

Cementing the European Green Deal

**REACHING CLIMATE NEUTRALITY ALONG THE CEMENT
AND CONCRETE VALUE CHAIN BY 2050**



The European Cement Association based in Brussels is the representative organisation of the cement industry in Europe. Currently, its Full Members are the national cement industry associations and cement companies of the European Union (except for Malta and Slovakia) plus the UK, Norway, Switzerland and Turkey. Croatia and Serbia are Associate Members of CEMBUREAU. A cooperation agreement has been concluded with Vassiliko Cement in Cyprus and the Cement Association of Ukraine.

The Association acts as spokesperson for the cement industry before the EU institutions and other public authorities, and communicates the industry's views on all issues and policy developments regarding technical, environmental, energy, employee health and safety and sustainability issues. In addition to the EU, permanent dialogue is maintained with other international organisations (e.g. OECD, IEA), the Global Cement and Concrete Association (GCCA) and sister associations in other parts of the world.

The cement sector's efforts to reduce its environmental footprint and support a carbon neutral economy are further explained on our **Low-carbon economy website**.

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Climate change is the defining issue of our times.

Because of a changing climate, we all have to change. Consumers will have to make new choices and change certain habits, governments at all levels will have to change regulation and industry will have to change the way products are made.

The European cement industry is ready to change. This document outlines our path towards carbon neutrality along the entire value chain. It looks at how carbon emissions reduction can be done at each step of the cement and concrete value chain in order to align our 2050 roadmap with the European Green Deal's objectives, and deliver carbon neutrality.

We have set bold goals and as an industry, we are ready to work hand in hand with our value chain, civil society and policy makers to ensure these are met. The transition to carbon neutrality will require efforts from industry and, on its turn, industry will need access to raw materials, renewable energy, and a facilitating regulatory framework that allows investments against reasonable returns.

Our Vision

for a carbon-neutral Europe in 2050

The cement industry – a local industry playing a global role for carbon neutrality

The cement and concrete industry plays an essential role to help Europe achieve its strategic objectives on growth, innovation, social inclusion and climate and energy.

Cement production has always been linked to the availability of its raw material: limestone. Cement plants are located next to limestone quarries and have become epicentres for local economic activity and prosperity. The use of locally available resources to produce cement and the limited transport ranges for the industry's end-product, concrete, firmly anchor the cement industry in the heart of Europe.

Asked about the role of cement and concrete, most people will refer to it as the material that builds our houses, industrial facilities, office buildings and infrastructure. More importantly, cement and concrete are pivotal to building a climate neutral Europe. Foundations of wind turbines, hydro-electric dams, passive housing, tidal power installations and new transport infrastructure all rely on the unique qualities of concrete.

In short, cement is not only the glue that makes a combination of aggregates and water into an amazing construction material, it also binds society's expectations in terms of growth and employment with environmental sustainability.





Plugging into the European Green Deal

The European Green Deal creates a blueprint for a European society that is climate neutral, innovative, forward looking, fair and circular. It outlines a Union where citizens, industry and biodiversity can thrive. It identifies climate change as one of the major societal challenges and consolidates all elements of a possible solution into a single visionary ambition.

The Green Deal also envisions a European society in 2050 that will be more urbanised, more connected, automated and smarter. That society will need cement and concrete to address its needs.

The Green Deal explicitly recognises the cement industry as one of the industries that is essential for the EU economy as it supplies several key value chains. It further identifies the construction sector as one of the key focus points for the circular economy action plan, promises a new initiative on renovation, emphasises the importance of sustainable product policies and announces a biodiversity strategy.

The cement industry is ready to play its role, especially when it comes to making the circular economy work. With 46% of its fuels now replaced by alternative fuels sourced from a variety of waste streams whereby waste is used to simultaneously recover energy and recycle the mineral content, which is known as co-processing, the cement industry is an essential player in the circular economy. This is equally the case from a downstream perspective where concrete is fully recyclable at the end-of-life of a built structure and CO₂ released during the cement manufacturing phase is re-absorbed at the end of the value chain through re-carbonation. We aim to position our industry as an integrated part of the circular economy and as a driving force for change in building techniques, leading to a smarter, more energy-efficient, more re-usable and recyclable built environment.

A joint effort

In the following pages, we explain how, by acting at every stage of the value chain, deep CO₂ emission cuts can be achieved to lead to carbon neutrality. In striving for this goal, the cement industry is optimistic on driving down its manufacturing emissions. We are also pleased to be recognised as an essential supplier of a product that is bringing value to society over its entire value chain.

Yet, we also recognise that delivering carbon neutrality is a collective effort. New plants or CO₂ pipeline networks are not built overnight and the use of alternative raw materials depends on their availability.

Technologies are rolled out at a faster pace than ever, but decarbonisation along the value chain requires out-of-the-box thinking on breakthrough technologies and solutions beyond our factory gates.

The process to go from our commitment to reality will be driven by people – from scientists working in our R&D teams to workers on site. It is crucial for a successful transition to take all workers on the climate neutrality journey and strongly focus on training and skills development.



The Importance of Policy

The importance of policy frameworks to enable and accelerate this transition to a climate neutral cement industry cannot be underestimated. To achieve its objectives, our industry will need a policy environment that offers confidence to allow us to leap forward.

We explain throughout the document how targeted policies, aligned with the European Green Deal agenda, could allow for deep CO₂ emissions reduction down the value chain. Yet, there are also a few key principles to that policymakers at European, Member State and local levels should adhere to support deep decarbonisation.

A Long-Term Vision with industry at its core

Given the long-term investments cycles in the industry, it is indispensable to provide investors with predictability. Investments in low-carbon technologies requires regulatory certainty from now until 2030.

Higher EU climate change targets need to be achieved with proper respect for the current legal framework against which companies are currently making their investment decisions.

