Concrete solutions for decarbonising the EU's cement sector

Briefing, October 2022

Cement production is one of the largest and most carbon-intensive sectors in the European Union. The industry emits 114 megatonnes of carbon dioxide each year. To ensure the EU achieves climate neutrality well before 2050, it is necessary to drastically reduce emissions in the cement sector.

The EU's Emissions Trading System (EU ETS) is the key instrument for incentivising emissions reduction in energy-intensive sectors, such as cement, but it has been underperforming compared with its potential.

The ongoing revision of the system is a crucial opportunity to strengthen the EU ETS and correct the flaws that have resulted in stagnating emissions and huge windfall profits in the cement sector over the past 10 years.

This will require updating the current benchmarks to ensure they encourage the uptake of cleaner technologies and the circular use of this material, as well as implementing the proposed Carbon Border Adjustment Mechanism in such a way that triggers more investments in emissions reductions. It will also require raising and channelling more revenues to fund innovation to support the sector in its green transition.

The scale of the problem

Cement is one of the most manufactured materials in the world. In Europe, cement is primarily used in the construction of buildings (50%), infrastructures (30%) and for various forms of maintenance and repair work across these two categories (20%).

Cement is used in construction to bind other materials together. It is mixed with sand, gravel and water to produce concrete. The industry standard and most common type of cement is called Portland, which is used in 98% of concrete globally.

The production of clinker, which acts as the binder, is a crucial step in making Portland cement. Limestone ($CaCO_3$) is "calcinated" at high temperatures in a cement kiln to produce lime (CaO), leading to the release of waste CO_2.

While there are energy-derived emissions from cement kilns, which reach internal temperatures of 1,450°C, the majority of CO_2 emissions from cement manufacturing result from the production of clinker.

In 2020, greenhouse gas emissions caused by the chemical reaction in the production of cement in the EU were about 114 million tonnes (Mt), which is roughly 2.5% of all EU emissions.

Table 1 - Top 10 most polluting cement plants in the EU

Cement Company	Plant Name	Verified Emissions 2019	Free Allowances Allocated 2019	Verified Emissions 2020	Free Allowances Allocated 2020	Country
Górażdże Cement Spółka Akcyjna	Górażdże Cement Spółka Akcyjna	2,669,377	1,921,969	2,711,325	1,882,336	Poland
Aalborg Portland A/S	Aalborg Portland A/S	2,189,152	1,836,497	2,339,867	1,793,211	Denmark
Cement Ożarów S.A.	Zakład Cementownia Ożarów	2,037,498	1,457,384	1,988,623	1,427,331	Poland
Cementownia Warta S.A.	Cementownia Warta S.A.	1,547,097	933,603	1,565,693	914,351	Poland
Cementa AB	Slitefabriken	1,548,979	1,183,746	1,467,600	1,159,166	Sweden
Titan AE	Εργοστασιο Καμαριου Βοιωτια	1,504,016	1,467,044	1,334,570	1,436,792	Greece
CEMEX Zement GmbH	Zementwerk Rüdersdorf	1,208,758	1,230,801	1,259,977	1,205,421	Germany
Compagnie Des Ciments Belges, C.C.B	CCB Cimenterie Gaurain	1,375,955	1,120,679	1,196,193	1,097,540	Belgium
Lafarge Cement Spółka Akcyjna	Lafarge Cement S.A. Oddział w Bielawach	1,203,503	805,036	1,147,102	788,436	Poland
CIMPOR – Indústria de Cimentos, S.A.	Cimpor - Centro de Produção de Alhandra	911,858	1,390,953	1,142,676	1,362,270	Portugal

Bad chemistry

Two-fifths (40%) of emissions in the cement sector come from burning fossil fuels to heat clinker kilns to the high temperatures (over 1,400 degrees) needed for the calcination process. The other 60% of the emissions are process emissions arising from the chemical reaction in the production of clinker.

In the EU, cement consists of 74% clinker which accounts for 95% of cement emissions. However, according to the Getting the Numbers Right (GNR) project, clinker to cementitious ratio rose to reach 75.1% in 2019 after a low of 72.7% reached in 2012 (see annex I).

