10.8%	12.7%

Emissions and production capacity of the largest cement clinker facilities in terms of emissions in the UK.
Source: EEA 2019, Own calculations based on Cemnet 2020.

The following map shows the location of the cement clinker production facilities participating in the EU ETS in 2019 in the UK. One facility emitted over 1 million tonnes of CO_2eq, 6 facilities emitted between 500,000 and 1 million tonnes of CO_2eq and 4 facilities had emissions below 500,000 tonnes of CO_2eq in 2019.

Figure 50: UK: Location of cement clinker production plants



Location of cement clinker production plants in the United Kingdom (2019), the size of the dots indicates the amount of verified emissions in 2019.
Source: EEA 2019

Cement clinker production companies

The largest cement clinker production company "Castle Cement Ltd" in terms of emissions emitted 1.75 million tonnes of CO_2eq in 2019. It encompasses 3 different production plants subject to EU ETS.

The second largest cement clinker production company "Tarmac Cement and Lime Limited", consisting of 3 plants, emitted 1.57 million tonnes of CO_2eq. The third largest company "Cemex UK Cement Limited" including 2 plants emitted 1.32 million tonnes of CO_2eq.

Together, these three companies account for 70 % of total verified emission from cement clinker production in 2019.

6.8 Facility data – examples of recent investments

Exemplary list of investments in the cement production sector:

- The cement clinker production company "Breedon Cement Limited", whose "Hope Cement" plant accounted for the largest emissions in 2019, acquired a solid contracting and asphalt production platform and secured assets from CEMEX in the UK. At the Hope plant, raw mill drive and kiln shell replacement projects were completed in 2019. The company continues to (re)open plants and quarries and to purchase new land and minerals (Breedon Group 2020).

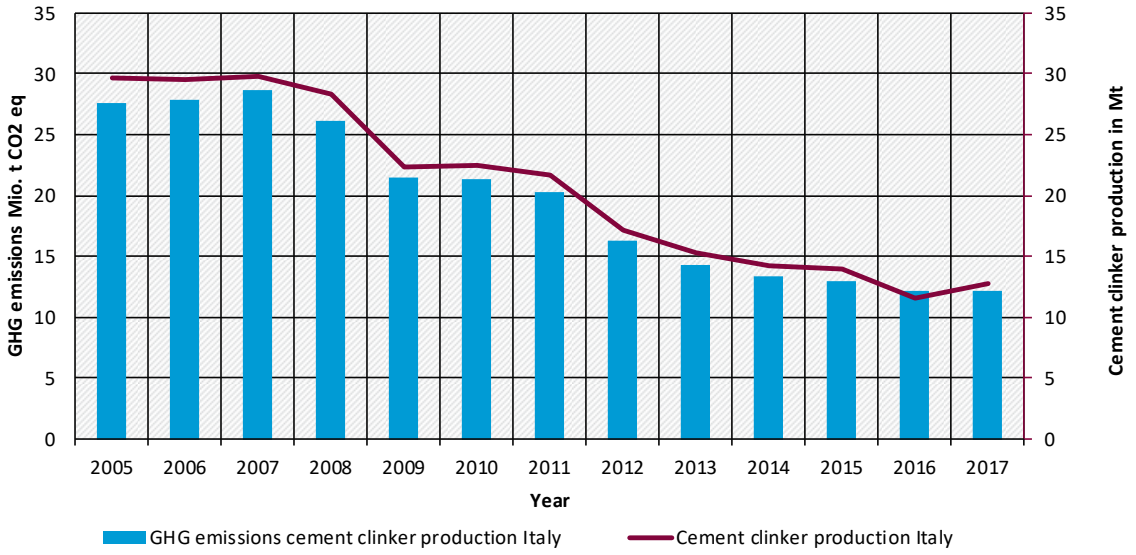
- A new cement mill as well as silos and facilities for rail and truck loading were commissioned in 2019 at the "Padeswood Works" plant owned by "Castle Cement Ltd", which is part of the German cement clinker production company "HeidelbergCement AG" (HeidelbergCement AG 2020).

7 Italy

7.1 Key messages

- GHG emissions from cement clinker production in Italy amounted to roughly 12 million tonnes of CO_2eq in 2017. Since 2013, they decreased by 15 %. In 2017, the cement clinker production accounts for roughly 7 % of total EU ETS emissions from Italy. This share continuously decreased slightly over time.
- Italy contributes a share of 10 % to total EU28 emissions of cement clinker production in 2017.
- Cement clinker production in Italy shows a very similar development over time as GHG emissions with a decrease of 16 % between 2013 and 2017 (see Figure 51). Cement clinker production of Italy also accounts for roughly 10 % of the total cement clinker production sector in the EU28 in 2017. This share slightly decreased since 2013.
- The similar trend of GHG emissions and cement clinker production in Italy indicates that the emissions intensity per tonne of clinker did not change substantially. Between 2013 and 2017, the emission intensity stayed roughly constant at 0.84 t CO_2eq/t clinker. The emission intensity is slightly higher than the EU28 average of 0.81 t CO_2eq/t clinker (see Table 4).

Figure 51: Italy: Total GHG emissions from the cement clinker production



Evolution of total GHG emissions from the cement clinker production and evolution of cement clinker production between 2005 and 2017 in Italy.
Source: GCCA 2020, EEA 2019

- The emission intensity is affected by the fuel composition (i.e. share of fossil fuels vs. biomass fuels) and the efficiency of production technology applied[64]:

[64] The condition, operating mode and kiln capacity of a plant as well as moisture and combustibility of the raw material are additional factors affecting the emission intensity. In this factsheet, individual plants were not analysed such that the focus lies on the fuel composition and production technology.

  - The use of alternative fossil and mixed wastes as well as biomass for energy consumption is very low (15 % Italy vs. 46 % EU28 average in 2017, see Figure 7). Italy has the lowest amount of alternative thermal energy among the countries analysed in the present report. However, the share of alternative fuels is increasing in recent years.

- The energy intensity shows a decreasing trend since 2013 (from 3.7 GJ/t clinker in 2013 to 3.2 GJ/t clinker in 2017).
- In Italy, mainly limestone is used as a substitute for clinker. The use of pozzolana is also quite common in Italy due to the natural occurrence of this material in Southern European regions but the share is decreasing. The clinker to cement ratio lies at roughly 77 % in 2017 (EU28 average 77 %, see Table 4) and is increasing over time.
- The production volume index for the construction industry, an important indicator of cement demand from the construction sector, correlates strongly positively with the cement production in Italy (correlation coefficient: 0.93). It shows a strong decrease between 2008 and 2014.
- Imports as well as exports of cement clinker are on a very low level and decreased since 2005. In 2017, imports accounted for only 3 %, exports for only 0.1 % of domestic clinker production. Since 2013, clinker is exported to countries outside the EU28, while cement clinker is mainly imported from other EU28 countries.
- At the beginning of 2005, 55 cement clinker production plants were in operation. Since 2005, a total of 25 plants closed. In 2017, 32 plants were in operation. Between 2017 and 2019, another two plants thus ceased production. The three largest facilities in terms of their emissions in 2019 are owned by Italcementi S.p.A. and Buzzi Unicem S.p.A. Average emissions per plant decreased between 2005 and 2019, in line with the decreased cement clinker production in this time period.

Table 13: Italy: Key figures on the cement clinker industry

Cement clinker industry characteristics	Unit	Year 2017	% change 2017 compared to 2013	Share of cement clinker production sector EU28 in 2017	Source
GHG emissions	Mt CO_2eq	12.2	-15 %	10 %	EEA 2019
Clinker production	Mt	12.8	-16 %	10 %	GCCA 2020
GHG emission intensity	t CO_2eq/t clinker	0.84[65]	-1 %	103 %[66]	GCCA 2020
Energy consumption	PJ	43	-26 %	9 %	EEA 2019
Energy intensity	GJ/t clinker	3.2	-12 %	90 %[67]	EEA 2019
Number of cement clinker production plants		32	-33 %	13 %	EEA 2019
Cement clinker plants with highest emissions					
Plant name (Company)	**Share of total capacity of cement clinker prod. facilities***	**Emissions in 2019 [Mt CO_2eq]****	**% change 2019 compared to 2013****	**Share of emissions from cement clinker prod. in Italy in 2019****	
Italcementi-Cementeria di Rezzato (ITALCEMENTI S.P.A.)	5.2 %	0.93	116 %	7.5 %	
Italcementi-Cementeria di Calusco d'Adda (ITALCEMENTI S.P.A.)	5.2 %	0.82	-9 %	6.6 %	
Cementeria di Robilante (Buzzi Unicem S.p.A.)	5.8 %	0.76	-11 %	6.1 %	

Key figures on the cement clinker production in Italy and on its largest cement clinker plants.
Source: Own table based on various sources. * Own calculations based on Cemnet 2020. **EEA 2019

[65] The GHG emission intensity is calculated based on data from GCCA 2020 and therefore differs from the calculation of emissions from EEA 2019 divided by clinker production.

[66] This value indicates that the emission intensity in Italy is 103 % of the EU28's emission intensity in 2017.

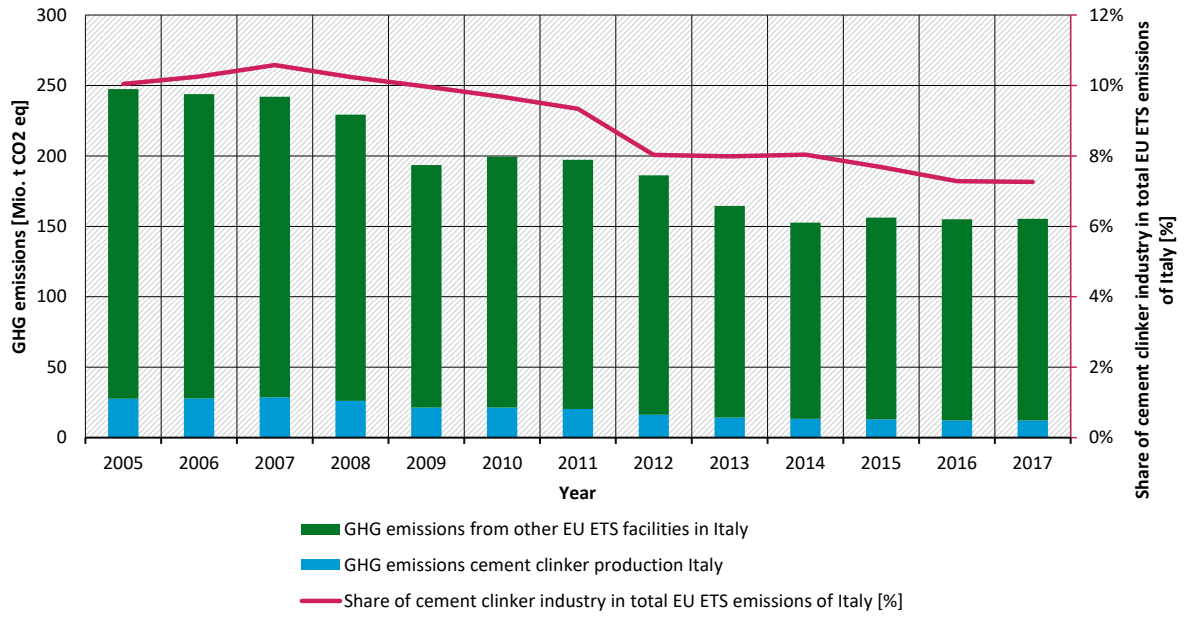
[67] This value indicates that the energy intensity in Italy is 90 % of the EU28's energy intensity in 2017.

7.2 Evolution of GHG emissions

The following trends can be observed for the emissions from the EU ETS facilities in Italy:

- In 2005 the emissions of stationary facilities participating in the EU ETS in Italy[68] amount to 250 million tonnes of CO_2eq. In 2017, the cement clinker production contributes a share of about 7 % (12 million tonnes of CO_2eq). This share declines between 2006 and 2017. Emissions from cement clinker production have decreased more strongly (-56 %) than in other EU ETS facilities (-35 %) between 2005 and 2017. Total GHG missions from stationary facilities of the EU ETS decreased by 37 % during this time period (EEA 2019).
- The observed decrease of emissions from cement clinker production is mainly due to the decrease in clinker production, a decrease in thermal energy input per ton of clinker and a slight increase in the share of biomass fuels.

Figure 52: Italy: Total GHG emissions from EU ETS facilities and share of emissions from cement clinker industry



Evolution of total GHG emissions from EU ETS facilities between 2005 and 2017 in Italy (left axis). The bars show the emissions from cement clinker production and other facilities of the EU ETS. The red line (right axis) indicates the relative share of GHG emissions from cement clinker production in total emissions from EU ETS facilities in Italy.
Source: EEA 2019, GCCA 2020, own calculations

- Total GHG emissions[69] in Italy amounted to about 580 million tonnes of CO_2eq in 2005 (Italy 2019). They decrease until 2017 to 428 million tonnes of CO_2eq. Emissions from EU ETS facilities accounted for 36 % of Italy's total GHG emissions in 2017 (EEA 2019).

[68] Total emissions from the EU-ETS facilities include verified emissions under the EU-ETS as well as an estimate of emissions for 2005-2012 reflecting the current scope of the EU-ETS.

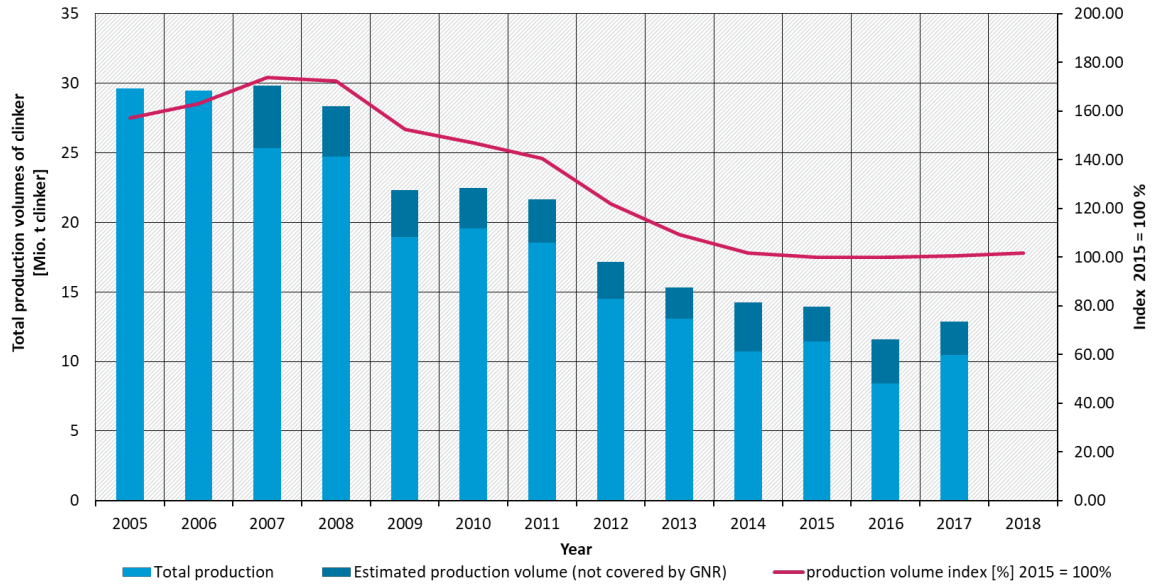
[69] Total GHG emissions reported here exclude emissions from land use, land use change and forestry. Indirect GHG emissions are excluded as well.

7.3 Evolution of cement clinker production

Production of grey cement clinker

The production of grey cement clinker is the most important driver of emissions from cement production. It shows an overall decreasing trend between 2005 and 2017, with a production volume[70] of about 30 million tonnes in 2005 and about 13 million tonnes in 2017, which corresponds to a decrease of 65 %. In the same period, total GHG emissions of the cement clinker production decreased by 56 % (see Figure 51). There is a strong positive correlation to the production volume index for the construction industry (correlation coefficient: 0.93). The production volume index for the construction industry relative to 2015 shows an increase between 2005 and 2007 and a strong decline between 2007 and 2014. Since then, the index is remaining at a constant level.

Figure 53: Italy: Production of grey cement clinker and evolution of production volume index of the construction sector



Evolution of total grey cement clinker production volume in Italy (2005-2017) estimated based on data reported by GNR (left axis). The red line (right axis) indicates the evolution of production volume index of the construction sector in Italy since 2005. 2015 corresponds to 100 %.
Source: GCCA 2020, EUROSTAT 2020b (Calendar adjusted data, non-seasonally adjusted data)

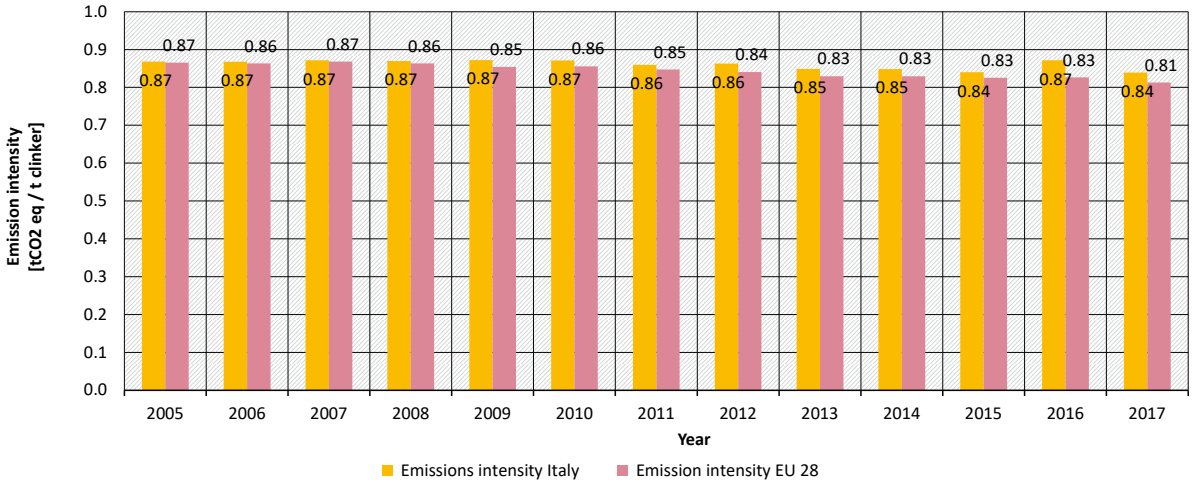
7.4 Evolution of GHG emission, energy intensity and clinker to cement ratio

Evolution of GHG emission intensity

The emission intensity per tonne of clinker is mainly affected by the fuel composition (i.e. share of fossil fuels vs. biomass fuels) and the efficiency of production technology applied. Since 2005, emission intensity of cement clinker production in Italy decreased by 3 % from 0.87 t CO_2eq/t clinker in 2005 to 0.84 t CO_2eq/t clinker in 2017. Emissions per tonne of clinker produced are higher than the EU28 average of around 0.81 t CO_2eq/t clinker possibly due to the high share of fossil fuels.

[70] Data of production volumes of clinker are affected by uncertainty, since not all facilities are reporting data in the cement sustainability initiative "Getting the numbers right" (GCCA) dataset.