In addition, a robust EU industrial transformation agenda will be key to deploy the many technologies we need to cut emissions.

This EU-wide policy should be coordinated with initiatives at Member State and local levels, which can all play a decisive role in reducing emissions.

A Level Playing Field

Reaching net zero emissions will require a level playing field on carbon vis-à-vis non-EU importers. Such a level playing field

is indispensable to stimulate low-carbon investments and support carbon emission reductions worldwide. This can be achieved through the design of a WTO-compatible carbon border mechanism that must co-exist with ETS carbon leakage measures until at least 2030.

Policies based on circularity and the life-cycle of products

When looking at a climate neutral cement and concrete industry, a holistic vision is paramount. This would involve looking beyond our factory gates both in terms of infrastructure and the lifetime of the product.

As outlined in the following pages, our work demonstrates that circularity and life-cycle approaches – in line with the European Green Deal and the circular economy action plan – will be key to reaching carbon neutrality.

A Focus on People

Change will be driven by people and we will need the right people to make it happen. Governments, at all levels, should place ever more emphasis on re-skilling and upskilling.

Investment

The cement sector alone will need substantial investments between now and 2050 to carry out research into the new technologies identified, to conduct demonstration scale projects and then to roll out these technologies across Europe. These investments will require innovative forms of funding and updated State Aid rules. Continued EU funding and innovative sources of financing, such as carbon contracts for difference, will be key for the roll-out of low-carbon technologies.



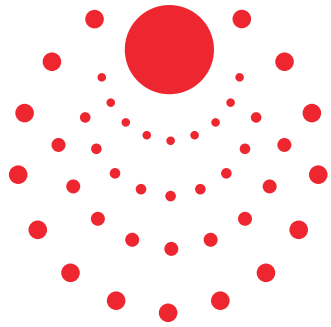
Our next steps

The European cement industry is ready to change. We pooled our technical expertise from across Europe to draft this document, which looks at realistic options and concrete numbers.

Our own conclusion from this work is that the objective of climate neutrality is ambitious, but possible. A concerted effort, by the European cement industry and its value chain with the support of governments at the European, Member State and local levels can move climate neutrality from vision to reality.

We would like to invite all stakeholders, from policymakers to the entire construction industry to get in touch to discuss details and join us on our exciting voyage towards climate neutrality.

Our approach to 2050 carbon neutrality down the value chain



CLINKER
CEMENT
CONCRETE
CONSTRUCTION
CARBONATION

The European cement industry has actively worked on reducing emissions for a long time. Since 1990, it has reduced its CO₂ relative emissions by about 15%.

CEMBUREAU elaborated a Roadmap in 2013 setting an 80% CO₂ reduction target for 2050. The Roadmap was complemented in 2018 by the “5C approach” that promotes a collaborative approach along the clinker-cement-concrete-construction-carbonation value chain involving all actors to help turn the low carbon vision into reality.

The publication of the European Green Deal and its setting-up of a 2050 carbon neutrality objective are game changers and require an ambitious vision from our industry. In the wake of these initiatives, the cement industry is accelerating its pace and takes action with investments in energy-efficiency and CO₂

reduction and with major demonstration projects underway or planned to meet the climate neutral ambition.

In the following pages, CEMBUREAU refines the goals already set in its 2013 Roadmap for clinker and cement and defines goals for the remaining three “C’s”, all with a view to identifying the different technical pathways and business opportunities to reduce CO₂.

For each of the 5C, we identify the areas that allow for significant emissions reduction, the key technologies that will get us there, as well as the policy levers which will play a pivotal role.

As shown in the below chart on our 2050 ambition (page 12), these emission reductions allow to meet the objective of carbon neutrality down the cement and concrete value chain.

Mapping the road

to climate neutrality by 2050

Our approach to 2030 targets the value chain

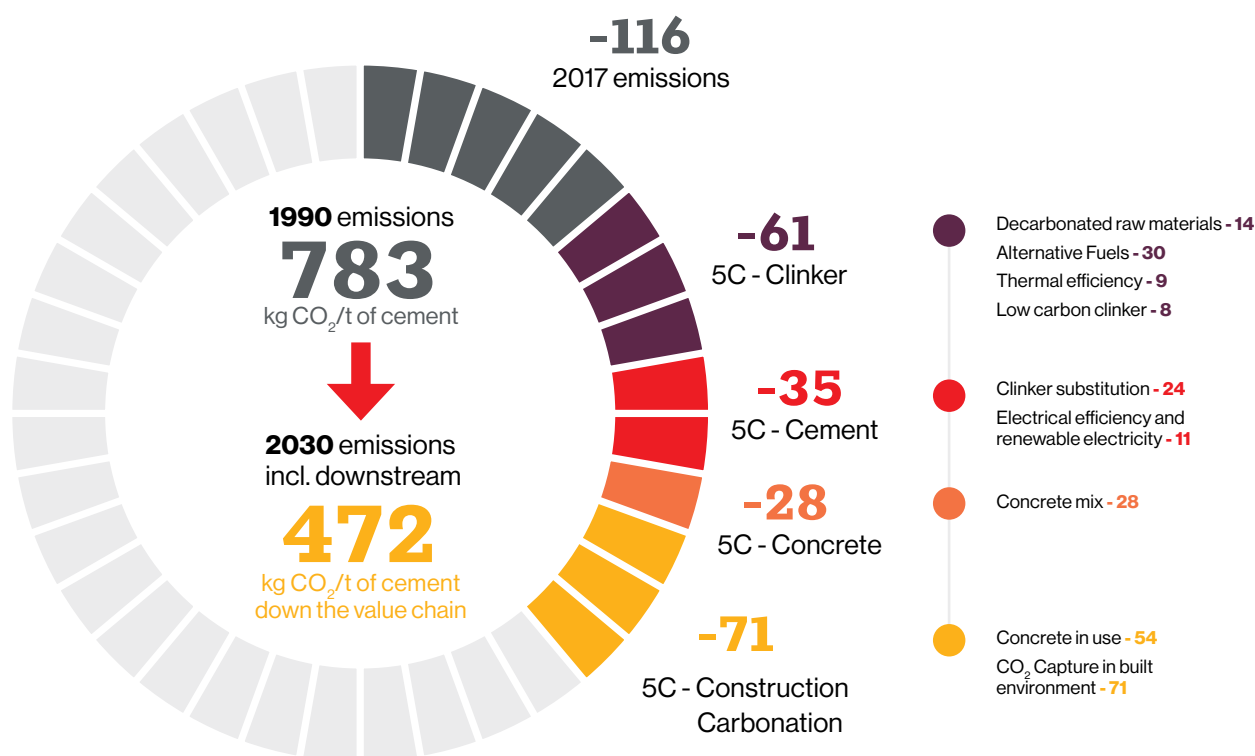
The path to carbon neutrality by 2050 requires intermediate goal posts. For 2030, CEMBUREAU aspires to be in line with the Paris Agreement's two degrees Scenario, by reducing its gross CO₂ emissions by 30% by 2030 for cement and 40% down the value chain. The CO₂ savings in this roadmap are expressed on a gross basis, it is however standard practice in cement to also refer to CO₂ savings for alternative waste fuels on a net basis (**refer to IEA Roadmap for cement**). Here we consider the additional CO₂ that would have been emitted by the incineration of these waste fuels if they were not used in the cement process.