When taking into account the emissions from fossil fuels and from the chemical reaction, clinker production results in 0.811 tonnes of CO_2 for every tonne of clinker (see annex II).

Considering only the emissions from the chemical reaction (60% of the total), producing clinker emits 0.54 tonnes of CO_2 for every tonne of clinker. These emissions are challenging to address: since this CO_2 is released by a chemical reaction, it cannot be eliminated by changing fuel or increasing efficiency.

Therefore, cement emissions depend largely on the proportion of clinker used in each tonne of cement. The type of fuel and the efficiency of equipment used during clinker production also have an impact.

The EU cement industry has reduced its emissions by 15% in the past three decades, 12% of which occurred between 1990 and 1999. Such reductions have been achieved through the implementation of some well-established mitigation measures, mainly through enhancing energy efficiency and switching fuels. Although the potential of these traditional mitigation measures has, at this point, largely been exhausted, yet the EU cement industry has a long way to go to achieve carbon-neutrality by 2050. This is partly reflected in how the bulk of the sector's emissions reductions occurred in the 1990s.

Cementing over the policy cracks

Greenhouse gas emissions in the cement sector are regulated by the EU's Emissions Trading System. The EU ETS utilises the 'cap and trade' principle, with a ceiling set on the total amount of allowable GHG emissions. This cap is divided into millions of tradeable individual emissions allowances, many of which are granted to installations for free. Installations must hand over enough allowances to cover their emissions. If an installation reduces its emissions, it can make use of its spare allowances to cover its future needs or sell them to another installation that needs them.

Despite its aim, the EU ETS has not been successful in triggering emissions reductions in the cement sector, especially in the last ten years. Cement CO_2 emissions per ton of material have remained stable since 2012 and with traditional mitigation measures they are not projected to decrease.

The key reasons for this are the numerous flaws and loopholes in the EU ETS legislation.

1. Free pollution permits

The cement sector has been receiving free pollution permits under the EU ETS since the system was launched. Between 2008 and 2019, the sector received 1.5 billion allowances for free, which is more than those it needed to cover its emissions (about 120%).

These freebies are meant to counteract the risk of carbon leakage, which is the hypothetical situation in which European companies competing at international level would shift their production and/or investments (and pollution) to countries with less stringent or no climate policies. By granting industries free allowances, legislators hope to keep them operating in the EU until they switch to clean production methods.

However, this practice has shielded industries from having to pay for their pollution, undermining the effectiveness of carbon pricing in creating financial incentives to reduce emissions. Evidence from the European Court of Auditors report (2020) has shown that these free pollution permits tend to slow down industrial decarbonisation.

Moreover, free pollution permits have often led to large profits for the companies receiving them. The cement sector in the EU made €3 billion in additional profits from overallocation of free allowances in the decade between 2008 and 2019, our research reveals.

This clearly shows that the problem of pollution remains unaddressed. While some adjustments in energy efficiency and fuel

switching have been made, the EU cement industry has, on the whole, failed to address the core of its emissions, those caused by clinker production. Moreover, those cement producers that have invested in cleaner techniques are being undermined by a system that continues to subsidise large, polluting incumbents.

2. Benchmarks

Carbon intensity benchmarks are used to determine the level of free allocation that each installation receives under the EU ETS. They are expressed as the greenhouse gases emitted per tonne of product produced and represent the average performance of the 10% best installations covered by the EU ETS.

If a sector is considered at risk of carbon leakage, individual installations receive 100% free emission allowances based on the relative benchmark. According to the EU ETS Directive, cement is considered at risk of carbon leakage. Therefore, every installation in the sector receives free allocation up to the benchmark level.[1] Those cement plants that are less emission intensive than the benchmark receive more allowances than they need, while those emitting more receive free allowances to cover their emissions up to the benchmark and must purchase additional allowances to cover the rest.

The ETS benchmarks are not static. They are designed to decrease over time to take into account technological developments, investments and best practices that reduce the emission intensity of the products.

However, the pace at which benchmarks improve is extremely slow and does not reflect the actual efficiency gains and improvements that happen in reality.The minimum improvement rate of benchmarks is 0.2% a year and the maximum is 1.6%.

This system provides little incentive for industrial sectors to reduce their emissions.