Figure 54: Italy and EU28: Emission intensity of clinker production



Evolution of GHG emission intensity of clinker production in Italy and EU28.
Source: GCCA 2020

Evolution of energy intensity

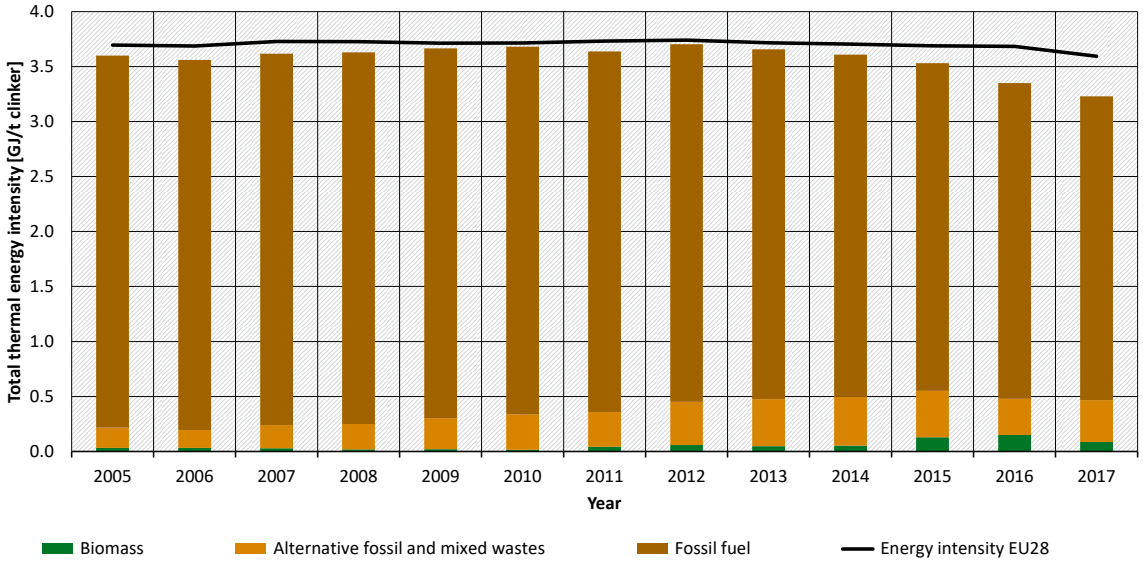
In Italy, total thermal energy consumption intensity[71] per tonne of grey cement clinker produced amounts to about 3.6 GJ/t clinker in 2005 with a slight decreasing trend since 2013 reaching 3.2 GJ/t clinker in 2017. In the EU28, total thermal energy consumption intensity per tonne of grey cement clinker is at a slightly higher level and shows a very slight decreasing trend. Since 2014, the energy intensity in Italy continued to improve more rapidly than the average energy intensity in the EU28 (GCCA 2020).

Thermal energy is produced from either regular fossil fuels, such as coal or oil, alternative fossil fuels[72] (such as waste solvents, plastics or tires) and biomass fuels. The share of alternative fossil fuels and biomass in thermal energy is increasing since 2005 at a low level from 6 % in 2005 to 14 % in 2017, with 3% of biomass in 2017 (GCCA 2020). This slow progress is driven by a poor landfill management and low co-processing rate in Italy (see chapter 7.6). Over the entire time period, the share of alternative fuels and biomass in Italy is substantially lower as compared to the EU28 average (see Figure 7). The share of fossil fuels in Italy was at 86 % in 2017.

[71] Besides thermal energy, the production of cement also requires electricity. Power consumption is however negligible compared to the thermal energy intensity. It is therefore not considered in the present report.

[72] Definition of "alternative fuels" according to WBCSD (2016): Products of fossil origin used as a source of thermal energy and not classified as traditional fossil fuel. This is mainly fossil waste such as plastics, solvents, waste oil, end-of-life tires, etc.

Figure 55: Italy: Total thermal energy consumption intensity and share of different energy carriers



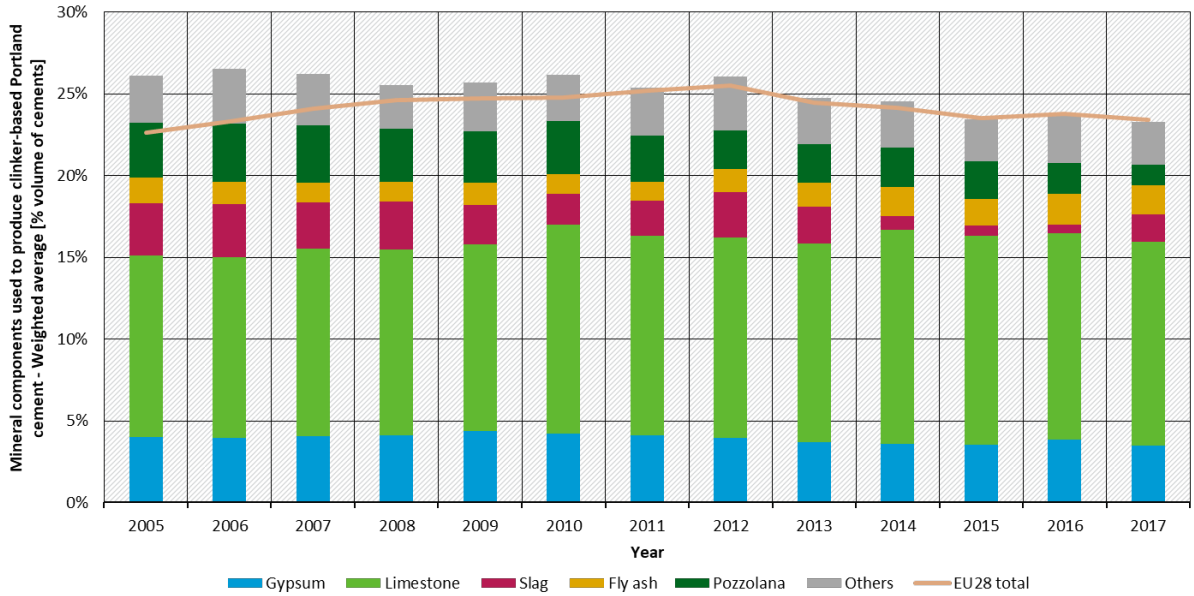
Evolution of thermal energy input for grey cement clinker production in Italy and EU28. For Italy, the share of alternative fossil and mixed wastes, biomass and fossil fuels are shown.
Source: GCCA 2020

Clinker to cement ratio and mineral components in cement

In the production of Portland cements besides grey cement clinker since 2005 mainly limestone is used in Italy (GCCA 2020). The other components account together for the same share as limestone. The use of pozzolana is quite common in Italy due to the natural occurrence of this material in Southern European regions but the share is decreasing.

Since 2012, Italy's share of mineral components is roughly equal to the one in the EU28 corresponding to a similar clinker to cement ratio and shows an increasing trend. In 2017, it reaches 76.7 % for Italy and 76.6 % for the EU28 average. Correspondingly, the share of mineral components shows a slight decreasing trend since 2012 reaching 23 % in 2017.

Figure 56: Italy: Share of mineral components used in production of Portland cement besides grey cement clinker



Evolution of the share of mineral components used in production of Portland cement besides grey cement clinker in Italy and in the EU28 since 2005.
Source: GCCA 2020

7.5 Market evolution, imports and exports

Import and export of Portland cement

Import and export of cement products were analysed for Portland cement, which is the most widely used type of cement[73]. For Portland cement, exports are smaller and remain at a low level compared to total import and sold production[74].

The market for Portland cement in Italy since 2005 shows no clear trends in imports and exports. Over the entire period imports and exports amount to roughly 1 to 2 million tonnes of Portland cement. So, volumes compared to domestic Portland cement production are rather small compared to the other analysed countries.

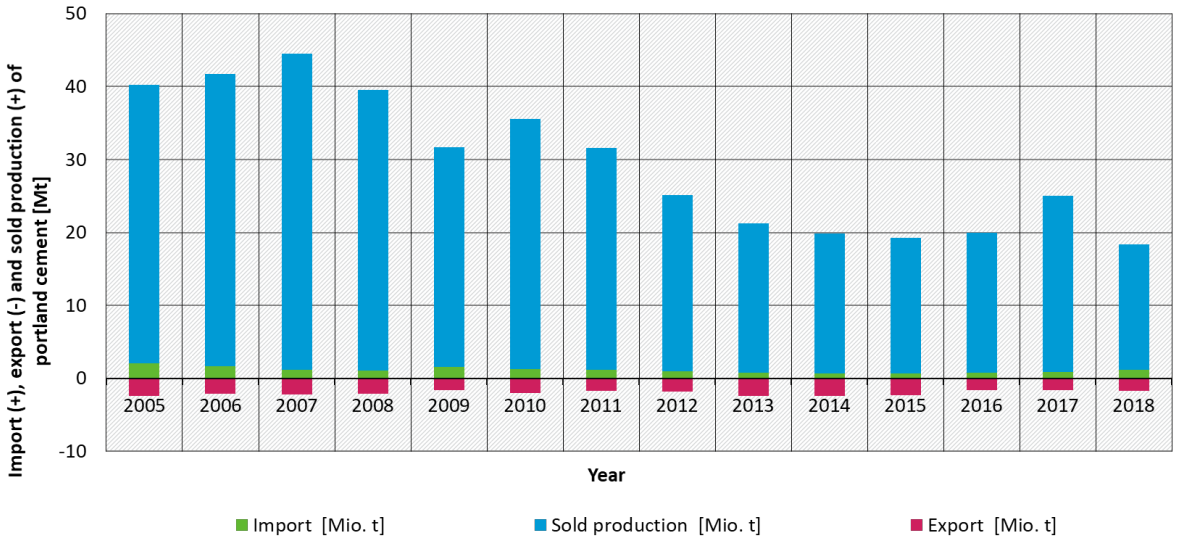
Sold production[75] of Portland cement however is increasing between 2005 and 2007 from 38 to 43 million tonnes but since then decreases to less than 20 million tonnes in 2018 (EUROSTAT 2020a).

[73] Portland cement (CEM I, II) constitutes more than 75 % of total cement sold in Europe in 2015.

[74] Sold production corresponds to the value and volume of the product sold by the enterprise it differs from total production (the volume of all production of the product, including both the proportion that is sold and the proportion that is retained by the enterprise for adding to stocks, using in further processing etc.).

[75] Sold production is smaller than total clinker production, since the amount of clinker that is directly processed to cement by the same company is not accounted for in the sold production.

Figure 57: Italy: Development of the Portland cement market



Evolution of import, export and sold production of Portland cement in Italy between 2005 and 2018.
Source: EUROSTAT 2020a

Import and export of cement clinker

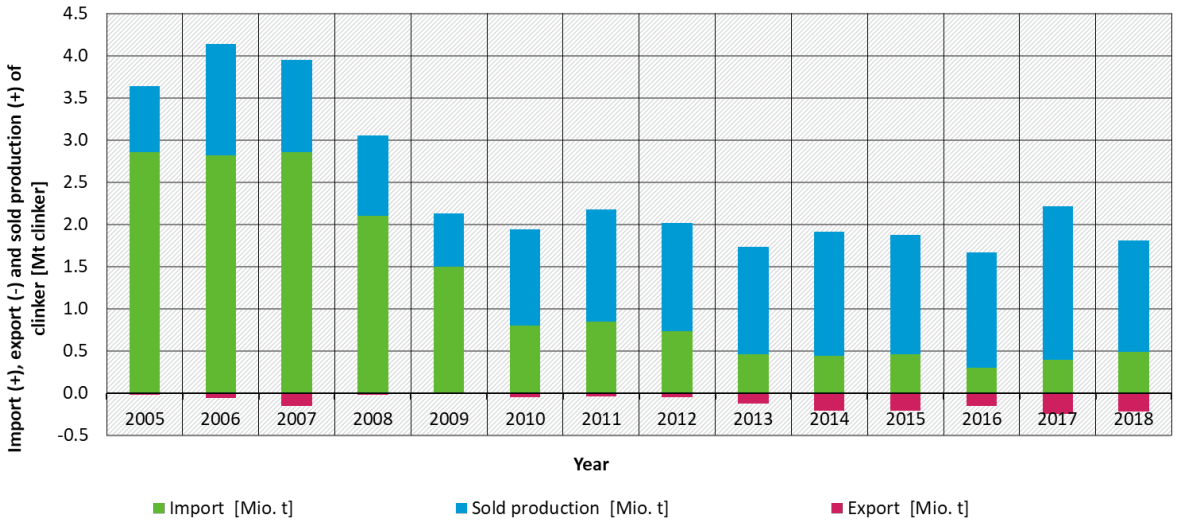
Sold production of cement clinker increased from almost 0.8 million tonnes in 2005 to over 1.8 million tonnes in 2017.

A clear decreasing trend in cement clinker imports can be seen. After 2007 clinker imports decreased to about 0.5 tonnes of cement clinker in 2013 and stayed roughly on this level. This can probably be explained with the financial crisis starting in 2008/2009 and shrinking economic activity. Imports made up a share of almost 10 % of total clinker production in 2005. Whereas in 2017, imports accounted for only 3 % of total clinker production.

Exports of cement clinker are small and account for only 0.1 % of Italy's cement clinker production over the entire period. However, they show a slight increasing trend in recent years. In 2017, the share of exports in total production was almost 2 % (EUROSTAT 2020a).

Overall, the shares of import and export volumes compared to of domestic clinker production (see chapter 7.3) are rather small compared to the other analysed countries.

Figure 58: Italy: Development of the cement clinker market



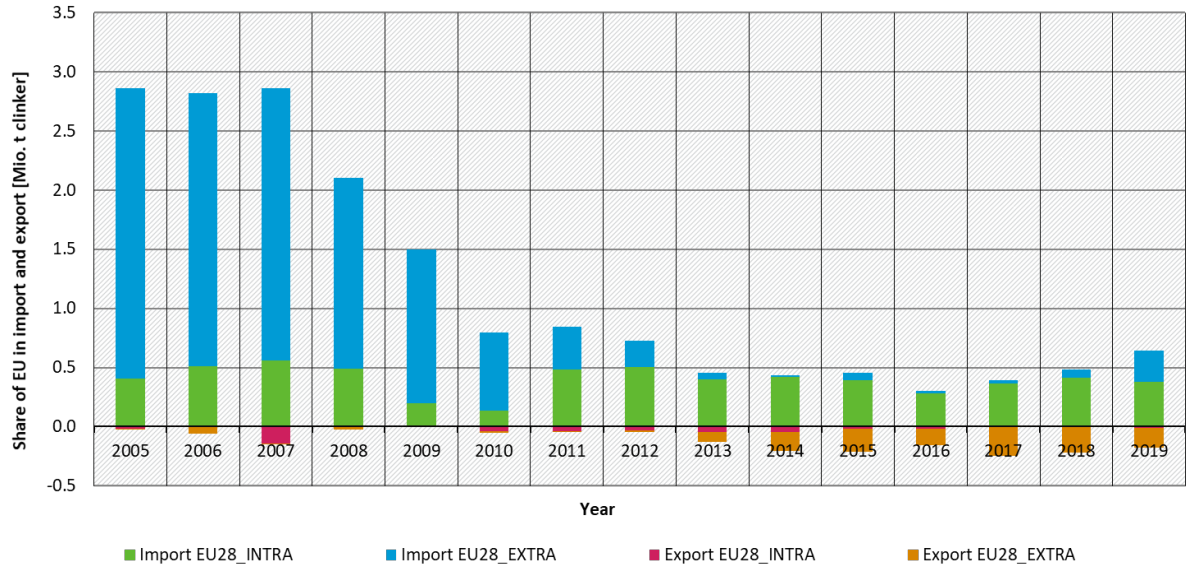
Evolution of import, export and sold production of cement clinker in Italy between 2005 and 2018. The blue bars only show the sold production of clinker, this does not include the cement clinker production that is directly processed to cement by the same company.
Source: EUROSTAT 2020a

Import and export of cement clinker within the EU28 and outside the EU28

Imports of cement clinker from other EU28 countries are less important than imports from countries outside the EU28 until 2010. After 2010, the imports from countries outside the EU28 declined drastically, though they slightly increased again in recent years (EUROSTAT 2020e).

Exports of cement clinker from Italy to countries outside the EU28 are increasing after 2013. Exports to other EU28 countries are very low (EUROSTAT 2020e).

Figure 59: Italy: Import and export of cement clinker to and from other EU28 countries/countries outside the EU28



Evolution of Italy's import of cement clinker from other EU28 countries (Import EU28_INTRA) and from countries outside the EU28 (Import EU28_EXTRA) and evolution of Italy's export of clinker to other EU28 countries (Export EU28_INTRA) and to countries outside the EU28 (Export EU28_EXTRA).
Source: EUROSTAT 2020e

7.6 Regulative, economic and political framework

The following sections summarize the regulative, economic and political framework affecting the cement sector in Italy. This includes the use of waste as alternative fuels and state aid.

Use of waste fuels in the cement industry

Public acceptance of co-processing of waste is low. Poor law enforcement in waste management and longer waiting times for the granting of permits make increased use in the cement industry more difficult (De Beer et al. 2017).

Despite a very high recycling rate in waste treatment (69 % in 2014), a significant part of the waste generated is landfilled and both co-processing and incineration options remain underdeveloped. Italy suffers from poor landfill management and insufficient landfill capacity (De Beer et al. 2017).

Landfill taxes vary considerably depending on the type of waste (1-103 EUR/tonne). Italy is one of the main European exporters of Solid Recovered Fuel[76] (SRF). If a strong domestic market for SRF is created (e.g. through higher uptake in cement kilns), the export rate could be significantly reduced (De Beer et al. 2017).

There are significant differences in waste infrastructure between the regions of Italy, where in the northern part there are both pre-treatment plants and end users (WtE, cement plants), while in the southern parts most of the waste is landfilled due to the poor infrastructure (despite the presence of cement plants) (De Beer et al. 2017).

Co-treatment has a strong position in the national waste management plans. However, permits for waste incineration are issued at municipal level, so that very often only small quantities of waste can be co-processed (De Beer et al. 2017).

State Aid

In the State Aid Transparency database of the European commission no information is provided on any case of state aid for the cement sector (C.23.51 Production of cement) in Italy (EC 2020).

7.7 Facility data - the largest emitters and their location

GHG emissions and production capacity

In 2019, 30 cement clinker production plants were subject to the EU ETS in Italy. The following table provides an overview on GHG emission and cement production capacity of the three largest cement clinker facilities in terms of emissions in Italy.

Table 14: Italy: Emissions and production capacity of the three largest cement clinker plants in terms of emissions

ID	Installation	Company	City	Emissions (Mt CO_2eq)					Share of total verified emissions	Share of total capacity
				2005	2009	2010	2015	2019	2019	2019
173	Italcementi-Cementeria di Rezzato	ITALCEMENTI S.P.A.	Rezzato (BS)	0.8	0.8	0.7	0.7	0.9	7.5%	5.2%
139	Italcementi-Cementeria di Calusco d'Adda	ITALCEMENTI S.P.A.	Calusco d'Adda (Bergamo)	1.1	1.0	1.0	0.9	0.8	6.6%	5.2%
63	Cementeria di Robilante	Buzzi Unicem S.p.A.	Robilante	1.3	0.9	1.1	0.8	0.8	6.1%	5.8%

Emissions and production capacity of the largest cement clinker facilities in terms of emissions in Italy.