From 2030, this results in an additional overall CO₂ saving at the cement stage of 10% for 2030 (from 30% to 40% CO₂ reduction) and 11% for 2050 (from 63% to 74%).

The below chart summarises the technical pathways to achieve a 40% gross reduction compared to the 1990 CO₂ emissions by 2030 along the cement and concrete value chain. Like for our 2050 objective, this is subject to a policy framework being in place which facilitates these technologies to be implemented and the necessary investment to be made.

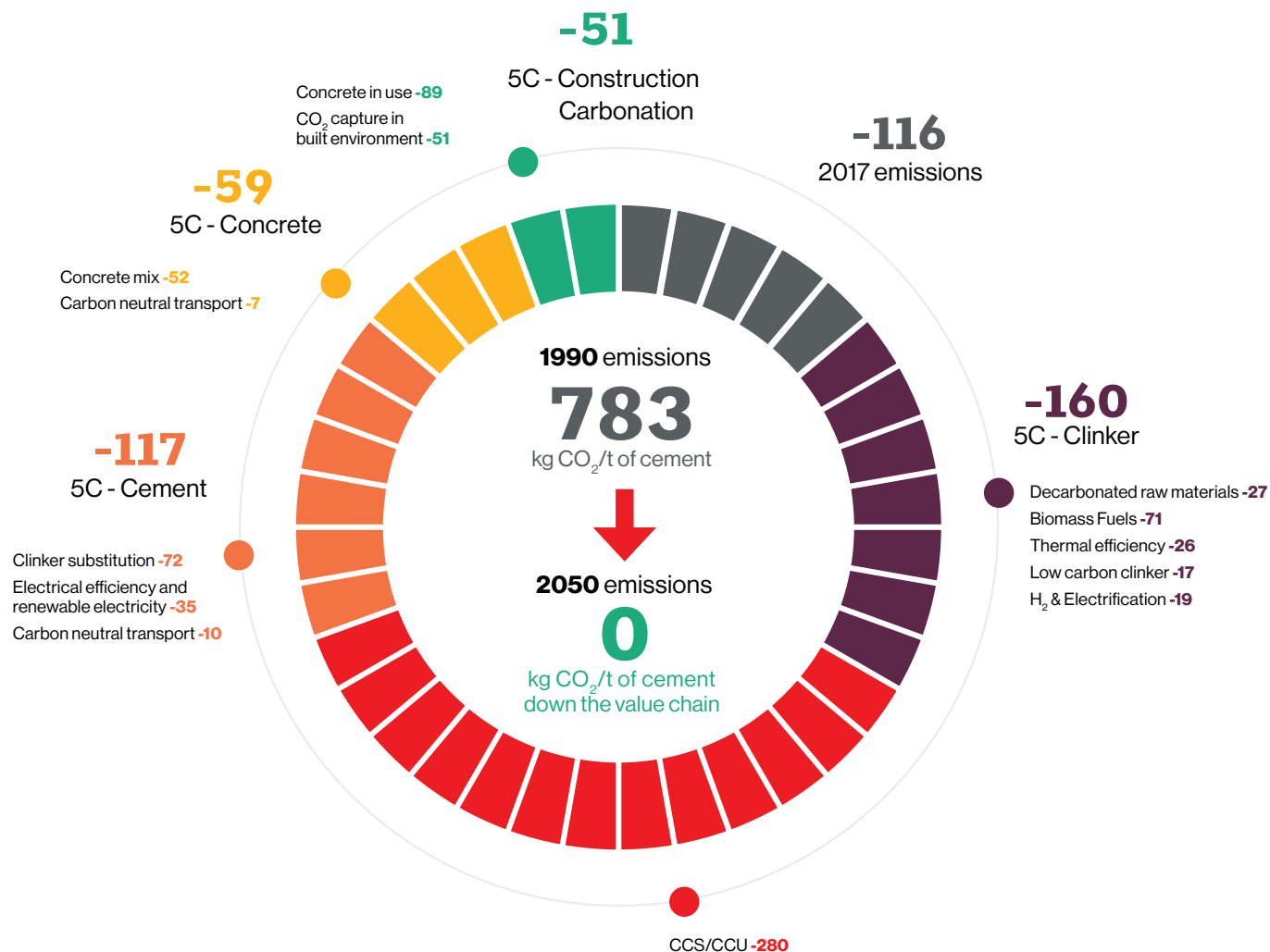
CEMBUREAU 2030 roadmap

CO₂ reductions along the cement value chain (5Cs: clinker, cement, concrete, construction, re-carbonation)