Table 2 - Overview of benchmarks related to cement production

Benchmark	*BM Value (2013 - 2020) tCO2e/t*	*Annual improvement rate*	*Total improvement rate (over 15 years)*	*BM value for 2021-2025 tCO2e/t*	*(Attributed) GHG emissions covered by benchmark in 2016/2017*	*No. of installations using the the benchmark for free allocation*
Grey cement clinker	*0.766*	*0.63%*	*9.5%*	*0.69*	*105,321,006*	*191*
White cement clinker	*0.98*	*0.2%*	*3%*	*0.96*	*2,646,157*	*12*
Lime	*0.95*	*1.6%*	*24%*	*0.72*	*21,751,588*	*171*

The pace at which benchmarks are improved is too slow to provide a meaningful incentive to cement producers to invest in cleaner production processes. Moreover, the generous overallocation of free pollution permits has put trailblazing cleaner competitors at a sharp disadvantage compared to incumbent manufacturers.

Concrete policy solutions

Better benchmarks

The ongoing revision of the EU ETS represents a golden opportunity to correct the current flaws of this legislation and strengthen its efficacy. Yet, the European Commission's proposal for the revision of the EU ETS fails to promote ambitious solutions. It includes a higher maximum annual reduction rate of the benchmarks, from 1.6% to 2.5%, but keeps the minimum annual reduction rate at 0.2%. In its agreed position, the European Parliament partially addresses this by increasing the minimum annual reduction rate to 0.4% for all ETS sectors, including cement. The EU Environment Council instead backed the European Commission proposal and did not touch the benchmarks improvement rates. The trialogue negotiations will tackle this important element of the revision.

In this scenario, the most polluting phase of clinker production would continue benefiting from an improvement rate that is much too slow to encourage the decarbonisation of the sector. Moreover, as shown in the impact assessment (page 87, annex IV)

1 In Phase 3 (2013-2020), this was multiplied for their 'historic activity level'. This means that installations that reduced production did not see a corresponding drop in their free allocation, leading to some perverse incentives to reduce production while still profiting from free pollution permits. In Phase 4 (2021-2030), this is partially being corrected by bringing free allocations closer in line with real production levels.

accompanying the ETS proposal, the potential for emissions reductions in the cement sector is much higher than 0.2% a year.

As new techniques to reduce cement emissions are being developed and some of the greatest potential resides in using fewer raw materials in the production process, cement production is estimated to have a potential for at least a minimum yearly improvement rate of 1%. The minimum annual reduction rate of the benchmarks should, therefore, be set at 1%.

In addition to this change, a more in-depth revision of the ETS benchmarks is needed. This should incentivise the uptake of cleaner technologies and account for the full potential of product substitution and the circular use of materials. The main potentials identified up to 2030 are linked to the use of low carbon cement (using less limestone and therefore reducing process emissions) and to the reduction of the clinker-to-cement ratio.

Cascade effect

In the case of cement, the benchmark revision should, therefore, take into account the potential for lowering the clinker content in cement production as well as substituting cement with alternative materials. This would trigger a cascade effect that would result in overall lower emissions throughout the sector's value chain. A study by ETH Zurich points to the following targets to be achieved at each stage of the value chain for the most effective results in lowering emissions:

1. For cement producers: a clinker with less than 0.7 t CO_2/t clinker
2. For concrete producers: a standard concrete containing less than 3.5 kg clinker/m^3/megapascal
3. For structural engineers: a structure containing less than 250 kg CO_2/m^2 of building
4. For construction companies: a building containing less than 500 kg CO_2/m^2

To effect change in this sector, such a revision should include the definitions and system boundaries of product benchmarks to take these features into account. This would be best achieved by moving away from the clinker benchmark and setting a broader one for cement.

A better targeting of free allowances is also possible through a tiered approach that ranks sectors according to exposure to carbon leakage risk as defined in the ETS Directive. Cement has a high carbon intensity but a low trade intensity,[2] which clearly indicates that the free emission allowances to the sector can be phased out even more rapidly than in other sectors. This would increase auctioning revenues for member states and create more incentives for industries to invest in decarbonisation. This option should be considered in parallel to the strengthened product benchmarks discussed above. A truly targeted approach would be the application of tiering of free allocation in addition to the proposed revision of the ETS benchmarks. The combination of the two would ensure that free allowances are allocated in a much more limited way to high-emitting sectors, and that new processes and technologies are properly accounted for to incentivise cleaner production and deeper emission reductions in line with the goal of achieving climate neutrality before 2050.