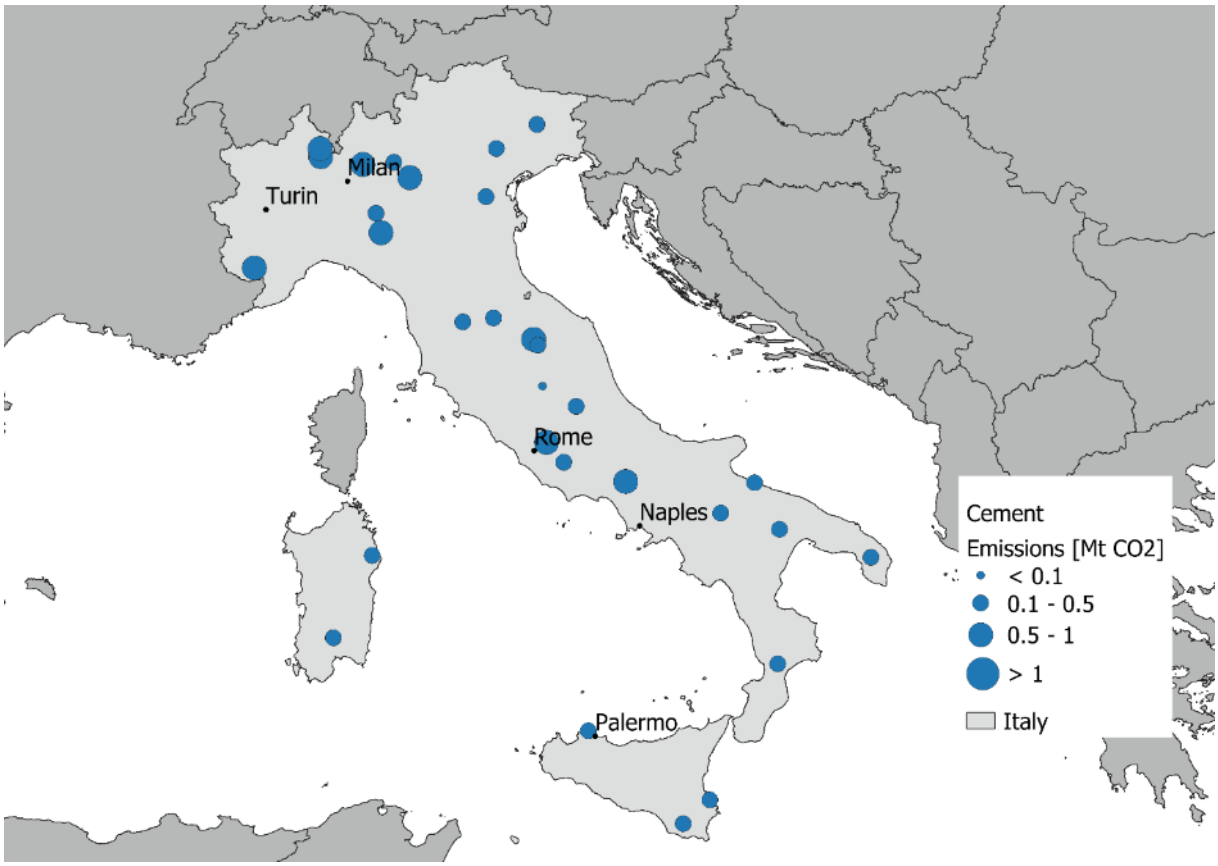
Source: EEA 2019, Own calculations based on Cemnet 2020.

The following map shows the location of the cement clinker production facilities participating in the EU ETS in 2019 in Italy. 9 facilities emitted over 500,000 tonnes of CO_2eq, 20 facilities

[76] Solid Recovered Fuel (SRF) is produced from recovered waste such as paper, card, wood, textiles and plastic and serves as a high-quality alternative to fossil fuel.

emitted between 100,000 and 500,000 tonnes of CO_2eq and one facility had emissions below 100,000 tonnes of CO_2eq in 2019.

Figure 60: Italy: Location of cement clinker production plants



Location of cement clinker production plants in Italy (2019), the size of the dots indicates the amount of verified emissions in 2019.
Source: EEA 2019

Cement clinker production companies

The largest cement clinker production company "Buzzi Unicem S.p.A." in terms of emissions emitted 3.49 million tonnes of CO_2eq in 2019. It encompasses 8 different production plants subject to EU ETS.

The second largest cement clinker production company "Dyckerhoff GmbH", consisting of 6 plants, emitted 3.1 million tonnes of CO_2eq. The third largest company "w&p Cementi SpA" including 4 plants emitted 1.96 million tonnes of CO_2eq.

Together, these three companies account for 69 % of total verified emission from cement clinker production in 2019.

7.8 Facility data – examples of recent investments

Exemplary list of investments in the cement production sector:

- Italy's largest cement clinker production company, "Buzzi Unicem S.p.A.", aims at improving the efficiency in technology, environment and occupational safety such that alternative fuels are now used in their "Cementeria di Vernasca" and "Cementeria di Augusta" plants.

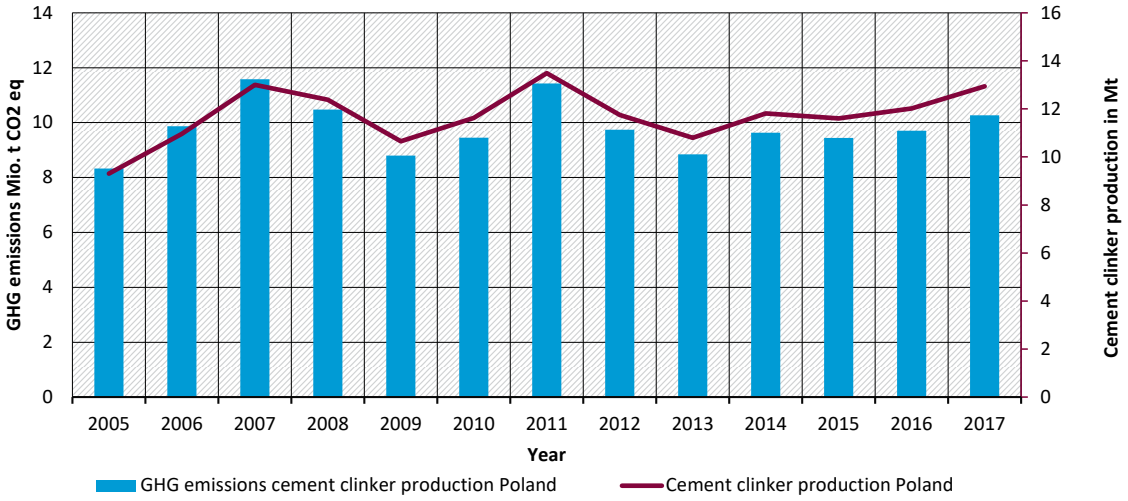
Furthermore, the grinding and transport department for cement and sulpho-aluminate cement were modernized in 2019 at the "Cementeria di Robilante" plant, which is Italy's third largest plant in terms of verified emissions in 2019. At the plant "Cementeria di Monselice" the electrofilter was conversed into a baghouse filter. In total, investments of these activities amounted to 5.5 million EUR in 2019 (Buzzi Unicem S.p.A. 2020).

8 Poland

8.1 Key messages

- GHG emissions from the cement clinker production in Poland amounted to roughly 10 million tonnes of CO_2eq in 2017. Since 2013 they increased by 16 %. Over the entire time period from 2005 to 2017, the cement clinker production accounts for roughly 5 % of total EU ETS emissions from Poland.
- Poland contributes a share of 9 % to total EU28 emissions of cement clinker production in 2017.
- Cement clinker production in Poland increased by 20 % between 2013 and 2017, more strongly than emissions (see Figure 61). Cement production of Poland accounts for roughly 10 % of the total cement clinker production sector in the EU28 in 2017. This share slightly increased since 2013.
- The different trend of emissions and production of the cement industry in Poland indicates a change in GHG emissions intensity per tonne of clinker. Between 2013 and 2017, the emission intensity decreased from 0.82 t CO_2eq/t clinker to 0.79 t CO_2eq/t clinker. The emission intensity is slightly lower than the EU28 average of 0.81 t CO_2eq/t clinker in 2017 (see Table 4).

Figure 61: Poland: Total GHG emissions from the cement clinker production



Evolution of total GHG emissions from the cement clinker production and evolution of cement clinker production between 2005 and 2017 in Poland.
Source: GCCA 2020, EEA 2019

- The emission intensity is affected by the fuel composition (i.e. share of fossil fuels vs. biomass fuels) and the efficiency of production technology applied[77]:

[77] The condition, operating mode and kiln capacity of a plant as well as moisture and combustibility of the raw material are additional factors affecting the emission intensity. In this factsheet, individual plants were not analysed such that the focus lies on the fuel composition and production technology.

- Thanks to a rapid development of the co-processing rate encouraged by the Polish government, the use of alternative fossil and mixed wastes as well as biomass for energy consumption substantially increased between 2005 and 2017. Whereas in 2005, fossil fuels still accounted for 89 % of energy consumption in Poland, alternative fuels and biomass contributed a share of 62 % in 2017 (EU28 average 46 % in 2017, see Figure 7). The share of biomass is the highest of the countries analysed in this report (23 % compared to EU28 average of 16 %).

- Energy intensity shows a slight increase since 2005 (from 3.5 GJ/t clinker in 2005 to 3.7 GJ/t clinker in 2017).

- The use of mineral components as a substitute for clinker is quite important in Poland with slag and fly ash being the most often used substitution for clinker, which can be traced back to the many steel and coal production plants existing in Poland. The clinker to cement ratio lies at roughly 75 % in 2017 and is increasing in recent years. It is lower than the EU28average (EU28 average 77 %, see Table 4).

- The production volume index for the construction industry, an important indicator of cement demand from the construction sector, shows a moderate positive correlation to the cement clinker production in Poland (correlation coefficient: 0.58), with a peak in 2011 and 2018. Imports as well as exports of cement clinker are on a very low level (0.4 % and 0.7 % of domestic cement clinker production in 2017) and decreased since 2005. Over the entire time period, imports and exports of cement clinker to other countries of the EU28 dominate.

- At the beginning of 2005, 33 cement clinker production plants were in operation. A total of 23 plants closed until 2017, which means that in 2017 10 plants were in operation. The three largest facilities in terms of their emissions in 2019 already account for more than half of total emissions in 2019. Average emissions per plant increased between 2005 and 2019 in line with the observed reduction of the number of plants but increased cement clinker production in this time period.

Table 15: Poland: Key figures on the cement clinker industry

Cement clinker industry characteristics	Unit	Year 2017	% change 2017 compared to 2013	Share of cement clinker production sector EU28 in 2017	Source
GHG emissions	Mt CO_2eq	10.3	16 %	9 %	EEA 2019
Clinker production	Mt	12.9	20 %	10 %	GCCA 2020
GHG emission intensity	t CO_2eq/t clinker	0.79	-3 %	98 %[78]	GCCA 2020
Energy consumption	PJ	48	20 %	10 %	GCCA 2020
Energy intensity	GJ/t clinker	3.7	0 %	103 %[79]	GCCA 2020
Number of cement clinker production plants		10	0 %	4 %	EEA 2019
Cement clinker plants with highest emissions					
Plant name (Company)	**Share of total capacity of cement clinker prod. facilities***	**Emissions in 2019 [Mt CO_2eq]****	**% change 2019 compared to 2013****	**Share of emissions from cement clinker prod. in Poland in 2019****	
GÓRAŻDŻE CEMENT SPÓŁKA AKCYJNA (GÓRAŻDŻE CEMENT SPÓŁKA AKCYJNA)	24.4 %	2.67	71 %	23.6 %	
CEMENT OŻARÓW S.A. - Zakład Cementownia Ożarów (CEMENT OŻARÓW S.A.)	16.5 %	2.04	34 %	18.0 %	
CEMENTOWNIA WARTA S.A. (CEMENTOWNIA WARTA S.A.)	13.4 %	1.55	7 %	13.7 %	

Key figures on the cement clinker production in Poland and on its largest cement clinker plants.
Source: Own table based on various sources. * Own calculations based on Cemnet 2020. **EEA 2019

8.2 Evolution of GHG emissions

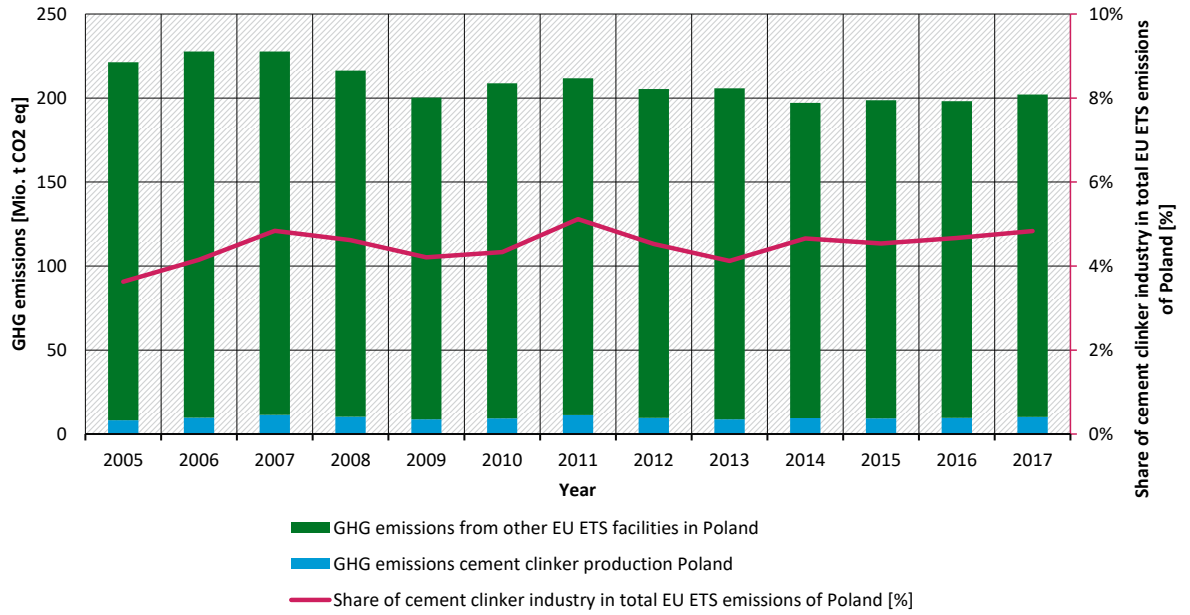
The following trends can be observed for the emissions from the EU ETS facilities in Poland:

[78] This value indicates that the emission intensity in Poland is 98 % of the EU28's emission intensity in 2017.

[79] This value indicates that the energy intensity in Poland is 103 % of the EU28's energy intensity in 2017.

- In 2005 the emissions of stationary facilities participating in the EU ETS in Poland[80] amount to roughly 221 million tonnes of CO_2eq. In 2017, the cement clinker production contributes a share of about 5 % (10 million tonnes of CO_2eq). This share is quite constant between 2005 and 2017. Emissions from cement clinker production increased (+23 %), whereas emissions from other EU ETS facilities decreased (-10 %) between 2005 and 2017. Total GHG missions from stationary facilities of the EU ETS decreased by 9 % during this time period (EEA 2019).
- The GHG emissions from cement clinker production increased due to an increase in clinker production volumes. The increase is partially compensated by a strong increase in the use of alternative fuels and biomass.

Figure 62: Poland: Total GHG emissions from EU ETS facilities and share of emissions from cement clinker industry



Evolution of total GHG emissions from EU ETS facilities between 2005 and 2017 in Poland (left axis). The bars show the emissions from cement clinker production and other facilities of the EU ETS. The red line (right axis) indicates the relative share of GHG emissions from cement clinker production in total emissions from EU ETS facilities in Poland.
Source: EEA 2019, GCCA 2020, own calculations

- Total GHG emissions[81] in Poland amounted to over 403 million tonnes of CO_2eq in 2005 (Poland 2019). They increased to roughly 414 million tonnes of CO_2eq in 2017. Emissions from EU ETS facilities accounted for 49 % of Poland's total GHG emissions in 2017 (EEA 2019).

[80] Total emissions from the EU-ETS facilities include verified emissions under the EU-ETS as well as an estimate of emissions for 2005-2012 reflecting the current scope of the EU-ETS.

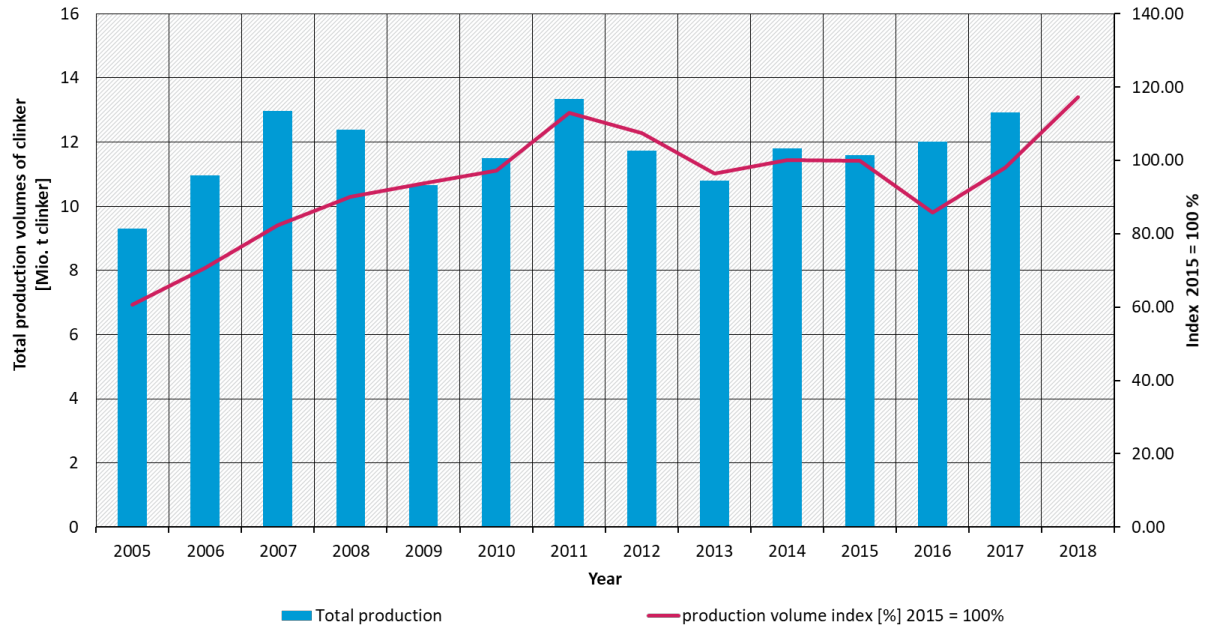
[81] Total GHG emissions reported here exclude emissions from land use, land use change and forestry. Indirect GHG emissions are excluded as well.