CEMBUREAU 2050 roadmap

CO₂ reductions along the cement value chain (5Cs: clinker, cement, concrete, construction, re-carbonation)



Further reductions of CO₂ emissions not covered in our roadmap

When drafting this roadmap, CEMBUREAU has only taken in consideration the emissions saving that our industry could achieve to reduce our own emissions. It is however important to underline that concrete, as a construction material, allows for deep CO₂ emissions saving in the building sector thanks to its thermal mass. Thermal mass is the ability of heavyweight materials, such

as concrete, to store energy, which is later released. This avoids overheating in buildings and keeps temperatures comfortable.

Similarly, it is a material of choice for the renewable energy equipment or mass transit transport. These savings are not accounted for in the present roadmap, which focuses only on reducing emissions from our sector.

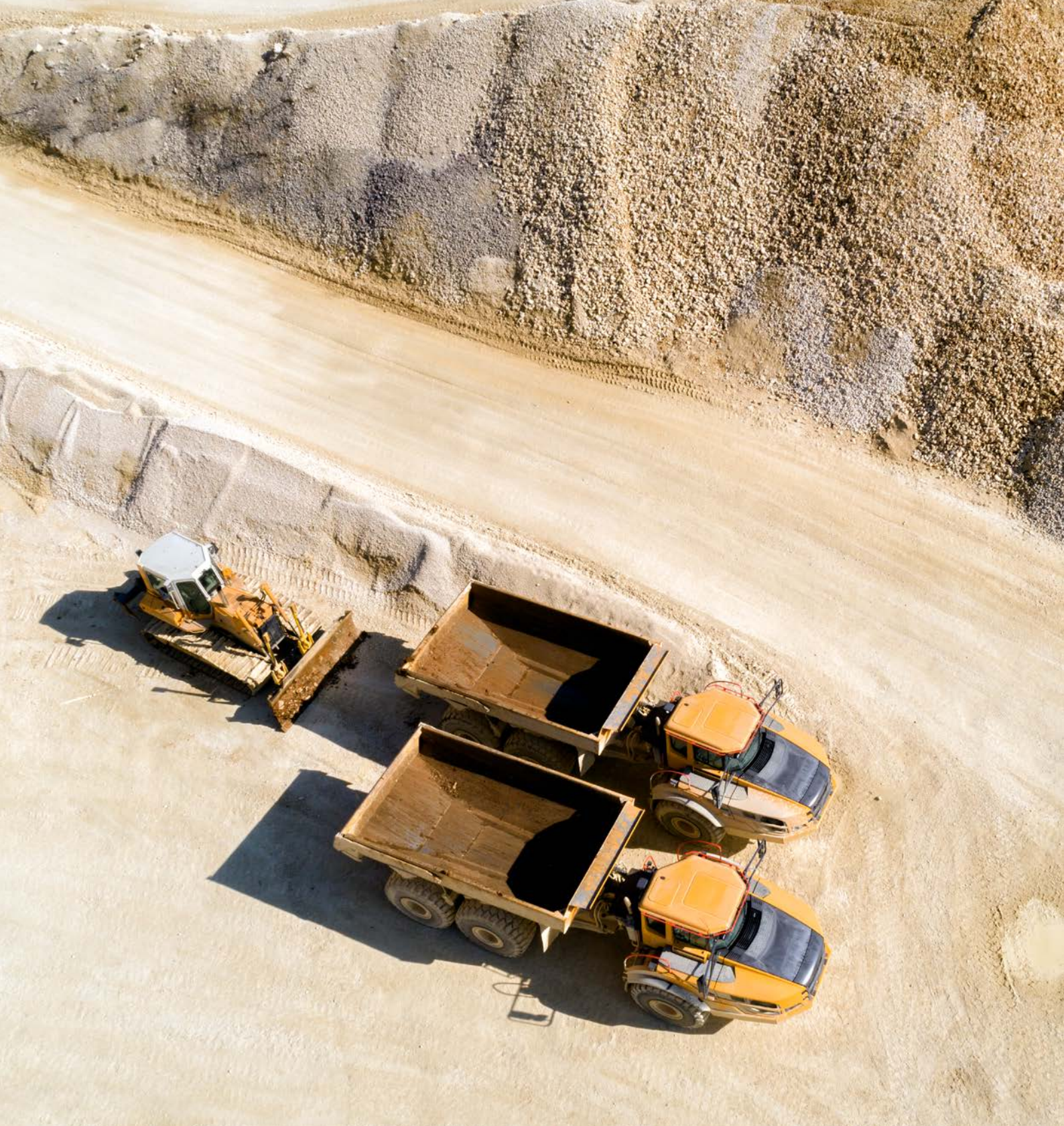
Next steps

CEMBUREAU will present and discuss this roadmap with a variety of stakeholders, from policy-makers to the entire construction sector and civil society.

We also intend to periodically review the progress made in reducing emissions where monitoring is, in certain cases, already possible (e.g. 46% alternative fuel use in cement kilns avoids 18 million tonnes of

CO₂ eq. emission annually and this can be monitored as the alternative fuel use rate increases) and, in other cases, will need to be further defined in studies and analysis (e.g. CO₂ performance of buildings or less concrete use in modern construction). As this is an evolving document, we will also track progress made in developing policies to support these objectives.





01. **Our 2050 Roadmap: The 5C Approach**

Clinker

As recognised in the European Green Deal, the circular economy goes hand in hand with carbon neutrality. Circularity is crucial to reduce emissions from clinker, which is the backbone of cement production. Already today, non-recyclable waste is used to phase-out fossil fuels from cement production. It will become even more crucial tomorrow, as CO₂ captured during clinker manufacturing will be used in other industrial applications.