Cement's high density and low product value result in high commodity transport costs and limit its regional and global trade. This lower risk of replacing domestic cement with cheaper foreign products makes cement an ideal candidate for a faster phase-out of free allowances and internalisation of carbon costs. This would provide the right financial incentives for companies to invest in material efficiency and develop zero-carbon technologies and practices across borders.

The next frontier

The creation of the Carbon Border Adjustment Mechanism (CBAM) as an alternative to the existing measures that address the risk of carbon leakage (free allowances) in the EU's Emissions Trading System would push the cement sector to invest in cleaner production processes while ensuring that exporters from trade partner countries competing in the EU single market are subject to the same carbon costs borne by EU cement producers.

This would help create a market for decarbonised cement in the EU and encourage cement companies inside and outside the Union to clean up their production processes. The CBAM will achieve this aim only if it fully replaces current carbon leakage protection measures.

The EU cement sector represented by industry association Cembureau in the past supported this idea, but changed its strategy during the previous ETS review. At the time, a former cement industry executive accused Cembureau of putting short-term profits ahead of low-

2 Cement is a bulk product and, due to its weight, it is typically not transported across great distances.

carbon investments by opposing plans to end its free allocation of pollution permits.

Today, Cembureau is more vocally in favour of the implementation of the CBAM but still advocates for the continuation of free pollution permits for at least for another decade, undermining the CBAM's effectiveness and utility as a climate instrument.

Powered by creativity

As mentioned above, the EU cement industry has made glacial progress in reducing its emissions. This is partly due to the fact that the sector has relied largely on measure to boost energy efficiency and to switch fuels which do nothing to tackle the pollution from the chemical process of limestone calcination in the clinker kiln, which accounts for about 60% of emissions from the sector.

Reducing these stubborn emissions will require greater circularity and material efficiency, which can help to reduce cement sector emissions by up to 65%. However, reaching carbon neutrality will likely require the roll-out of some emerging technologies which are currently not technically fully developed or economically feasible.

Injecting enough funding to develop these technologies and innovations is crucial to fully decarbonise such an energy and carbon-intensive sector. Through private and public investments, EU cement has the potential to become one of the first carbon-neutral basic materials in the world.

The ETS Innovation Fund has already started funding low-carbon innovative technologies, including in the cement sector. But much more capital is needed to help the industry fully decarbonise.

Currently, the Innovation Fund allocates the revenue generated from auctioning 450 million ETS allowances. At an ETS price of €25 per tonne, for the first call for projects, the fund disbursed €1 billion. However, the demand and variety of low-carbon projects that applied was more than 20 times what was available in the pot.

This meant that, in the first call for the Innovation Fund, only one project focusing on the cement sector received funding, even though four were shortlisted, according to data released by the European Commission.

This suggests that the Innovation Fund can play a crucial role in helping the cement industry decarbonise but does not have enough resources to do so. The ongoing revision of the EU ETS represents a crucial opportunity to increase the size and impact of the fund.

Long-term gain

The European Commission's proposal of July 2021 included an increase of the Innovation Fund's budget by 50 million additional allowances. Moreover, allowances resulting from the reduction of free allowances for sectors covered by the CBAM would also be injected into the fund.

These changes could potentially increase the Innovation Fund's resources substantially but it largely depends on how many allowances are auctioned in the future instead of being allocated for free following the introduction of the CBAM.

Table 3 - CBAM implementation and implications for the Innovation Fund

EC proposal	*Additional revenues for Innovation Fund*	*Share of revenues coming from cement auctioned allowances*
CBAM fully phased-in in 2035	*€7 billion a year*	*€2.8 billion a year*
CBAM fully implemented in 2026	*€13.4 billion a year*	*€5 billion a year*

According to the Commission's impact assessment for CBAM, phasing in CBAM over a 10 year period would generate €7 billion a year of additional revenues for the Innovation Fund by 2030, nearly half of which would be generated from auctioning allowances in the cement sector.