8.3 Evolution of cement clinker production

Production of grey cement clinker

The production of grey cement clinker is the most important driver of emissions from cement production. There is no clear trend in production volumes in Poland, however grey cement clinker production has increased since 2013 from roughly 11 million tonnes to 13 million tonnes in 2017. There is a moderate positive correlation to the production volume index for the construction industry (correlation coefficient: 0.58). The production volume index for the construction industry relative to 2015 shows an increase between 2005 and 2011. A slight decrease is observed until 2016. Since then, the index is increasing again.

Figure 63: Poland: Production of grey cement clinker and evolution of production volume index of the construction sector



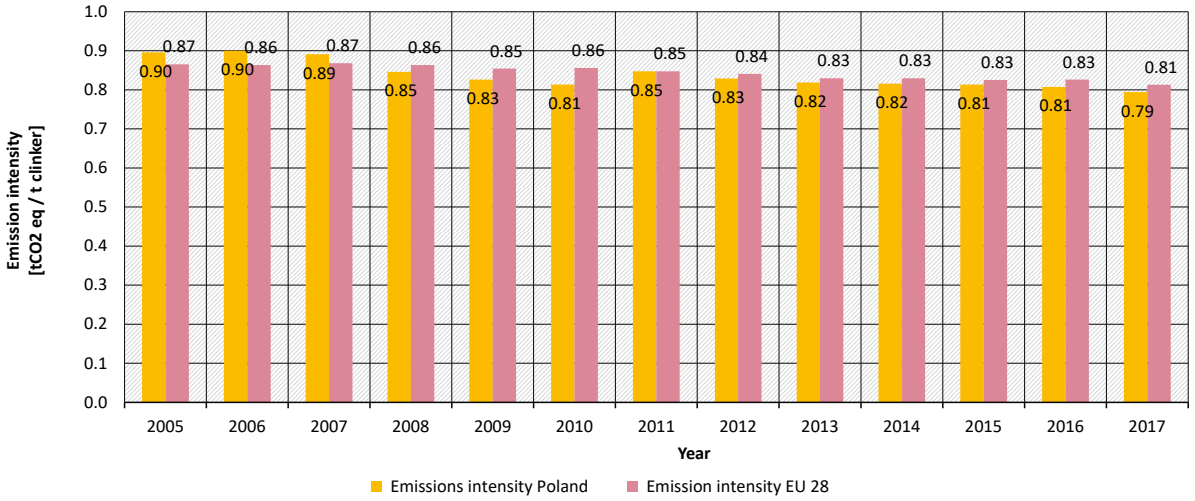
Evolution of total grey cement clinker production volume in Poland (2005-2017) estimated based on data reported by GNR (left axis). The red line (right axis) indicates the evolution of production volume index of the construction sector in Poland since 2005. 2015 corresponds to 100 %.
Source: GCCA 2020, EUROSTAT 2020b (Calendar adjusted data, non-seasonally adjusted data)

8.4 Evolution of GHG emission, energy intensity and clinker to cement ratio

Evolution of GHG emission intensity

The emission intensity per tonne of clinker is mainly affected by the fuel composition (i.e. share of fossil fuels vs. biomass fuels) and the efficiency of production technology applied. In 2017, emissions per tonne of clinker produced amount to about 0.79 t CO_2eq/t clinker in Poland, while the EU28 average is at around 0.81 t CO_2eq/t clinker. Since 2005, emission intensity shows a decreasing trend, from 0.87 t CO_2eq/t clinker in 2005 to 0.78 t CO_2eq/t clinker in 2017. This corresponds to a relative reduction of 11 % compared to 2005. Among the seven countries analysed, Poland has the lowest emission intensity, possibly due to a high share of biomass and other alternative fuels.

Figure 64: Poland and EU28: Emission intensity of clinker production



Evolution of GHG emission intensity of clinker production in Poland and EU28.
Source: GCCA 2020

Evolution of energy intensity

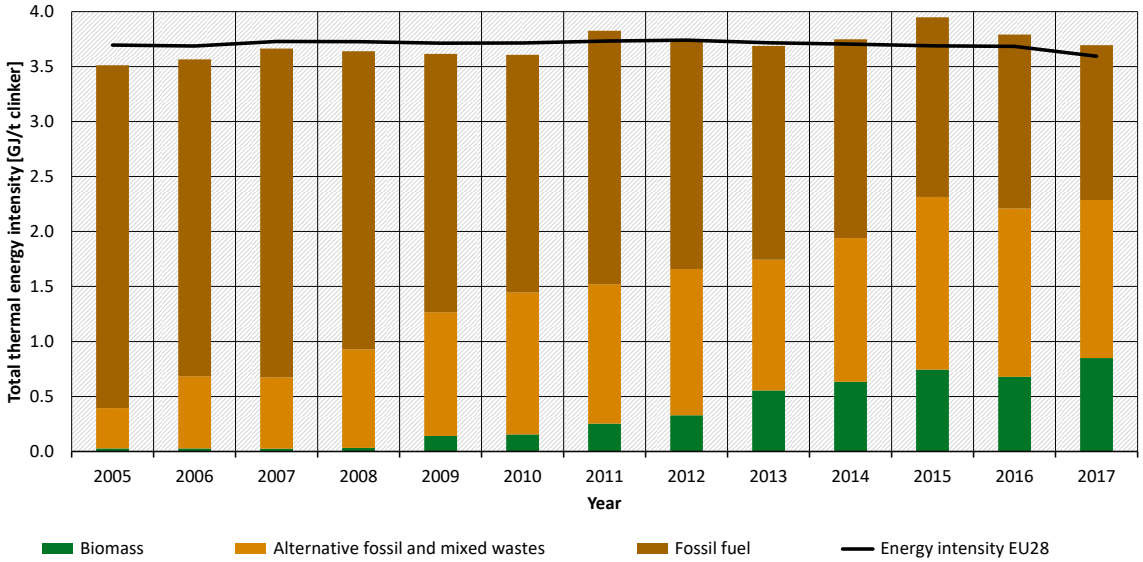
In Poland, total thermal energy consumption intensity[82] per tonne of grey cement clinker produced amounts to about 3.5 GJ/t clinker in 2005 with a slightly increasing trend over time reaching 3.7 GJ/t clinker in 2017. In the EU28, total thermal energy consumption intensity per tonne of grey cement clinker is at a similar level and shows a very slight decreasing trend (GCCA 2020).

Thermal energy is produced from either regular fossil fuels, such as coal or oil, alternative fossil fuels[83] (such as waste solvents, plastics or tires) and biomass fuels. The share of alternative fossil fuels and biomass in thermal energy is increasing since 2005. In 2005, the share of "alternative fossil fuels and mixed wastes" and biomass amounted to 10 % and 1 % respectively and until 2017, the share increased to 39 % and 23 % respectively (GCCA 2020). The rapid increase of alternative fuel use is due to improvements in the waste management in Poland (see chapter 8.6). Over the entire time period, the share of alternative fuels and biomass in Poland is much higher as compared to the EU28 average (in 2017: 62 % for Poland vs. 46 % in the EU28) (Figure 7). The remaining fossil fuel share in Poland was 38 % in 2017.

[82] Besides thermal energy, the production of cement also requires electricity. Power consumption is however negligible compared to the thermal energy intensity. It is therefore not considered in the present report.

[83] Definition of "alternative fuels" according to WBCSD (2016): Products of fossil origin used as a source of thermal energy and not classified as traditional fossil fuel. This is mainly fossil waste such as plastics, solvents, waste oil, end-of-life tires, etc.

Figure 65: Poland: Total thermal energy consumption intensity and share of different energy carriers



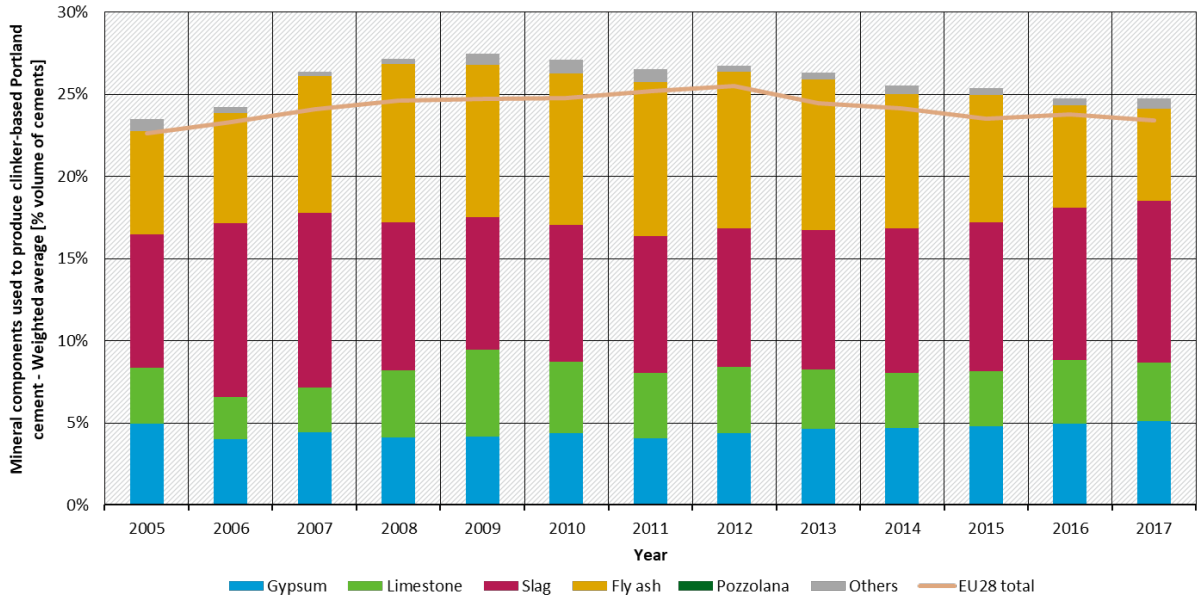
Evolution of thermal energy input for grey cement clinker production in Poland and EU28. For Poland, the share of alternative fossil and mixed wastes, biomass and fossil fuels are shown.
Source: GCCA 2020

Clinker to cement ratio and mineral components in cement

In the production of Portland cements in Poland mainly gypsum, slag and fly ash are used besides grey cement clinker (GCCA 2020). The common use of slag and fly ash in Poland as a substitute for clinker can be traced back to the many steel and coal production plants existing in Poland.

The share of mineral components in Poland is slightly higher than the EU28 average over the entire time period corresponding to a lower clinker to cement ratio (75 % vs. 77 % EU28 average). Between 2005 and 2009, the share of mineral components increased from 23 % to 27 %. Since then, a decreasing trend can be observed reaching 25 % in 2017.

Figure 66: Poland: Share of mineral components used in production of Portland cement besides grey cement clinker



Evolution of the share of mineral components used in production of Portland cement besides grey cement clinker in Poland and in the EU28 since 2005.
Source: GCCA 2020

8.5 Market evolution, imports and exports

Import and export of Portland cement

Import and export of cement products were analysed for Portland cement, which is the most widely used type of cement[84]. For Portland cement, import and export remain at a low level compared to total sold production[85].

Sold production of Portland cement increased from 11 million tonnes in 2005 to over 15 million tonnes in 2008. Between 2008 and 2011, sold production increases further to a bit over 17 million tonnes. Until 2013, sold production shows a decline to around 13 million tonnes. Since then, the sold production shows again an increasing trend to about 17 million tonnes in 2018 (EUROSTAT 2020a).

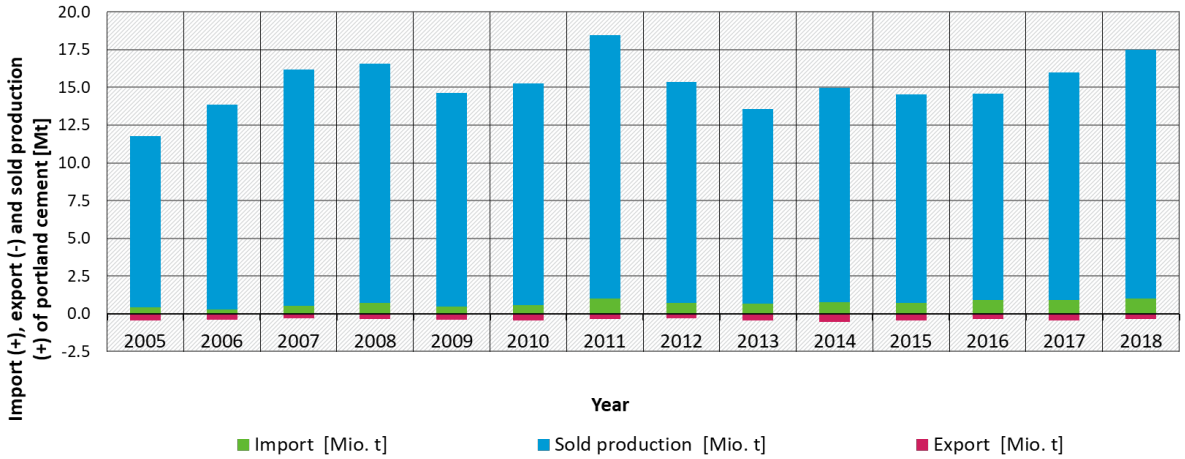
Exports of cement remain roughly constant at around 0,4 million tonnes between 2005 and 2018.

Imports show a slight increasing trend in this time period but remain on a very low level with 1 million tonnes in 2018.

[84] Portland cement (CEM I, II) constitutes more than 75 % of total cement sold in Europe in 2015.

[85] Sold production corresponds to the value and volume of the product sold by the enterprise it differs from total production (the volume of all production of the product, including both the proportion that is sold and the proportion that is retained by the enterprise for adding to stocks, using in further processing etc.).

Figure 67: Poland: Development of the Portland cement market



Evolution of import, export and sold production of Portland cement in Poland between 2005 and 2018.
Source: EUROSTAT 2020a

Import and export of cement clinker

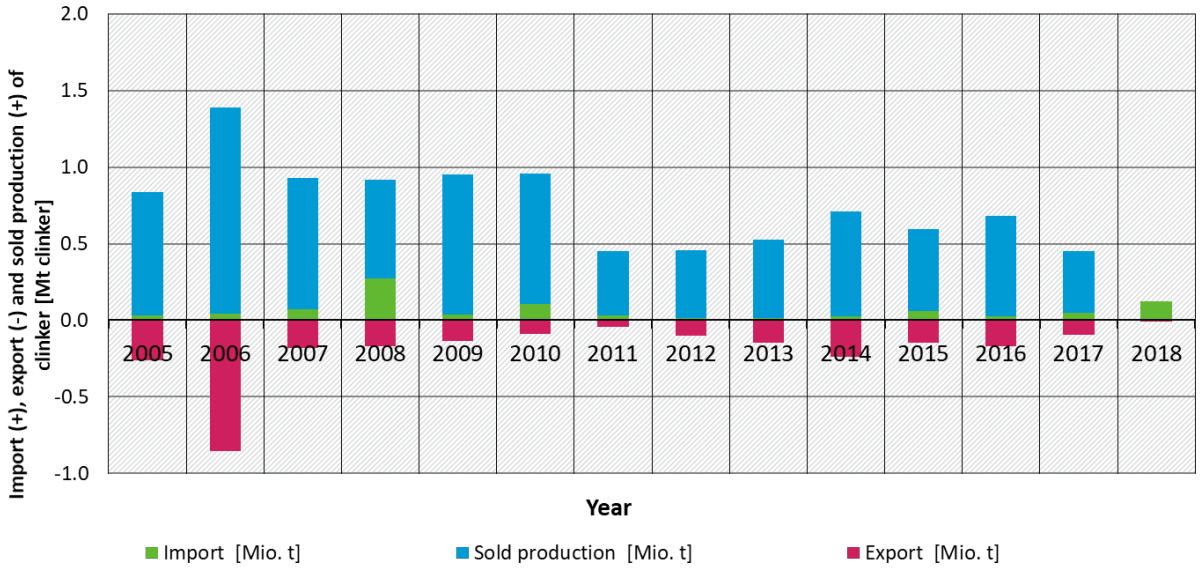
The market for cement clinker in Poland is small compared to domestic production and shows a decreasing trend in sold production[86] since 2005, indicating that most of the cement clinker is directly processed to cement and not sold on the market. Imports account for only 0.4 % of domestic cement clinker production in 2017 (see Figure 61) and also exports only make up a share of 0.7 %. Import and export levels with regard to total domestic clinker production are among the lowest compared to the other analysed countries.

The amount of sold cement clinker increases to almost 1.5 million tonnes in 2006. After 2006, it drops to roughly 1 million tonnes until 2010. Since then, the sold production volume declined to less than 1 million tonnes. The share of exported cement clinker is below 0.1 million tonnes, except in 2006 it increases to 0.9 million tonnes. After this event it drops to the previous level (EUROSTAT 2020a).

The imports of cement clinker are at a very low level. In most years, it is at or below 0.1 million tonnes, except in 2008 it increases to 0.3 million tonnes (EUROSTAT 2020a).

[86] Sold production is smaller than total clinker production, since the amount of clinker that is directly processed to cement by the same company is not accounted for in the sold production.

Figure 68: Poland: Development of the cement clinker market



Evolution of import, export and sold production of cement clinker in Poland between 2005 and 2018. The blue bars only show the sold production of clinker, this does not include the cement clinker production that is directly processed to cement by the same company.

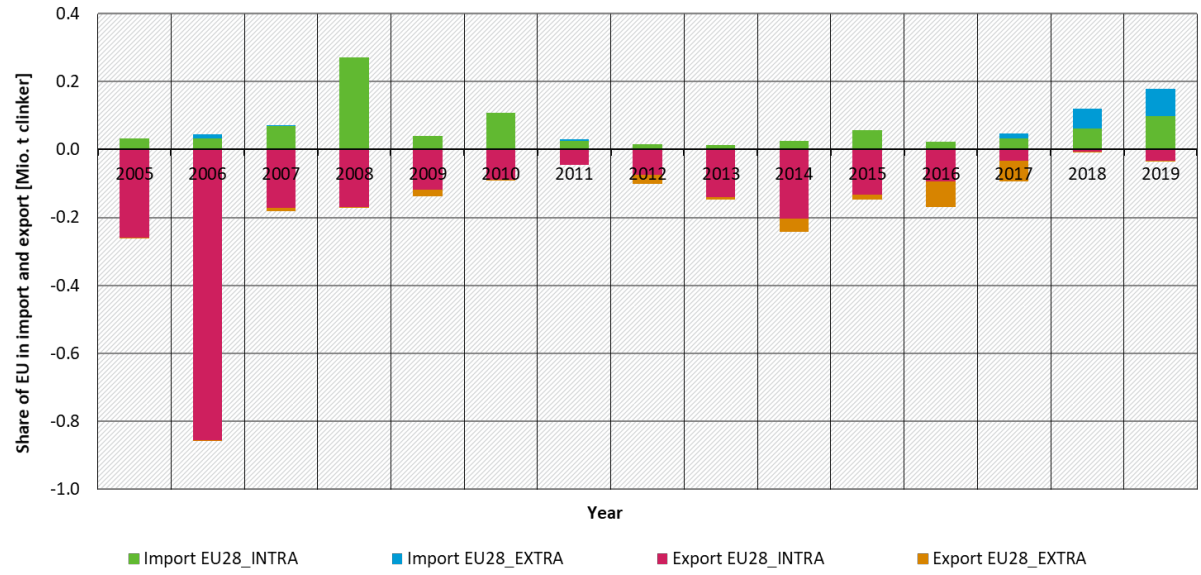
Source: EUROSTAT 2020a

Import and export of cement clinker within the EU28 and outside the EU28

Imports of cement clinker originate mainly from other EU28 countries, though in most recent years cement clinker was also imported from non-EU28 countries (EUROSTAT 2020e).