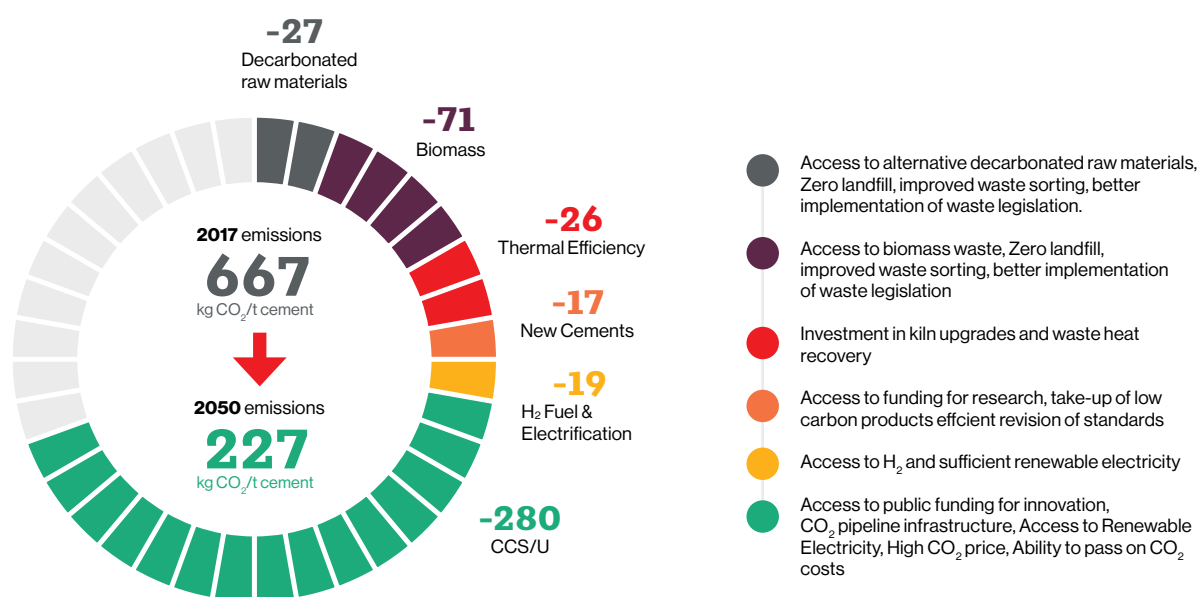
Clinker is produced by heating crushed limestone and a mix of other materials (clay and sand) to 1450 °C in a rotary kiln. Clinker is later ground down to a fine powder and mixed with gypsum and other ingredients to make cement.

The rotary kiln is the heart of the manufacturing process where raw materials are heated up and decarbonisation of the limestone takes place through a chemical reaction referred to as calcination.

It is this chemical process which causes 60%-65% of cement manufacturing emissions (process emissions).

The remainder of CO₂ emissions comes from the fuels used to heat the kiln (combustion emissions). Since clinker production represents the lion share of emissions, this is obviously the area that offers most opportunities for deeper CO₂ emission cuts.

Opportunities to Achieve CO₂ Reductions for Clinker



How can we reduce emissions from clinker?



Alternative Decarbonated Raw Materials

As the largest source of CO₂ comes from calcining the raw materials in the kiln, the use of alternative sources of decarbonated materials is one option for significantly reducing CO₂ emissions. Waste materials and by-products from other industries can be used to replace some of the limestone, a good example of industrial symbiosis. These materials can include recycled cement paste from demolition waste, air-cooled slag and waste lime. A study will be conducted by CEMBUREAU to determine potential sources of alternative waste raw materials and clinker replacement materials from different industries.

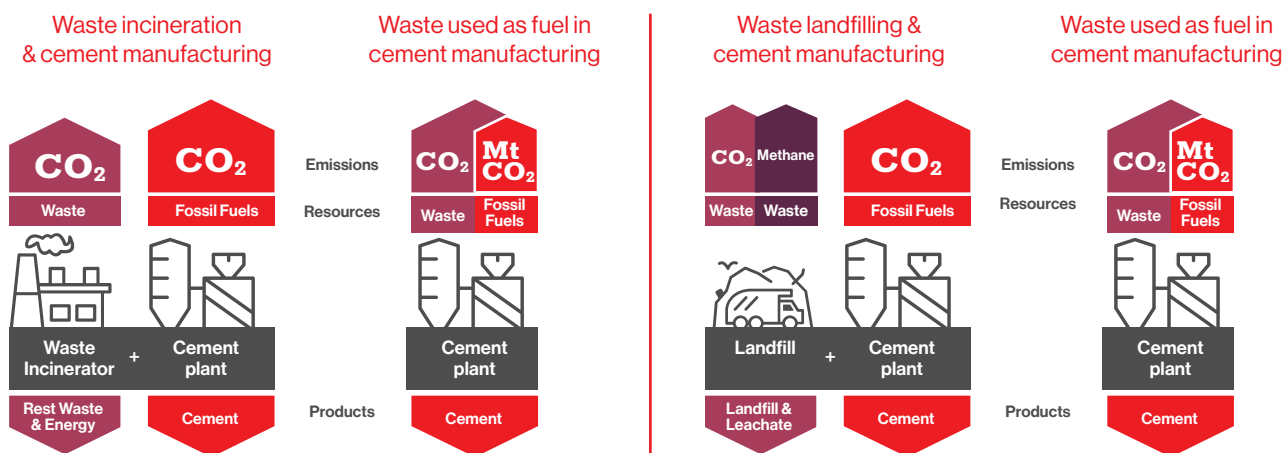
CEMBUREAU envisages up to a **3.5% reduction of process CO₂** using decarbonated materials by 2030 and up to **8% reduction by 2050.**



Fuel Substitution and Zero Fuel Emissions Research

Fuel emissions account for approximately 35% to 40% of total CO₂ emissions from cement manufacturing. In producing cement we simultaneously recover energy and recycle minerals from a variety of waste streams (Co-processing) and use biomass. Co-processing puts the cement industry at the heart of the circular economy, and plays a key role in terms of waste management in local areas and municipalities. CO₂ is saved by replacing fossil fuels with the alternative waste streams, but also through those emissions not being made through incineration or through methane emissions from landfill. Refer to figures below.