However, in the current trading phase, the Commission proposal would allocate around 5 billion allowances to industry for free. At a carbon price of €80 a tonne, this amounts to €400 billion. This means that the value of free allowances would be 10 times than the value of the ETS Innovation Fund. This shows that there is plenty of room to enlarge the Innovation Fund by speeding up the elimination of free pollution permits, which provide heavy industry with short-term gain but long-term pain. Investing in innovation would instead both protect the climate and safeguard the cement sector's long-term viability.

Moving to full auctioning in the CBAM sectors by 2026 would generate more than €13 billion a year that could be channelled to the Innovation Fund, €5 billion of which would be generated by the cement sector.

With that kind of firepower, the Innovation Fund could help the cement sector accelerate its decarbonisation and become a world leader in climate-friendly production. This makes it imperative upon the EU institutions to agree to the full and speedy phase out of free pollution permits during their trilogue in the autumn of 2022.

K6 - Cement Project

K6 is the only project in the cement sector that received funding through the Innovation Fund.'s first call. It was developed in partnership between the French cement company Eqiom, German cement association VDZ and multinational company Air Liquide.

The project aims to develop carbon capture technology at the Eqiom cement plant in Lumbres (France) as well as the transport, storage and use of the captured CO_2. The innovative technology implements a new kind of oxyfuel kiln, which uses oxygen in the heating process instead of air, thereby increasing the CO_2 concentration in the process emissions. This in turn should render capturing the CO_2 emissions from the kiln easier.

Of the captured CO_2, 90% is then transported by train and ship for storage in North Sea sites or utilised in concrete products. The project promises an overall avoidance of 8.1 Mt CO_2e emissions over the first 10 years of operation.

However, retrofitting an existing kiln to turn it into an oxyfuel kiln has not proven possible yet. This means that the technology would require building a new type of kiln.

Nevertheless, the new kiln would boost production at the Lumbres cement plant, publicly available information on the project suggests.

The Lumbres cement plant currently has a capacity of 600,000 tonnes of clinker. The K6 project aims to capture around 8 million tonnes of CO_2 per year over the first 10 years of operation, according to an Air Liquid's press release. This means that it will capture on average 800,000 tonnes of CO_2 per year. Considering that the average carbon intensity of clinker is 811 kg of CO_2 per ton of clinker, this means that the new oxyfuel kiln has a clinker capacity of 1 million tonnes a year.

The project would not only reduce emissions, but it would also help increase the output of the Lumbres cement plant, almost doubling its current production - and all thanks to a technology developed with EU funding.

Conclusions and recommendations

Accounting for more than 2% of all EU emissions, cement is a very polluting sector that needs to radically reduce its emissions in the coming decade to ensure the EU achieves climate neutrality well before 2050.

The ongoing revision of the Emissions Trading System represents a key opportunity to strengthen the scheme and turn it into an instrument for incentivising emissions reduction in the cement sector. To do so, the reform needs more than anything to correct the flaws that have resulted in stagnating emissions and huge windfall profits in this industry over the past 10 years.

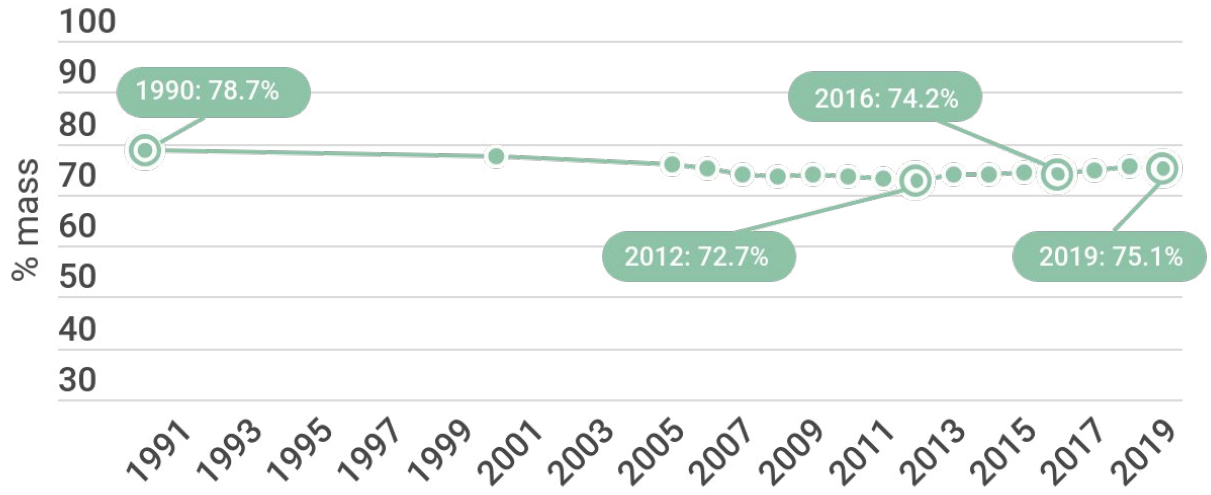
In this context, Carbon Market Watch recommends that the ongoing revision of the carbon market rules:

- Ends free pollution permits for cement as soon as possible to incentivise climate action in this sector
- For the short period while free allowances are still allocated, updates the current benchmarks to ensure they encourage the uptake of cleaner production processes, a reduction of the clinker content in cement
- Implements the proposed Carbon Border Adjustment Mechanism as an alternative to free allowances to trigger more investments in emissions reductions
- Ensures more revenues are raised and channelled to fund innovation to support clean technologies
- Promotes more circularity and material efficiency in the cement sector

Annex 1

Clinker factor evolution in EU28 (before Brexit)

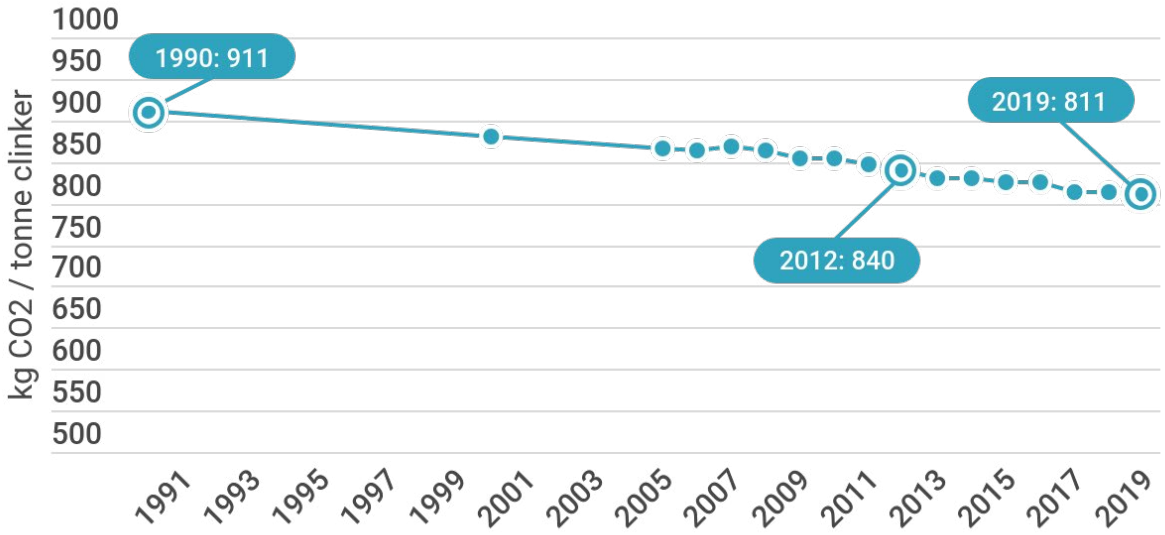
Clinker to cementitious ratio - Weighted average
Grey and white clinker in total cements and substitutes (92AGW)
All GNR Participants - EU28 (Estimated coverage: 95% in 2010, 92% in 2018, 90% in 2019)



Annex 2

Gross CO2 emissions from grey clinker in EU28

Gross CO2 emissions - Weighted average
Excluding CO2 from on-site power generation - Grey clinker (59cAG)
All GNR Participants - EU28 (Estimated coverage: 95% in 2010, 92% in 2018, 90% in 2019)



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