Exports of cement clinker from Poland to countries inside the EU28 are also more common than exports to non-EU28 countries (EUROSTAT 2020e).

Figure 69: Poland: Import and export of cement clinker to and from other EU28 countries/countries outside the EU28



Evolution of Poland's import of cement clinker from other EU28 countries (Import EU28_INTRA) and from countries outside the EU28 (Import EU28_EXTRA) and evolution of Poland's export of clinker to other EU28 countries (Export EU28_INTRA) and to countries outside the EU28 (Export EU28_EXTRA).

Source: EUROSTAT 2020e

8.6 Regulative, economic and political framework

The following sections summarize the regulative, economic and political framework affecting the cement sector in Poland. This includes the use of waste as alternative fuels and state aid.

Use of waste fuels in the cement industry

In Poland, co-processing has developed rapidly over the last decade, in parallel with progress in the country's waste management. The fuel substitution rate in Poland was well above EU28 average in 2014: 52 % (compare to EU28 average 41 %). Two cement plants already have substitution rates of over 80 %. Co-processing is encouraged by the Polish government and viewed positively by the society. The cement industry is the largest consumer of processed waste as a fuel (1.2 million tonnes/a). Between 70 % and 80 % of alternative fuels used originates from municipal solid waste.

In 2014, 27 % of total generated waste was landfilled (EU28 average 28 %) and about 65 % recycled (EU28 average 55 %). There are plans to undertake major investments in the coming years with construction and modernization of 1.2 million tonnes waste processing, 1.8 million tonnes waste sorting capacity and 6 WtE plants (De Beer et al. 2017).

State Aid

In the State Aid Transparency database of the European commission no information is provided on any case of state aid for the cement sector (C.23.51 Production of cement) in Poland (EC 2020).

8.7 Facility data – the largest emitters and their location

GHG emissions and production capacity

In 2019, 9 cement clinker production plants were subject to the EU ETS in Poland. The following table provides an overview on GHG emission and cement production capacity of the three largest cement clinker facilities in terms of emissions in Poland.

Table 16: Poland: Emissions and production capacity of the three largest cement clinker plants in terms of emissions

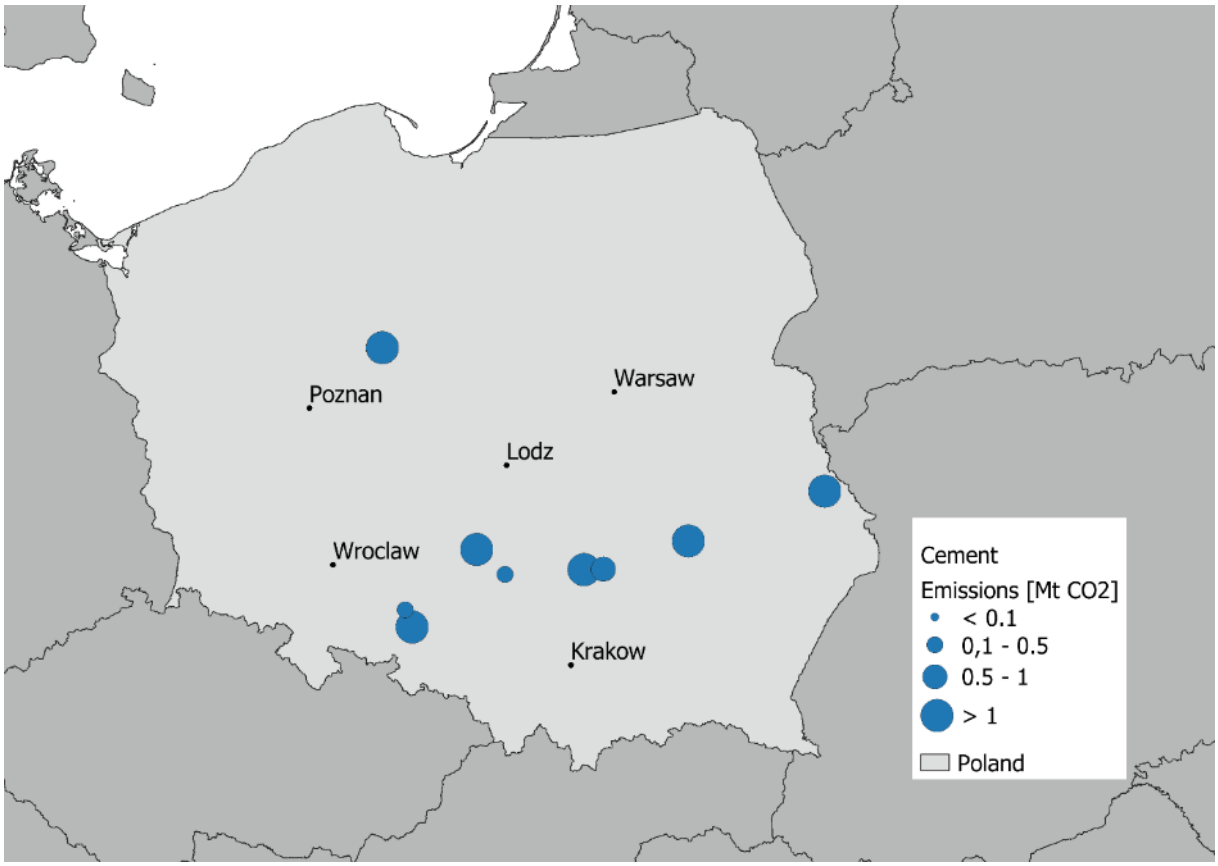
ID	Installation	Company	City	Emissions (Mt CO_2eq)					Share of total verified emissions	Share of total capacity
				2005	2009	2010	2015	2019	2019	2019
490	GÓRAŻDŻE CEMENT SPÓŁKA AKCYJNA	GÓRAŻDŻE CEMENT SPÓŁKA AKCYJNA	CHORULA-poczta Górażdże	1.6	1.9	2.0	1.8	2.7	23.6%	24.4%
491	CEMENT OŻARÓW S.A. - Zakład Cementownia Ożarów	CEMENT OŻARÓW S.A.	Ożarów	1.4	1.6	1.7	1.9	2.0	18.0%	16.5%

ID	Installation	Company	City	Emissions (Mt CO_2eq)					Share of total verified emis-sions	Share of total capa-city
				2005	2009	2010	2015	2019	2019	2019
492	CEMENTOWNIA WARTA S.A.	CEMENTOWNIA WARTA S.A.	TRĘBACZEW	0.6	0.9	0.7	1.4	1.5	13.7%	13.4%

Emissions and production capacity of the largest cement clinker facilities in terms of emissions in Poland.
Source: EEA 2019, Own calculations based on Cemnet 2020.

The following map shows the location of the cement clinker production facilities participating in the EU ETS in 2019 in Poland. 6 facilities emitted over 1 million tonnes of CO_2eq, one facility emitted between 500,000 and 1 million tonnes of CO_2eq and two facilities had emissions below 500,000 tonnes of CO_2eq in 2019.

Figure 70: Poland : Location of cement clinker production plants



Location of cement clinker production plants in Poland (2019), the size of the dots indicates the amount of verified emissions in 2019.
Source: EEA 2019

Cement clinker production companies

The largest cement clinker production company in terms of emissions "GÓRAŻDŻE CEMENT SPÓŁKA AKCYJNA", which is part of the "HeidelbergCement AG" group, emitted 2.67 million tonnes of CO_2eq in 2019. In Poland, it encompasses 1 production plant subject to EU ETS.

The second largest cement clinker production company "LAFARGE CEMENT SPÓŁKA AKCYJNA", consisting of 2 plants, emitted 2.43 million tonnes of CO_2eq. The third largest company "CEMENT OŻARÓW S.A." including 2 plants emitted 2.04 million tonnes of CO_2eq.

Together, these three companies account for 63 % of total verified emission from cement clinker production in 2019.

8.8 Facility data – examples of recent investments

Exemplary list of investments in the cement production sector:

- At Poland's cement clinker production plant with the highest emissions in 2019 "GÓRAŻDŻE CEMENT SPÓŁKA AKCYJNA" owned by "GÓRAŻDŻE CEMENT", which is part of the "HeidelbergCement AG" group, the construction of a loading facility for silo cement has started in 2019. The company pursues several projects on resource conservation, recycling and CO_2 capture, which is why cement with a reduced clinker share is now in use at the "GÓRAŻDŻE CEMENT SPÓŁKA AKCYJNA" plant (HeidelbergCement AG 2020).
- At the "CEMENTOWNIA RUDNIKI CEMEX" plant owned by "Cemex Polska Sp. z o.o." a new kiln was put into operation in 2019 as part of the continuous improvement investment process of the company to optimize and modernize existing plants. This investment amounted to a total of 60 million USD (52 mln EUR) (CEMEX 2020).

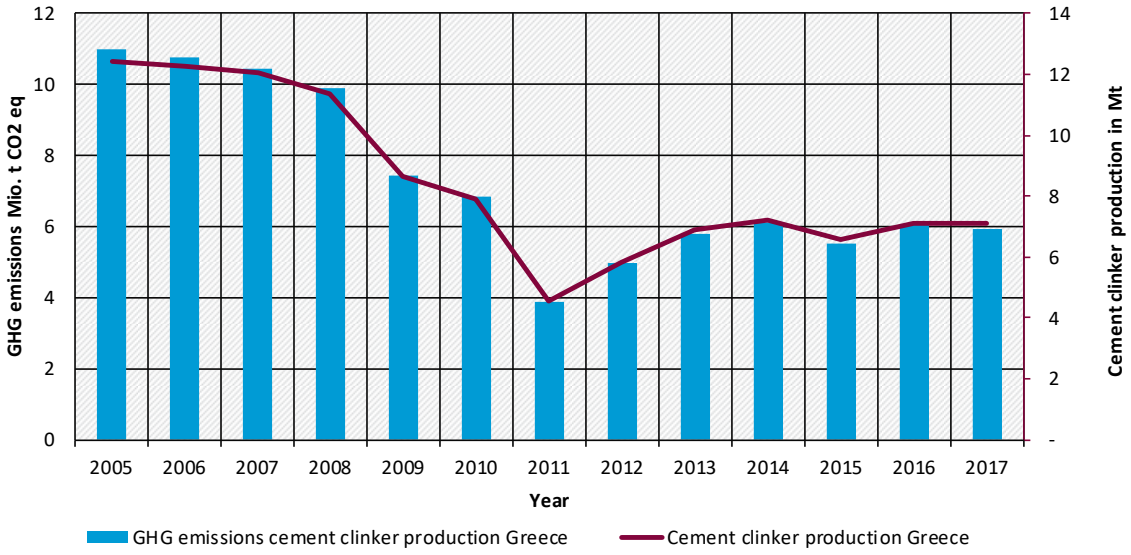
9 Greece

For Greece a shorter factsheet is provided due to limited data availability. Therefore, the tables and figures of the following sections are not as comprehensive as the information provided in the other factsheets.

9.1 Key messages

- GHG emissions from the cement clinker production in Greece amounted to roughly 6 million tonnes of CO_2eq in 2017. Since 2013 they increased by 2 %. In 2017, the cement clinker production accounts for roughly 10 % of total emissions from EU ETS installations in Greece.
- Greece contributes a share of 5 % to total emissions of cement clinker production in the EU28 in 2017.
- Cement clinker production in Greece shows an increase of 3 % between 2013 and 2017, in line with the increase in GHG emissions (see Figure 71). Cement clinker production of Greece accounts for 6 % of the total cement clinker production sector in the EU28 in 2017.
- The similar trend of GHG emissions and cement clinker production in Greece indicates that the emissions intensity per tonne of clinker did not change substantially. Emission intensity stayed constant at 0.84 t CO_2eq/t clinker between 2013 and 2017. The emission intensity is slightly higher than the EU28 average of 0.81 t CO_2eq/t clinker in 2017 (see Table 4).

Figure 71: Greece: Total GHG emissions from the cement clinker production



Evolution of total GHG emissions from the cement clinker production and evolution of cement clinker production between 2005 and 2017 in Greece.
Source: GCCA 2020, EEA 2019

- The production volume index for the construction industry, an important indicator of cement demand from the construction sector, shows a strong positive correlation to the cement clinker production in Greece (correlation coefficient: 0.86). Between 2005 and 2011 there is a strong decrease in both the cement clinker production as well as the production

volume index. However, since 2011, the cement clinker production is again increasing whilst the production volume index remains at a low level. Since a relevant share of total cement clinker production is exported, the production also depends on the construction activity of the export countries.

- Greece is a net-exporter of cement clinker. Export volumes compared to domestic clinker production are higher than in the other analysed countries and increased mainly in the years after the financial crisis of 2009. Imports of cement clinker to Greece are negligible.
- At the beginning of 2005, 8 cement clinker production plants were in operation. Until 2017, two plants ceased their operation, thus in 2017 6 cement clinker production plants were still in operation. Two facilities emitted over 1 million tonnes of CO_2eq, three facilities emitted between 500,000 and 1 million tonnes of CO_2eq and one facility had emissions below 500,000 tonnes of CO_2eq in 2019.

Table 17: Greece: Key figures on the cement clinker industry

Cement clinker industry characteristics	Unit	Year 2017	% change 2017 compared to 2013	Share of cement clinker production sector EU28 in 2017	Source
GHG emissions	Mt CO_2eq	5.9	2 %	5 %	EEA 2019
Clinker production	Mt	7.1	3 %	6 %	Greece 2019
GHG emission intensity	t CO_2eq/ t clinker	0.84	-1 %	103 %[87]	EEA 2019, Greece 2019
Number of cement clinker production plants	-	6	-25 %	3 %	EEA 2019
Cement clinker plants with highest emissions					
Plant name (Company)	**Emissions in 2019 [Mt CO_2eq]**		**% change 2019 compared to 2013**	**Share of emissions from cement clinker prod. in Greece in 2019**	**Source**
ΕΡΓΟΣΤΑΣΙΟ ΚΑΜΑΡΙΟΥ ΒΟΙΩΤΙΑΣ/Facility Kamari (Titan Cement SA)	1.50		-4 %	28.1 %	EEA 2019
ΕΡΓΟΣΤΑΣΙΟ ΒΟΛΟΥ/Facility Volos (Heracles General Cement SA)	1.25		-5 %	23.4 %	EEA 2019

[87] This value indicates that the emission intensity in Greece is 103 % of the EU28's emission intensity in 2017.

Cement clinker industry characteristics	Unit	Year 2017	% change 2017 compared to 2013	Share of cement clinker production sector EU28 in 2017	Source
ΕΡΓΟΣΤΑΣΙΟ ΜΥΛΑΚΙΟΥ/Facility Milaki (Heracles General Cement SA)	0.85		-16 %	15.9 %	EEA 2019

Key figures on the cement clinker production in Greece and on its largest cement clinker plants.
Source: Own table based on various sources.

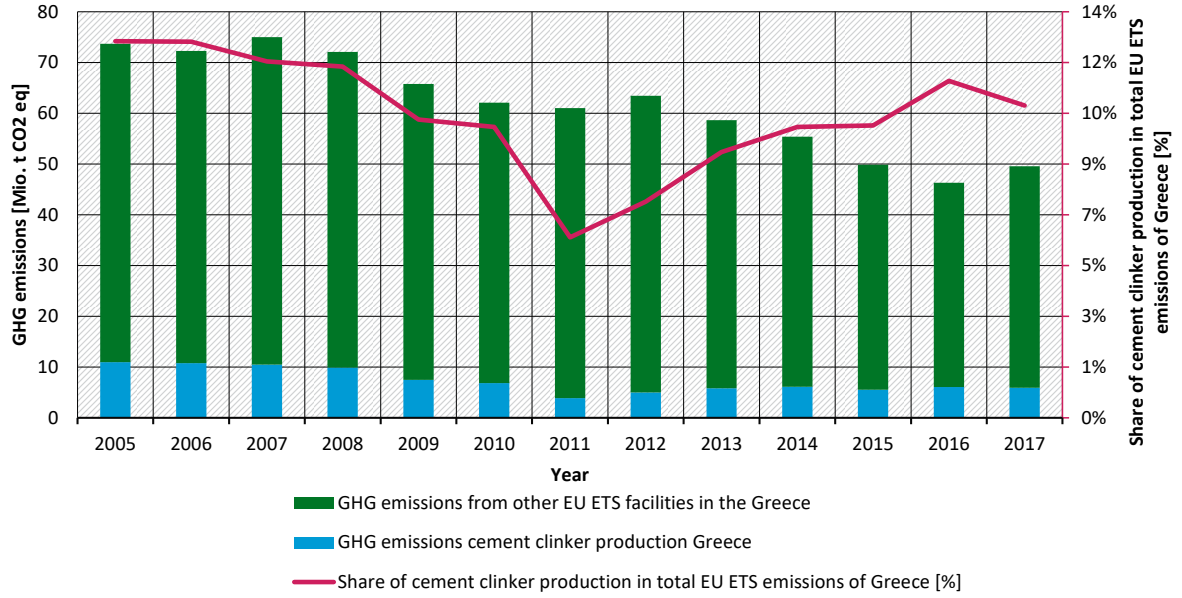
9.2 Evolution of GHG emissions

The following trends can be observed for the emissions from the EU ETS facilities in Greece:

- In 2005 the emissions of stationary facilities participating in the EU ETS in Greece[88] amount to 74 million tonnes of CO_2eq. In 2005, the cement clinker production contributes a share of about 13 % (i.e. 11 million tonnes of CO_2eq). This share decreases between 2005 and 2017 to 11 %, with a minimum share in 2011 of only 6 % (i.e. 4 million tonnes of CO_2eq). Emissions from cement clinker production have decreased more strongly (-46 %) than in other EU ETS facilities (-30 %) between 2005 and 2017. Total GHG missions from stationary facilities of the EU ETS decreased by 33 % during this time period (EEA 2019).
- The observed increase in emissions from cement clinker production between 2011 and 2017 is mainly due to the increase in domestic clinker production (fuel composition and energy intensity was not analysed for Greece).

[88] Total emissions from the EU-ETS facilities include verified emissions under the EU-ETS as well as an estimate of emissions for 2005-2012 reflecting the current scope of the EU-ETS.