Co-Processing CO₂ Emission vs Incineration or Landfill CO₂ Emissions



In 2017, alternative fuel use represented 46% of the total fuel needs of kilns across Europe of which 16% was biomass.

There are no technical impediments to increase the use of alternative fuels to over 90% if the materials are locally available. In fact, several plants do achieve that level thanks to the correct regulatory environment, public acceptance and investment support.

Examples are Allmendingen, Germany operated by Schwenk Cement and Retznei, Austria operated by LafargeHolcim which both use up to 100% alternative fuels and 12% alternative raw materials and Brevik, Norway operated by HeidelbergCement, which uses 72% alternative fuels.

In addition, research is ongoing, although it is at an early stage to use electrical heating, plasma or solar energy to calcine the raw materials which could in the future result in saving 55% of the fuel CO₂ if renewable electricity is used. Combined with the use of hydrogen and biomass fuels for the clinker process, this could result in near zero fuel CO₂ emissions.

CEMBUREAU targets to reach 60% alternative fuels containing 30% biomass in 2030, and 90% alternative fuels with 50% biomass by 2050.

New types of Cement Clinkers and the use of Mineralisers

New types of cement clinkers are being developed that are chemically different from conventional Portland cement clinker. These result in 20 – 30% CO₂ savings by reducing the amount of limestone in the formulation and because they require less energy. It should be noted, however, that because these cements have different properties, they can only be used for specific applications. Examples of these include Sulpho-Aluminate Clinker (SAC), Ferro-Aluminate Clinker (FAC), Belite-Ye'elimite-Ferrite Clinker, Calcium Aluminate Clinker and Amorphous Clinker (X-Clinker).



CEMBUREAU has targeted a **2% reduction in process CO₂ emissions by 2030** and **5% by 2050**. These numbers consider limits in application of some of these cements and the time needed for market acceptance.







Thermal Efficiency

Cement kilns are already efficient, typically operating at levels between 70 to 80% efficiency¹. However, improvements can still be made to the thermal efficiency of some of our kilns through converting preheater and other kiln types to precalciner kilns and by recovering heat from the cooler to generate up to 20% of electricity needs for the cement plant.

CEMBUREAU is targeting a **4% improvement** in thermal efficiency **by 2030**, moving to **14% in 2050**.

Carbon Capture, Utilisation and Storage (CCUS)

Last but not least, CCUS will be a key technology to reduce CO₂ emissions from cement plants. In recent years, significant research has been undertaken at a pilot scale level to optimise reagent and membrane capture techniques. Trials are underway to find ways of concentrating the CO₂ in the gas stream as to make the carbon capture more efficient and cost-effective (refer to the Cleanker and Catch4climate projects below). Captured CO₂ can then be transported to geological formations (such as empty gas fields), where it is permanently stored (example: Brevik plant in Norway, operated by Heidelberg Cement). Other permanent CO₂ capture techniques include the use of recycled concrete aggregates and minerals (such as olivine and basalt). Algae can also be used to absorb CO₂ and grow biomass, which can later be used to fuel the kiln, refer to the CIMENTALGUE project below.

The captured CO₂ can also be used to create new products such as carbon neutral aviation fuel (refer to the WestKuste 100 below).

Whilst there are plans aiming for full scale implementation of CCUS, its development will largely depend on the development of a CO₂ pipeline infrastructure, as well as the development of an overall business case. The development of appropriate policies will play a key role in this respect. A study will be conducted by CEMBUREAU to identify the potential carbon storage sites in relation to the location of cement works in the EU and to determine which of the existing pipelines should be allocated for CO₂ transport.



By 2050 the total use of the different carbon capture techniques **will reduce CO₂ emissions by 42%**.

¹"Evaluation of energy performance in cement kilns in the context of co-processing, European Cement Research Academy, 2016."

How can policy support this transformation?

Reducing clinker emissions will necessitate considerable investments in low-carbon technologies. As highlighted earlier, creating a favourable framework for these investments to happen – through a level playing field on carbon, appropriate funding for research, and a long-term vision – will be critical.

EU policy will also play a pivotal role in reducing clinker emissions through two policies that are at the core of the Green Deal: circular economy and the development of lead technologies for decarbonisation such as CCUS.



We will require more access to non-recyclable waste and biomass waste to phase out the use of fossil fuels. Policies should facilitate waste shipment between EU countries, discourage landfill and prohibit exports of waste outside of the EU. In addition, sufficient access to biomass and non-recyclable waste should be guaranteed for co-processing in cement kilns, as the most ecological solution for the majority of materials.

Energy-intensive industries, including cement, will need sufficient infrastructure to transport, re-use and store the CO₂ it captures. The EU should urgently look at developing a pan-European CO₂ transportation network that responds to the industry's needs. Continued support for CCUS technologies, as well as measures to support the business case of this technology (such as State Aid), are urgently needed.



Innovation in action

Some examples of research projects aiming to reduce CO₂ emissions

CEMZero

The CEMZero project is investigating the use of electricity to heat kilns.

SOLCEMENT

This project aims at developing and evaluating an integrated system on the basis of using concentrated solar radiation for the process of limestone (CaCO₃) decomposition to calcium oxide (CaO), mainly serving the needs of the cement industry.