Figure 72: Greece: Total GHG emissions from EU ETS facilities and share of emissions from cement clinker industry



Evolution of total GHG emissions from EU ETS facilities between 2005 and 2017 in Greece (left axis). The bars show the emissions from cement clinker production and other facilities of the EU ETS. The red line (right axis) indicates the relative share of GHG emissions from cement clinker production in total emissions from EU ETS facilities in Greece.
Source: EEA 2019, GCCA 2020, own calculations

- Total GHG emissions[89] in Greece amounted to about 136 million tonnes of CO_2eq in 2005 (Greece 2019). They decrease until 2017 to 95 million tonnes of CO_2eq. Emissions from EU ETS facilities accounted for 52 % of Greece's total GHG emissions in 2017 (EEA 2019).

9.3 Evolution of cement clinker production

Production of grey cement clinker

The production of cement clinker is the most important driver of emissions from cement production. It shows a strong decrease between 2005 and 2011 from around 12 million tonnes to around 4.5 million tonnes of cement clinker, which corresponds to a decrease of 63 %. In the same period, total GHG emissions of the cement clinker production decreased by almost the same share (-64 %) (see Figure 71) . Since 2011, cement clinker production is again increasing to a level of around 7 million tonnes in 2017, still substantially below the levels of 2005-2007 (GCCA 2020).

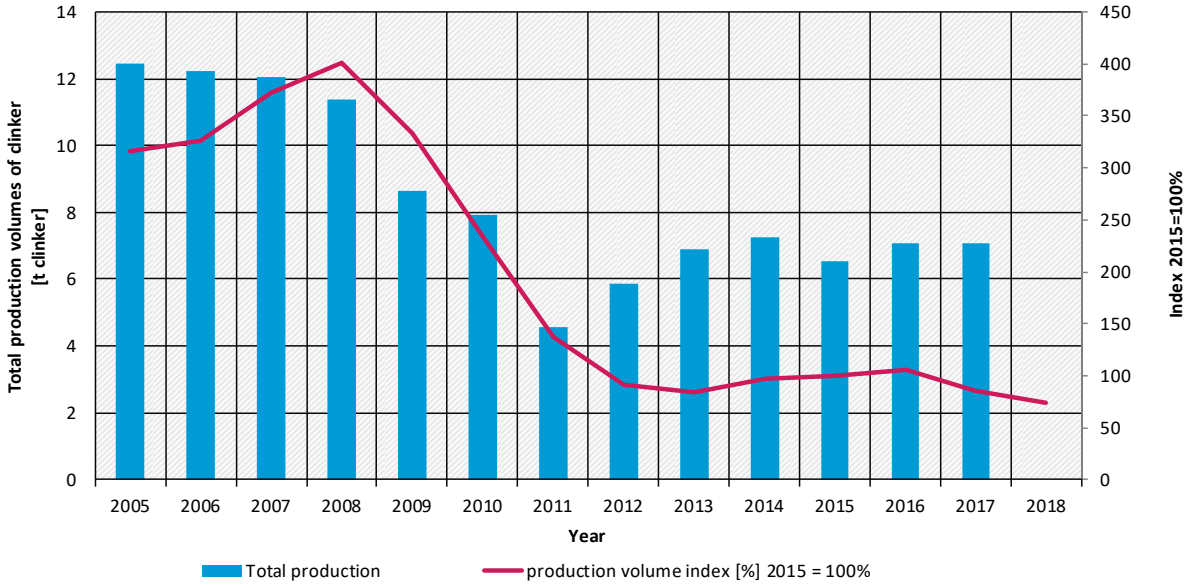
The production volume index for the construction industry relative to 2015 shows an increase between 2005 and 2008. There is a strong decline of more than 300 percentage points between 2008 and 2013 and a very slight increase between 2013 and 2016. The evolution of the production volume index shows a strong positive correlation to the cement clinker production (correlation coefficient: 0.86).

Since a large part of cement clinker produced in Greece is exported (23% of total sold production), the production does not only depend on the construction activity in Greece but also on the demand of cement clinker from other countries. Therefore, the correlation with the

[89] Total GHG emissions reported here exclude emissions from land use, land use change and forestry. Indirect GHG emissions are excluded as well.

production volume index decreases after 2012 due to increasing exports of clinker (see chapter 9.5).

Figure 73: Greece: Production of cement clinker and evolution of production volume index of the construction sector



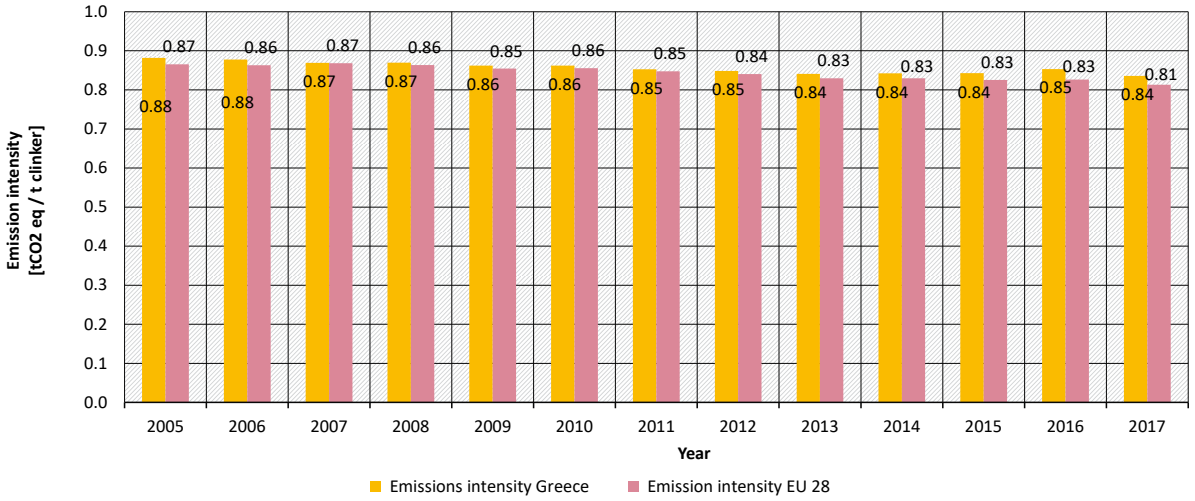
Evolution of total grey cement clinker production volume in Greece (2005-2017) estimated based on data reported by Greece (left axis). The red line (right axis) indicates the evolution of production volume index of the construction sector in Greece since 2005. 2015 corresponds to 100 %.
Source: Greece 2019, EUROSTAT 2020b (Calendar adjusted data, non-seasonally adjusted data)

9.4 Evolution of GHG emission intensity

Evolution of GHG emission intensity

The emission intensity per tonne of cement clinker is mainly affected by the fuel composition (i.e. share of fossil fuels vs. biomass fuels) and the efficiency of production technology applied. In 2017, emissions per tonne of clinker produced amount to about 0.84 t CO_2eq/t clinker in Greece, while the EU28 average is at around 0.81 t CO_2eq/t clinker. Emission intensity in Greece shows a decreasing trend between 2005 and 2014, from 0.88 t CO_2eq/t clinker in 2005 to 0.84 t CO_2eq/t clinker in 2014. This corresponds to a relative reduction of 5 % compared to 2005.

Figure 74: Greece and EU28: Emission intensity of clinker production



Evolution of GHG emission intensity of clinker production in Greece and EU28.
Source: GCCA 2020, GCCA 2020

9.5 Market evolution, imports and exports

Import and export of Portland cement

Import and export of cement products were analysed for Portland cement, which is the most widely used type of cement[90]. In Greece, substantial amounts are exported (i.e. after 2013 exports constitute more than 50 % of the sold production[91] of Portland cement). Imports of Portland cement are negligible (below 0.5 million tonnes during the entire time period).

Sold production of Portland cement shows a decline, especially between 2008 and 2012 from around 14 million tonnes to around 5 million tonnes. In 2016, a slight increase is observed to around 6 million tonnes (EUROSTAT 2020a).

Figure 75: Greece: Development of the Portland cement market

[90] Portland cement (CEM I, II) constitutes more than 75 % of total cement sold in Europe in 2015.

[91] Sold production corresponds to the value and volume of the product sold by the enterprise it differs from total production (the volume of all production of the product, including both the proportion that is sold and the proportion that is retained by the enterprise for adding to stocks, using in further processing etc.).

Evolution of import, export and sold production of Portland cement in Greece between 2005 and 2018.
Source: EUROSTAT 2020a

Import and export of cement clinker

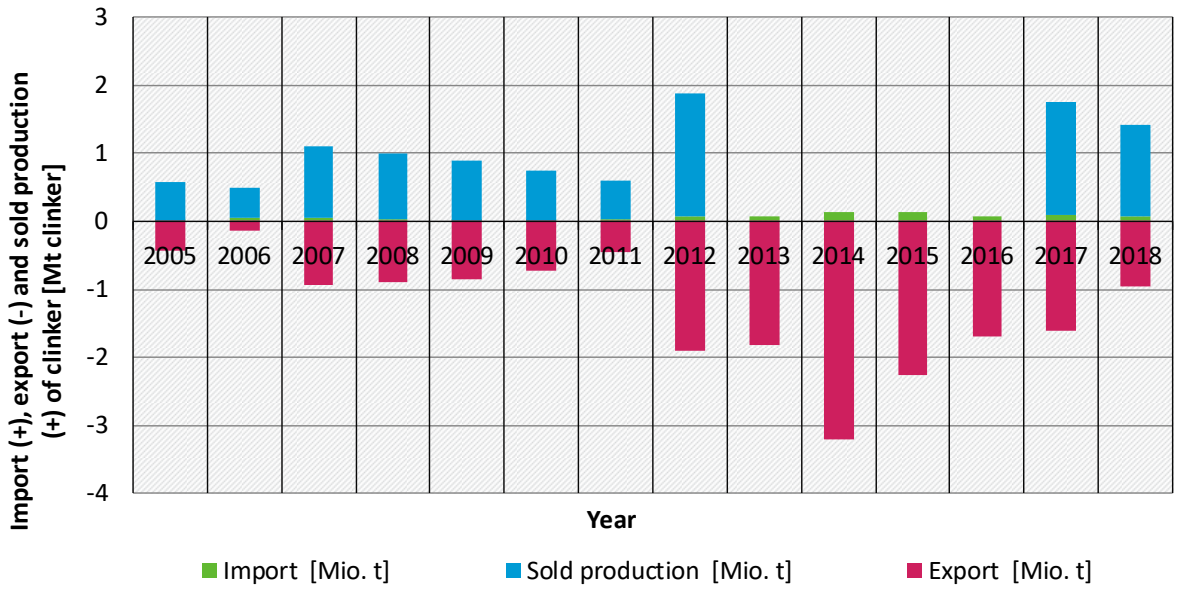
Greece is a net-exporter of cement clinker. Export volumes compared to domestic clinker production (see chapter 9.3) are higher than in the other analysed countries. Between 2012 and 2017, exports in absolute terms were second after Spain.

Sold production[92] of cement clinker fluctuates between less than one million tonne and around 2 tonnes of cement clinker. This indicates that most of the clinker produced is further processed to cement directly rather than sold on the market.

The amount of exported cement clinker increased since 2005 from below 1 million tonne to around 3 tonnes in 2014. Since then, the exports are decreasing and reach a level of around 1 million tonnes in 2018 (EUROSTAT 2020a). Export volumes account for 23 % of domestic clinker production (see chapter 9.3) in 2017 (EUROSTAT 2020a) and are much higher than in the other analysed countries.

The amount of imported cement clinker is negligible. It is below 0.2 million tonnes during the entire time period (EUROSTAT 2020a).

Figure 76: Greece: Development of the cement clinker market



Evolution of import, export and sold production of cement clinker in Greece between 2005 and 2018. For the years 2013-2016 no data on sold production are available. The blue bars only show the sold production of clinker, this does not include the cement clinker production that is directly processed to cement by the same company.
Source: EUROSTAT 2020a

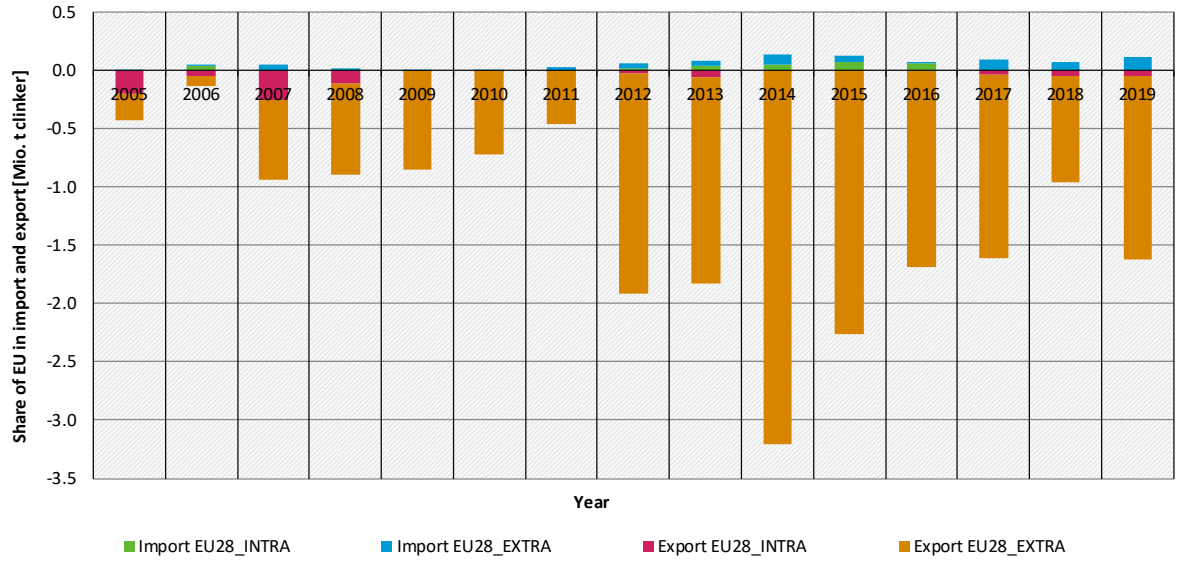
Import and export of cement clinker within the EU28 and outside the EU28

Greece exports cement clinker mainly to countries outside the EU28. Before 2009, small amounts of cement clinker were exported to countries within the EU28 (EUROSTAT 2020e).

Imports of cement clinker are negligible (EUROSTAT 2020e).

[92] Sold production is smaller than total clinker production, since the amount of clinker that is directly processed to cement by the same company is not accounted for in the sold production.

Figure 77: Greece: Import and export of cement clinker to and from other EU28 countries/countries outside the EU28



Evolution of Greece's import of cement clinker from other EU28 countries (Import EU28_INTRA) and from countries outside the EU28 (Import EU28_EXTRA) and evolution of Greece's export of clinker to other EU28 countries (Export EU28_INTRA) and to countries outside the EU28 (Export EU28_EXTRA).
Source: EUROSTAT 2020e

9.6 Regulative, economic and political framework

The following sections summarize the regulative, economic and political framework affecting the cement sector in Greece. This includes the use of waste as alternative fuels and state aid.

Use of waste fuels in the cement industry

In Greece, the amount of high-quality waste available to the cement sector is not sufficient and the waste processing industry is not well-developed. In addition, the economic situation of Greece does not allow for the necessary investments in waste industry.

Greece has a poor waste management system with 88 % of total waste being disposed of in landfills and only 11 % being recycled.

Greece has the lowest co-processing rate of the EU28. It is at an average level of 7 %, whilst the co-processing rate of the EU28 is in average at a level of 41 % (De Beer et al. 2017).

State Aid

In the State Aid Transparency database of the European commission only one instrument is listed for the cement sector (C.23.51 Production of cement) in Greece. It consists of "Tax advantage or tax exemption" in the amount of around 4.3 million EUR (EC 2020).

9.7 Facility data – the largest emitters and their location

GHG emissions and production capacity

In 2019, 6 cement clinker production plants were subject to the EU ETS in Greece. The following table provides an overview on GHG emission and cement production capacity of the three largest cement clinker facilities in terms of emissions in Greece.

Table 18: Greece: Emissions and production capacity of the three largest cement clinker plants in terms of emissions

ID	Installation	Company	City	Emissions (Mt CO_2eq)					Share of total verified emis-sions
				2005	2009	2010	2015	2019	2019
59	ΕΡΓΟΣΤΑΣΙΟ ΚΑΜΑΡΙΟΥ ΒΟΙΩΤΙΑΣ (Facility Kamari)	TITAN AE (Titan Cement)	ΚΑΜΑΡΙ ΒΟΙΩΤΙΑΣ	2.1	1.7	1.5	1.6	1.5	28.1%
49	ΕΡΓΟΣΤΑΣΙΟ ΒΟΛΟΥ (Facility Volos)	ΑΓΕΤ ΗΡΑΚΛΗΣ (Heracles General Cement)	ΒΟΛΟΣ	2.9	1.8	1.4	1.3	1.3	23.4%
52	ΕΡΓΟΣΤΑΣΙΟ ΜΥΛΑΚΙΟΥ (Facility Milaki)	ΑΓΕΤ ΗΡΑΚΛΗΣ (Heracles General Cement)	ΜΥΛΑΚΙ ΑΛΙΒΕΡΙΟΥ	1.4	1.0	1.2	0.9	0.9	15.9%

Emissions and production capacity of the largest cement clinker facilities in terms of emissions in Greece.
Source: EEA 2019.

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Appendix

A.1 Energy prices

The production of cement clinker has a high energy intensity. In 2017, the thermal energy consumption intensity per tonne of clinker in the EU28 was 3.7 GJ (GCCA 2020). For this reason, a look at the development of energy prices is helpful for understanding the trends in cement clinker production in the EU28.

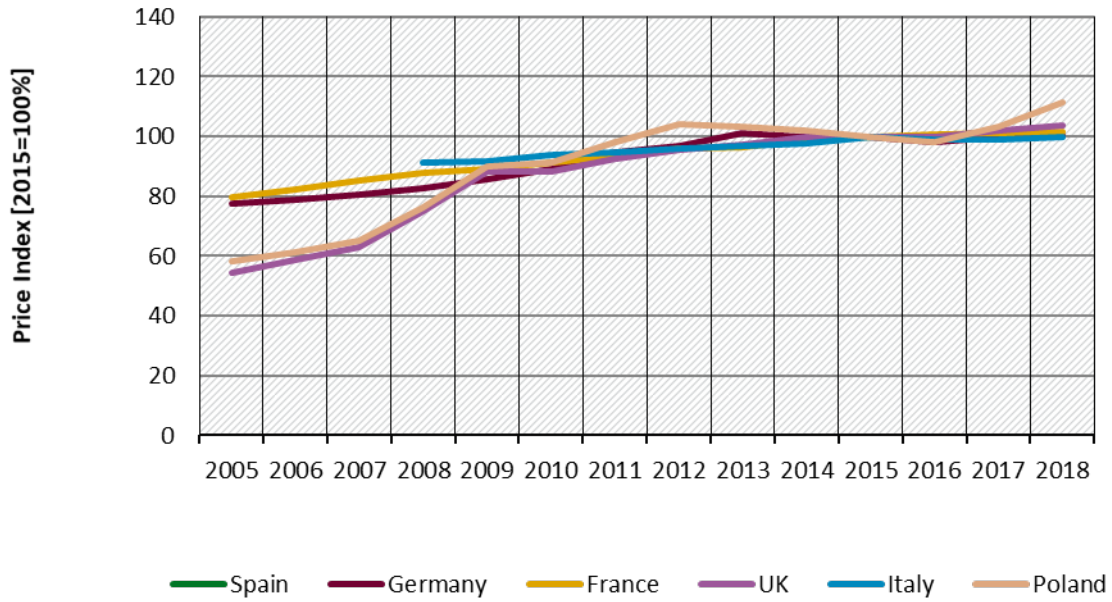
In 2012, the main energy carriers used in cement production of were coal (41%) and oil (30%), and to a lesser extent biofuels and waste (14%), natural gas (4%) and electricity (10%) (average for OECD countries, IEA 2015).

The following sections describe the evolution of energy prices for coal, oil products and natural gas in the countries analysed in the present report.

Coal

The retail price of coal, however, fluctuates much less than the one of oil products and natural gas. A general increasing trend can be observed between 2005 and 2018, which is more pronounced in the UK and Poland and rather constant for other countries. For Spain, no data was available for the retail price of coal in this time period and for Italy only since 2008 (IEA 2019).

Figure 78: Evolution of prices of coal across countries

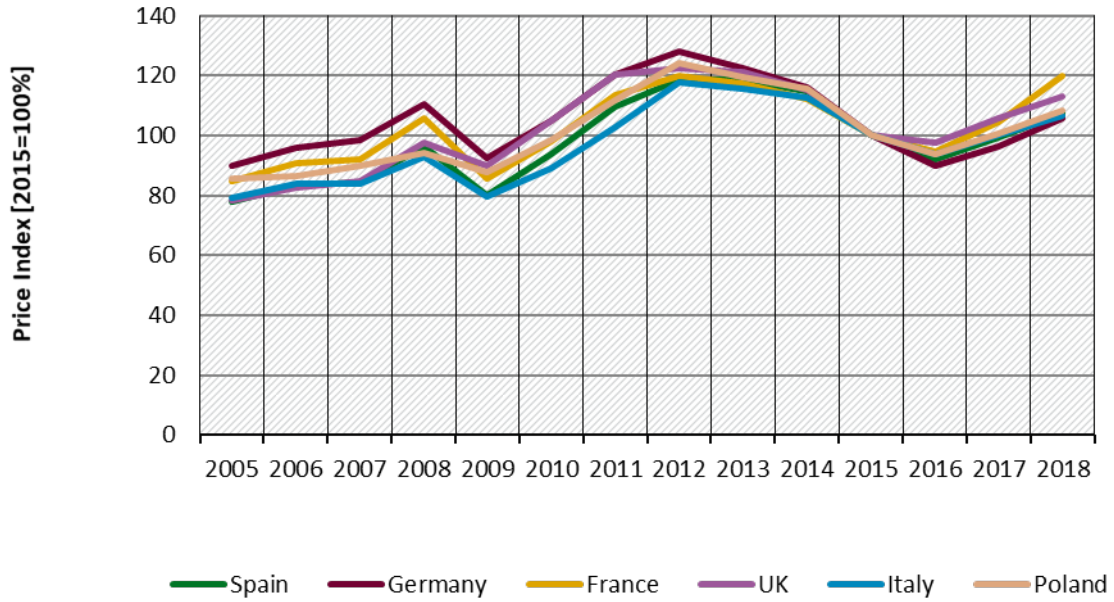


Evolution of indexed retail price of coal across countries. The prices are indexed, 2015 is 100 %.
Source: IEA 2019.

Oil products

The development of the retail price of oil products (i.e. liquid petroleum products from refining of crude oil) across the six countries analysed in the present report is very similar. The price increases from 2005 to 2008, but then drops in 2009, showing a clear and quick reaction to the financial crisis in all countries. Between 2009 and 2012, the price recovers and exceeds the level of 2005, before declining again in 2016. Since then, the retail price of oil products again shows an increasing tendency with the average price in 2018 being slightly higher than in 2005 (IEA 2019).

Figure 79: Evolution of prices of oil products across countries

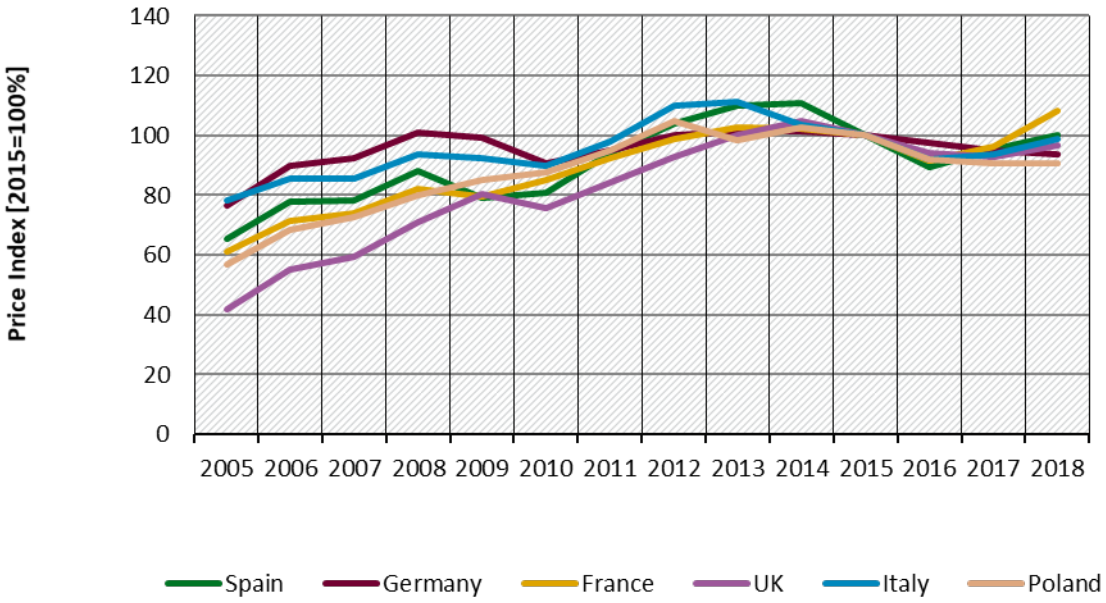


Evolution of indexed retail price of oil products across countries. The prices are indexed, 2015 is 100 %.
Source: IEA 2019.

Natural gas

The trend for the retail price of natural gas is similar to the one of oil products but the drops in 2009/2010 and 2016 are less pronounced. The development is again very similar across all six countries, especially since 2015 (IEA 2019).

Figure 80: Evolution of prices of natural gas across countries



Evolution of indexed retail price natural gas across countries. The prices are indexed, 2015 is 100 %.
Source: IEA 2019.

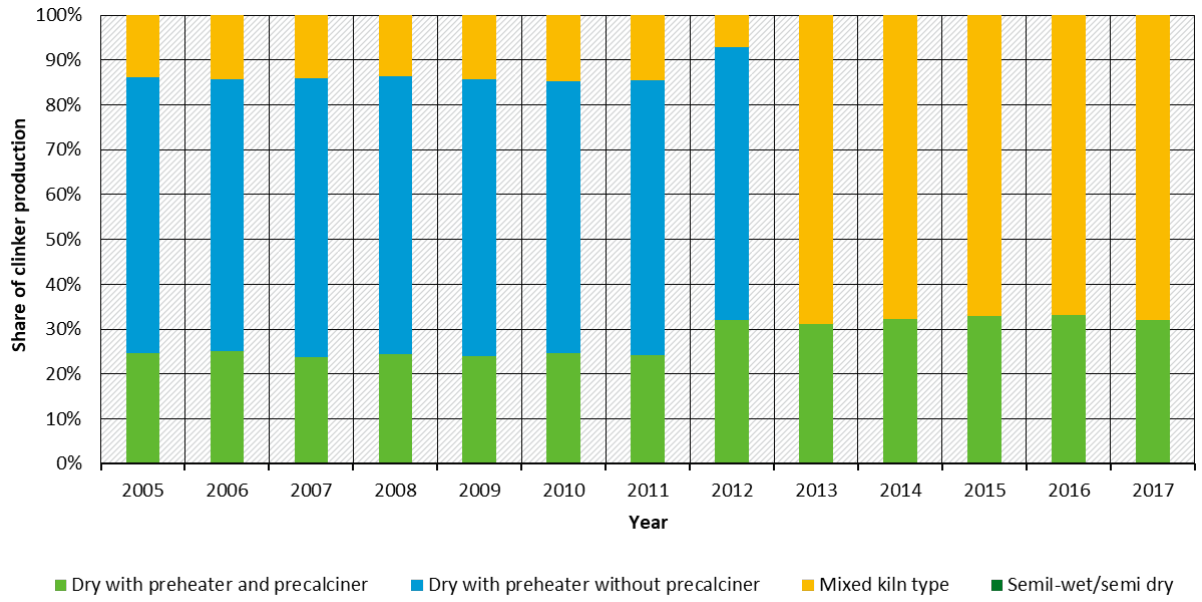
A.2 Evolution of cement clinker production technology

Germany

In Germany, clinker is produced mostly in dry kilns or dry kilns with preheater until 2012. After 2012 the largest share is mixed kiln type and the rest dry with preheater and precalciner (GCCA 2020). We suspect that changes in technology over short time periods (e.g. 2012-2013) are due to errors in the data source and do not reflect the actual development.

The wet kiln technology, which has the highest emission intensity, does not occur in Germany (GCCA 2020).

Figure 81: Share of cement clinker production by kiln type in Germany

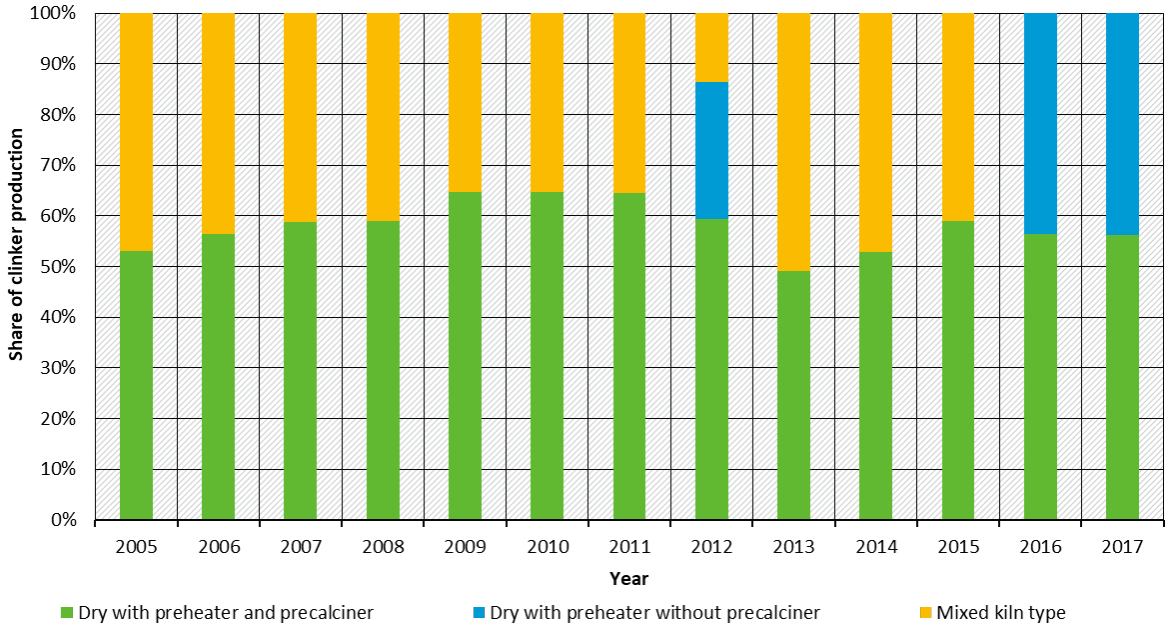


Evolution of the kiln technology applied in the cement clinker production in Germany. The technologies are listed in increasing order of emission intensity, given that the installation is operated under optimal conditions (lowest emission intensity: "dry with preheater and precalciner", highest emission intensity: "semi-wet/semi dry").
Source: GCCA 2020

Spain

In Spain, cement clinker is produced mostly in dry kilns with preheater and precalciner and in mixed kilns. The share of cement clinker production from kilns with preheater and precalciner is increasing between 2005 (50 %) and 2011 (60 %) and shows a decreasing tendency since then. In 2017, the share is at about 55 %. Mixed kilns show a decreasing share in cement clinker production since 2005. It decreased from 50 % in 2005 to 0 % in 2016 (GCCA 2020). We suspect that changes in technology over short time periods (e.g. 2011-2012, 2015-2016) are due to errors in the data source and do not reflect the actual development. Other technologies (dry without preheater, semi-wet/semi-dry and wet kilns) do not occur in Spain (GCCA 2020).

Figure 82: Share of cement clinker production by kiln type in Spain



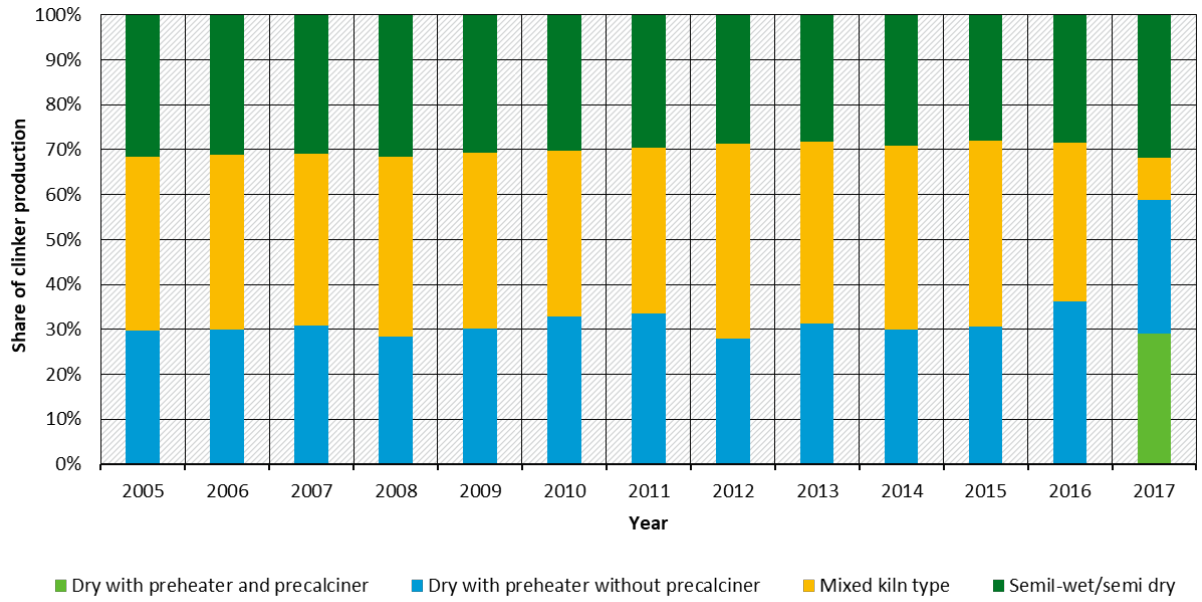
Evolution of the kiln technology applied in the cement clinker production in Spain. The technologies are listed in increasing order of emission intensity, given that the installation is operated under optimal conditions (lowest emission intensity: "dry with preheater and precalciner", highest emission intensity: "mixed kiln type").
Source: GCCA 2020

France

In France, clinker is produced mostly in dry with preheater, mixed kiln type and semi-wet/semi dry. The mix of clinker production is constant between 2005 and 2016. In 2017, the share of mixed kilns is much smaller (about 10 %) and dry with preheater and precalciner accounts for 30 % (GCCA 2020). We suspect that changes in technology over short time periods (e.g. 2017) are due to errors in the data source and do not reflect the actual development.

Other technologies (dry without preheater and wet kilns) do not occur in France (GCCA 2020).

Figure 83: Share of cement clinker production by kiln type in France



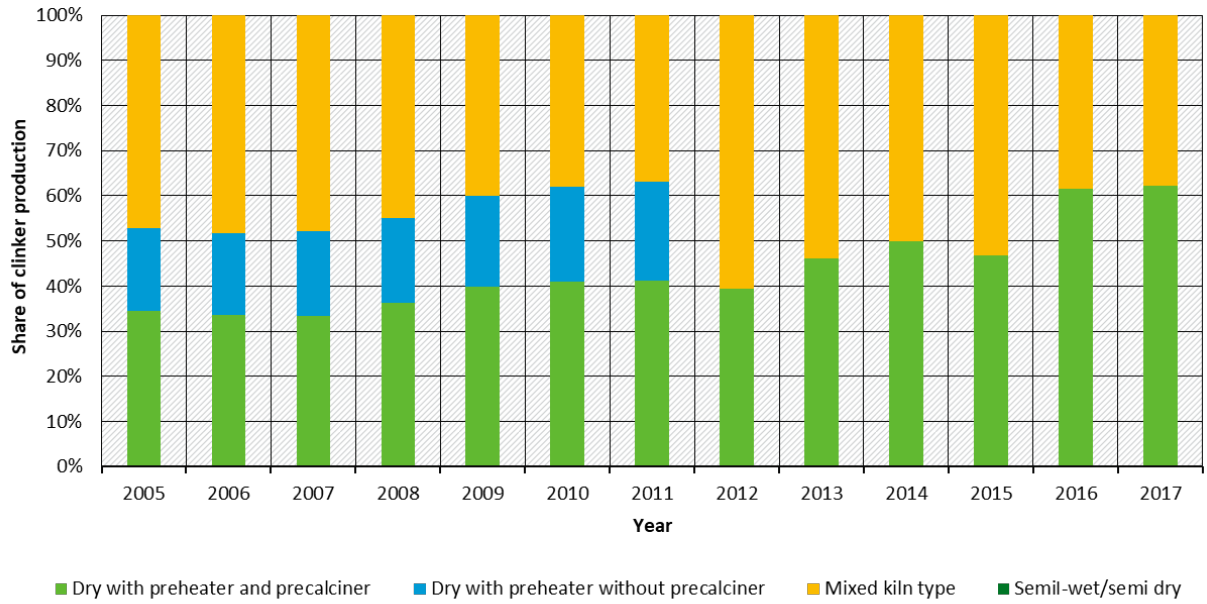
Evolution of the kiln technology applied in the cement clinker production in France. The technologies are listed in increasing order of emission intensity, given that the installation is operated under optimal conditions (lowest emission intensity: "dry with preheater and precalciner", highest emission intensity: "semi-wet/semi dry").
Source: GCCA 2020

United Kingdom

In the UK, clinker is produced mostly in dry kilns with preheater and precalciner and in mixed kilns. The share of clinker production from kilns with preheater and precalciner is increasing between 2005 (35 %) and 2017 (60 %). Mixed kilns and dry kilns with preheater without precalciner show a decreasing share in clinker production since 2005. It decreased from more than 75 % in 2005 to 40 % in 2017 (GCCA 2020).