Leilac

The Leilac project carries the calcination of raw materials in a separate vessel from the kiln through conduction producing a gas stream with over 95% CO₂.

CIMENTALGUE

The CIMENTALGUE is testing the use of algae to capture CO₂ from the exhaust gases in warmer climates. The algae could be used as a source of biomass fuel for the kiln.

WestKuste 100

WestKuste 100 is a joint project between several industries and the local authorities, that uses oxyfuel combustion and CO₂ capture at the Largerdorf Cement Works to create green methanol.

Cleanker

Cleanker uses oxyfuel combustion (replacing air with oxygen and recycled CO₂) and CO₂ recycling to produce a CO₂ gas stream of over 90%.

Catch4climate

An oxyfuel test facility at semi-industrial scale was installed at the premises of the cement plant in Mergelstetten, Southern Germany. This will utilize oxyfuel combustion to concentrate the CO₂ stream for CCU.

Recode

This project aims to use CO₂ from the flue gases of a rotary kiln in a cement industry to produce value-added chemicals (acid additives for cement formulations) and materials (CaCO₃ nanoparticles to be used as concrete fillers).



02. **Our 2050 Roadmap: The 5C Approach**

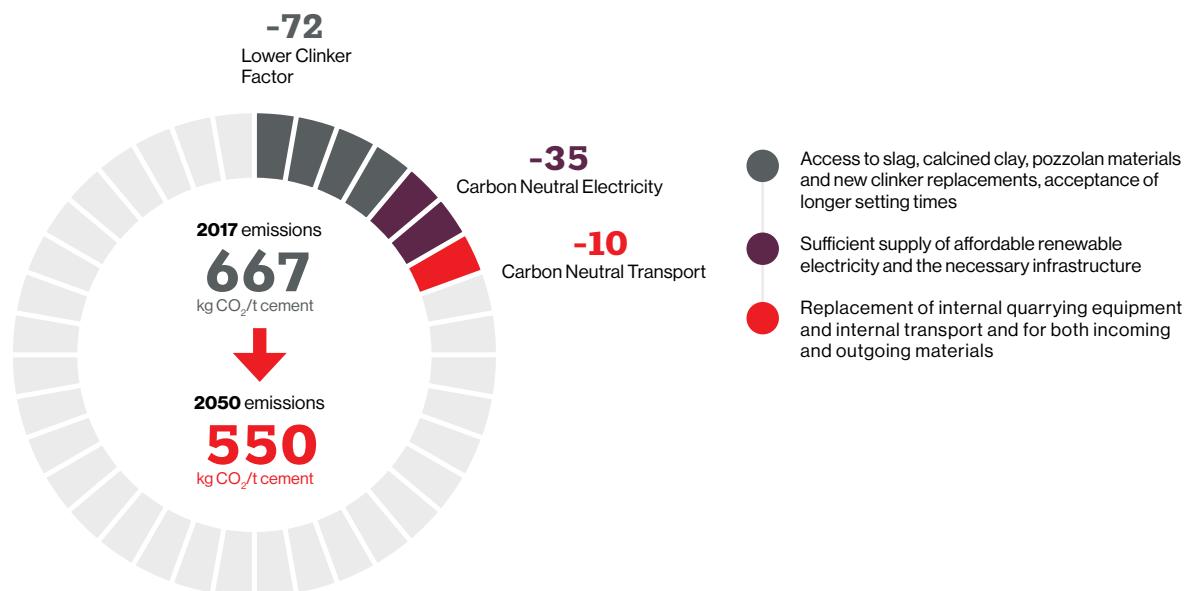
Cement

Once clinker is produced, it is mixed with gypsum and clinker substitutes which are then ground to the correct fineness to create cement. Importantly, there are no further CO₂ emissions at this stage – however, electricity is used for grinding and mixing, and incoming materials as well as final cement products are transported.

The opportunities in cement manufacturing are therefore clear: some cements can be made with less clinker, or even alternatives to clinker, to achieve significant emission savings.

In addition, a reliable and affordable supply of renewable energy as well as zero carbon alternatives to diesel for industrial vehicles can further reduce emissions at the cement stage.

Opportunities to Achieve CO₂ Reductions for Cement



How can we reduce emissions from cement?



Low clinker cements

In 2017 the clinker to cement ratio in Europe was 77%. This means that, on average, 23% of clinker was substituted by alternative materials such as granulated slag from steel blast furnaces and fly ash from coal-fired power plants. The cement industry is conscious that the phase-out of coal fired power plants will limit the supply of fly ash (currently 10% of total substitutes) and the use of slag from the steel sector (currently 33% of total substitutes) will decrease. Already today, however, 21% of the total substitutes are natural pozzolans, limestone or burnt oil shale and non-traditional substitutes such as calcined clay and silica are being assessed. Further research is ongoing to look at other materials which could be used in the future such as pozzolan materials from waste streams and slag from other industries. Depending on national legislation and market conditions, these substitutes can also be added at the concrete manufacture stage.

CEMBUREAU is targeting to move from **an average of 77% to 74% clinker in cement by 2030** and to move to **65% by 2050**.



New cements

New types of cements have been developed. Examples of these types of cements are **Aether**, **Alpenat** and **Ternacem** (Belite-Ye'elimite-Ferrite), **Calcium Aluminate Cement** and **Futurecem** (Calcined Clay Limestone Cement). These cements typically have a 20 – 30% lower carbon footprint than Ordinary Portland Cement (CEM I). The CO₂ savings for these new cements have been included under the clinker stage, as they will result in a reduction of calcination emissions and also the thermal energy to make the clinker. Other types of non-cement-based binders are also being researched including Celitement, which is calcium hydrosilicate-based cement.