Other technologies (semi-wet/semi-dry and wet kilns) do not occur in the UK.

Figure 84: Share of cement clinker production by kiln type in the UK

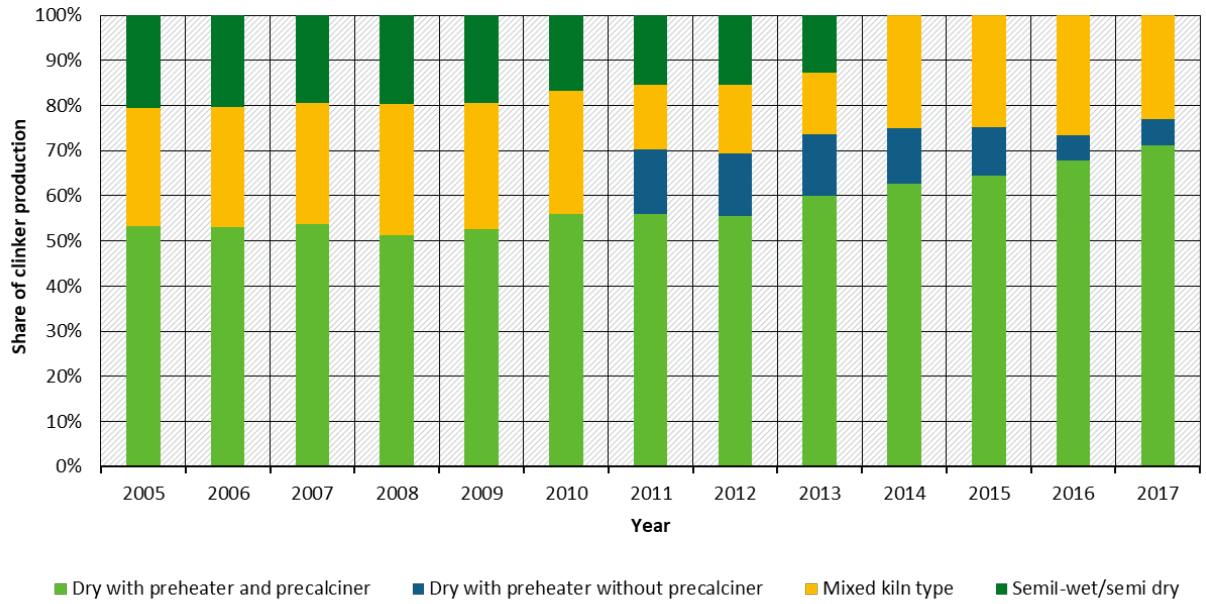


Evolution of the kiln technology applied in the cement clinker production in the UK. The technologies are listed in increasing order of emission intensity, given that the installation is operated under optimal conditions (lowest emission intensity: "dry with preheater and precalciner", highest emission intensity: "semi-wet/semi dry").
Source: GCCA 2020

Italy

In Italy, clinker is produced mostly in dry kilns with preheater and precalciner. Between 2005 and 2010 about 25 % are produced in mixed kilns. The share of clinker production from kilns with preheater and precalciner is increasing between 2005 (50 %) and 2017 (70 %) (GCCA 2020). We suspect that abrupt changes in technology over short time periods (e.g. 2011) are due to errors in the data source and do not reflect the actual development. Other technologies (dry without preheater and wet kilns) do not occur in Italy (GCCA 2020).

Figure 85: Share of cement clinker production by kiln type in Italy

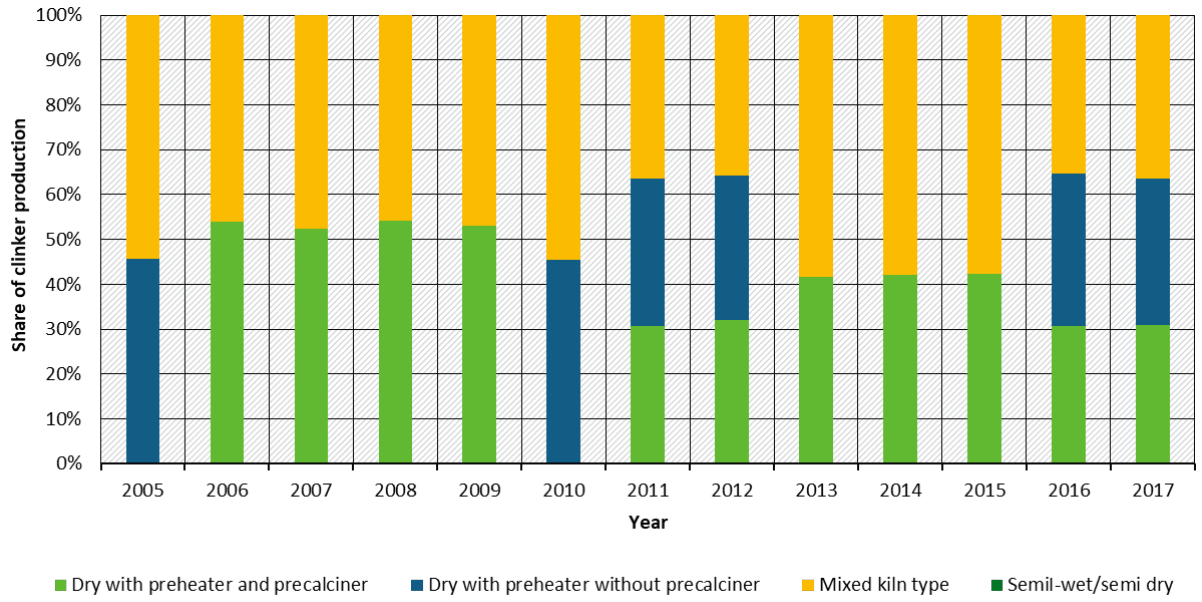


Evolution of the kiln technology applied in the cement clinker production in Italy. The technologies are listed in increasing order of emission intensity, given that the installation is operated under optimal conditions (lowest emission intensity: "dry with preheater and precalciner", highest emission intensity: "semi-wet/semi dry").
Source: GCCA 2020

Poland

In Poland, clinker is produced in equal shares in mixed kilns, in dry kilns with preheater and precalciner as well as without precalciner in 2017. The share of clinker production from kilns with preheater and precalciner is decreasing between 2006 (55 %) and 2017 (30 %). Mixed kilns also show a decreasing share in clinker production since 2005. It decreased from almost 60 % in 2005 to roughly 30 % in 2017 (GCCA 2020). We suspect that abrupt changes in technology over short time periods (e.g. 2005-2006, 2009-2013, 2015-2016) are due to errors in the data source and do not reflect the actual development. Other technologies (dry without preheater, semi-wet/semi-dry and wet kilns) do not occur in Poland (GCCA 2020).

Figure 86: Share of cement clinker production by kiln type in Poland



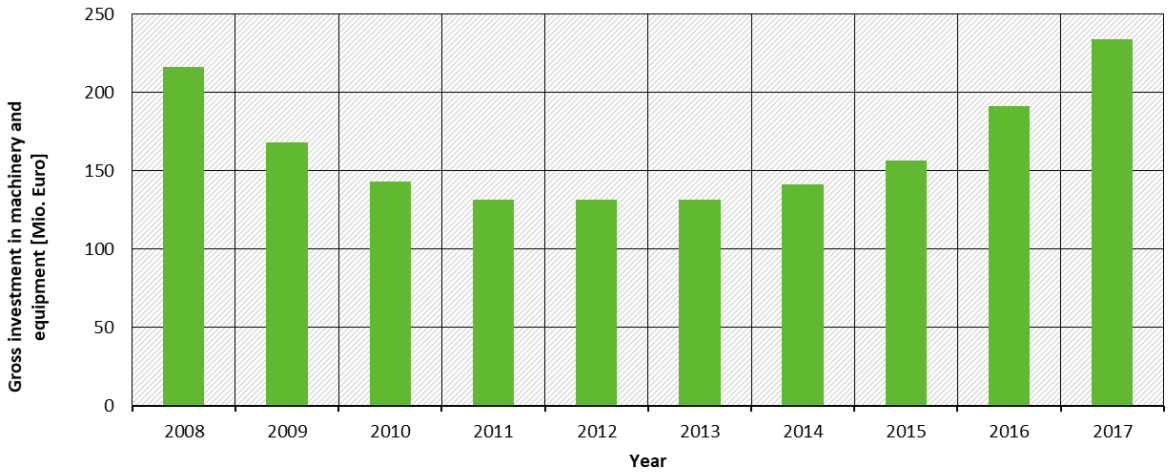
Evolution of the kiln technology applied in the cement clinker production in Poland. The technologies are listed in increasing order of emission intensity, given that the installation is operated under optimal conditions (lowest emission intensity: "dry with preheater and precalciner", highest emission intensity: "semi-wet/semi dry").
Source: GCCA 2020

A.3 Evolution of investments

Germany

According to structural business statistics of EUROSTAT, gross investments in machinery and equipment in the cement sector in Germany decreased between 2008 and 2012 from 220 million EUR to 130 million EUR due to the financial crisis in 2008/2009. After 2013, the investment increased to 240 million EUR (EUROSTAT 2020d).

Figure 87: Evolution of gross investments in machinery and equipment in the cement sector in Germany

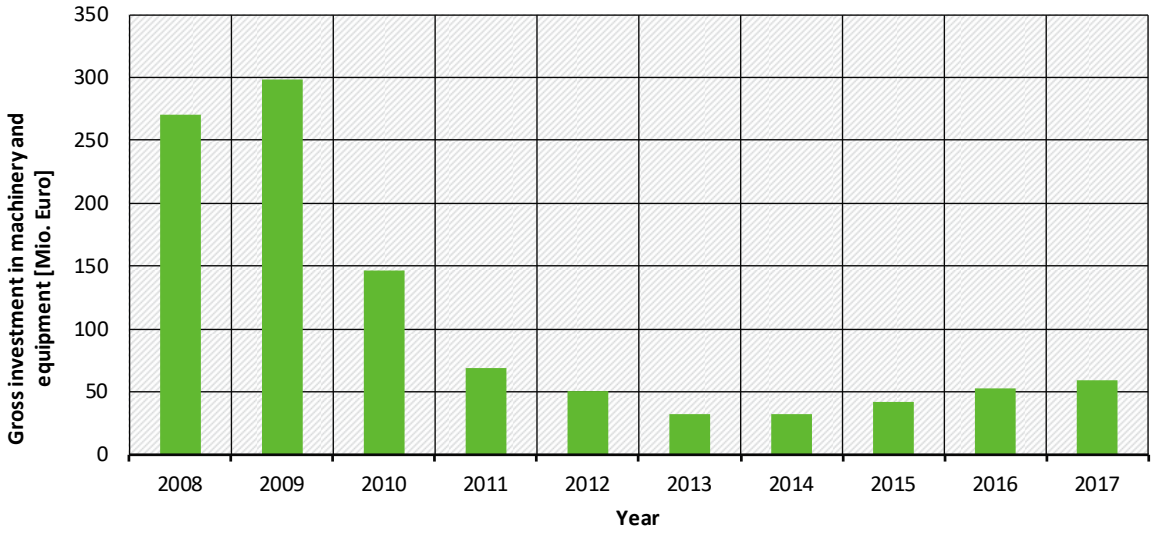


Evolution of gross investments in machinery and equipment in the cement sector.
Source: EUROSTAT 2020d.

Spain

According to structural business statistics of EUROSTAT, gross investments in machinery and equipment in the cement sector in Spain increased between 2008 and 2009 from 270 million EUR to 300 million EUR. Between 2009 and 2013 a sharp drop occurred due to the financial crisis in 2008/2009. In 2013, annual gross investments reached a level of about 30 million EUR. Since then, an increase is observed to about 60 million EUR in 2017 (EUROSTAT 2020d).

Figure 88: Evolution of gross investments in machinery and equipment in the cement sector in Spain



Evolution of gross investments in machinery and equipment in the cement sector.
Source: EUROSTAT 2020d.

France

In structural business statistics of EUROSTAT, there are no specific data for France (EUROSTAT 2020d).

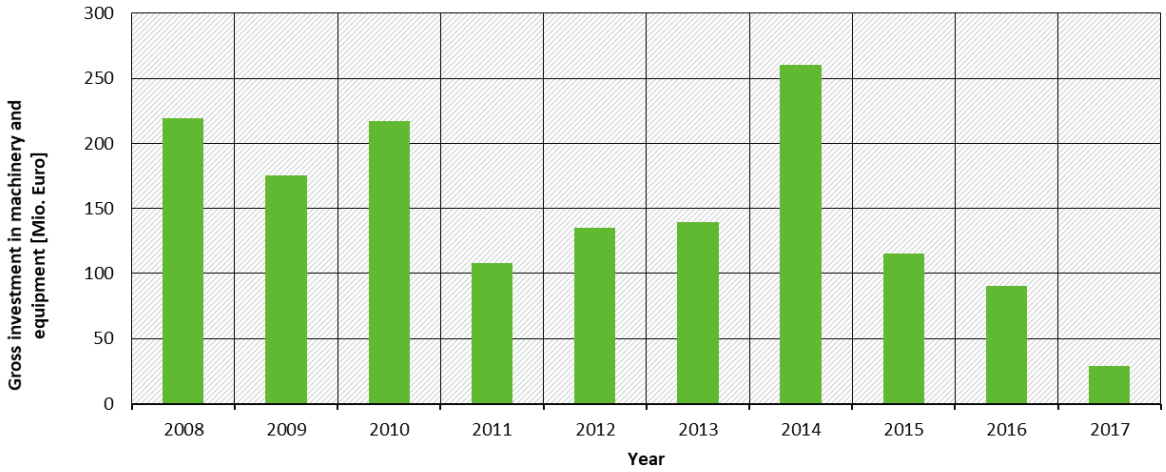
United Kingdom

In the structural business statistics of EUROSTAT, gross investments in machinery and equipment in the cement sector in the UK has only one value for 2009. In this year the gross investment was about 20 million EUR. So, no trends can be observed (EUROSTAT 2020d).

Italy

According to structural business statistics of EUROSTAT, gross investments in machinery and equipment in the cement sector in Italy shows no clear trend but they sharply dropped between 2014 and 2017 (EUROSTAT 2020d).

Figure 89: Evolution of gross investments in machinery and equipment in the cement sector in Italy

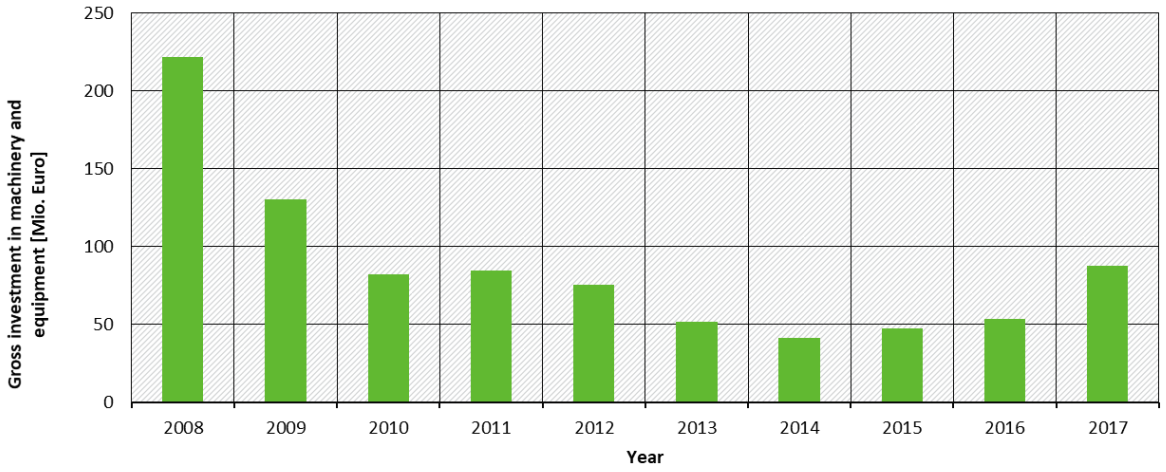


Evolution of gross investments in machinery and equipment in the cement sector.
Source: EUROSTAT 2020d.

Poland

According to structural business statistics of EUROSTAT, gross investments in machinery and equipment in the cement sector in Poland decreases between 2008 and 2014 from 220 million EUR to 40 million EUR due to the financial crisis in 2008/2009. Since then a slight increasing trend can be observed (EUROSTAT 2020d).

Figure 90: Evolution of gross investments in machinery and equipment in the cement sector in Poland

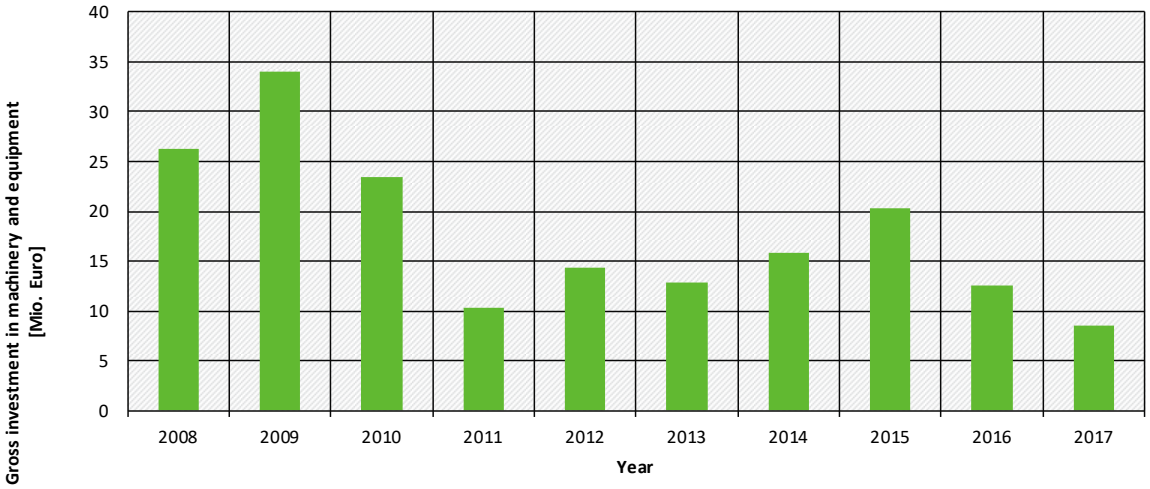


Evolution of gross investments in machinery and equipment in the cement sector.
Source: EUROSTAT 2020d.

Greece

According to structural business statistics of EUROSTAT, gross investments in machinery and equipment in the cement sector in Greece decreased between 2009 and 2011 from 35 million EUR to 10 million EUR due to the financial crisis in 2008/2009. Since then a slight increasing trend is observed until 2015, with investments reaching a level of around 20 million EUR in 2015. Since then, there is again a decreasing trend with investments reaching a level of less than 10 million EUR in 2017 (EUROSTAT 2020d).

Figure 91: Evolution of gross investments in machinery and equipment in the cement sector in Greece



Evolution of gross investments in machinery and equipment in the cement sector.
Source: EUROSTAT 2020d.