Electrical Energy

In 2017, electrical energy represented 13% of total energy use and 6% of total CO₂ emissions related to cement manufacturing. Electrical efficiency can be improved by changes to the preheater design on the kilns and improved grinding. Land that will not be used for decades or has been restored at cement sites can also be used for renewable energy generation. By 2050, we expect the electrical energy consumption at cement plants to double after incorporating Carbon Capture technology.



The move to 100% renewable energy will result in an **overall CO₂ saving of 6%.**



Transport

Transport currently accounts for 1.5% of total CO₂ emissions in cement manufacturing. This includes transport within the quarry and cement plant, transportation of raw materials and fuels brought into a cement plant and the transportation of cement products to end consumers. There is significant research ongoing at present for industrial scale vehicles for both within the quarry and plant and on-road vehicles – which includes hybrid vehicles using electricity, biodiesel and hydrogen, as well as testing on electrically operated vehicles. We assume that by 2050 all transportation for materials and fuels will emit zero carbon as vehicles will move to electric powertrains, hydrogen engines or a combination of both.

How can policy support this transformation?

Policy can play a decisive role to incentivise the take-up of low-carbon cements, and the use of carbon-neutral energy across cement sites. The availability of renewable electricity at an affordable price, and the necessary upgrade in infrastructure

to supply the increased electrical needs will be critical. There is still significant research needed to switch the industrial scale vehicles to electricity or hydrogen and sufficient supply of each energy source to meet this demand.



The development of low-carbon cements and concrete must be incentivised. Green public procurement and the upcoming EU sustainable product policy offers key opportunities in this respect. The EU should work with standardisation bodies to ensure the timely adoption of product standards to allow low-carbon cement and concrete to be put on the market, and look at facilitating access to raw materials allowing for lower CO₂ cements.

We need policies that make renewable energy affordable for industry. The electrification of industry should be encouraged through tax exemptions for electricity use in industrial processes (Energy Taxation Directive) or appropriate compensation mechanisms (State Aid Guidelines).

Innovation in action

Some examples of research projects aiming to reduce CO₂ emissions

Aether

Aether cements are a new generation of lower-carbon cements that offer similar performances to Portland Cement in a wide range of concrete applications. They require less limestone and are produced at lower temperatures.

Grinding technology project

This ECRA project focused on the optimisation of existing grinding plants, the future development of optimum plant layouts using existing technology and the development of new future grinding technologies.



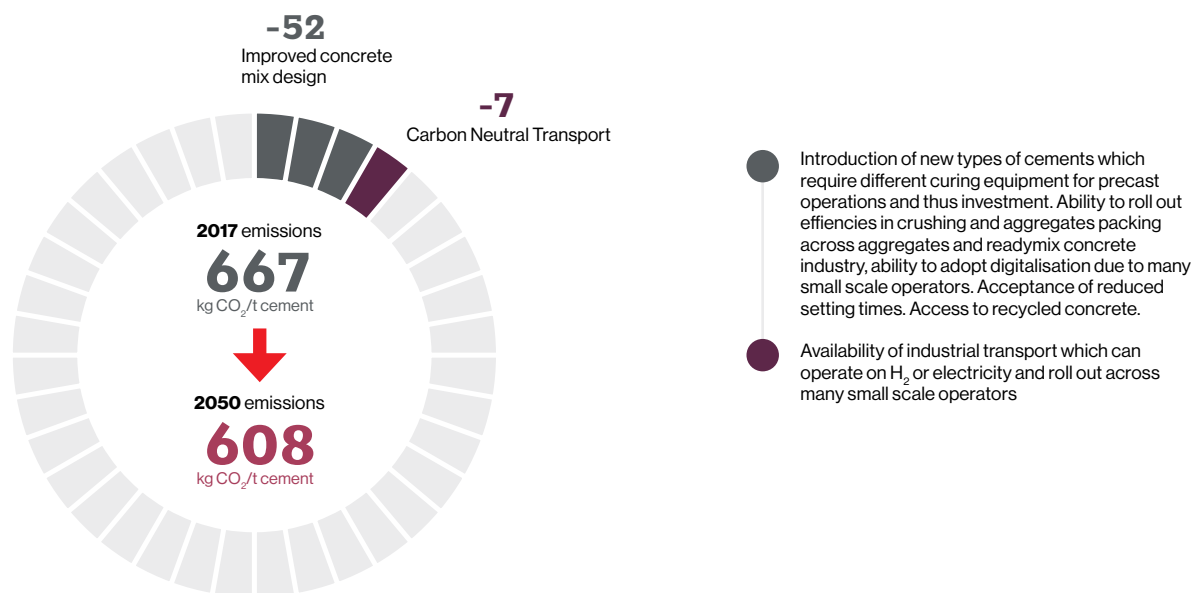
03. Our 2050 Roadmap: The 5C Approach

Concrete

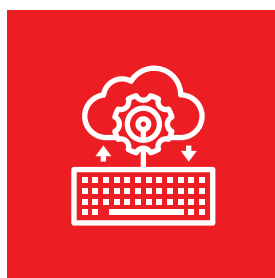
Cement's main end-product is concrete, which is the most commonly-used material on earth after water. Concrete is manufactured by mixing cement with water and aggregates with small quantities of chemical admixtures used to improve the properties of the concrete and

to meet specific product requirements, where cement represents about 10-15% in this mix. The direct CO₂ emissions related to concrete largely come from cement production. The largest indirect CO₂ emissions come from transportation of concrete to the end user.

Opportunities to Achieve CO₂ Reductions for Concrete



How can we reduce emissions from concrete?



Digitalisation, Improved Mix Design and New Admixtures

Digitalisation offers significant opportunities to reduce CO₂ emissions from concrete. Improved data and data processing will enable builders to get the exact amount of concrete delivered on site to get the job done. Digitalisation will also help monitor the concrete during transport and ensure it is poured correctly. Data for the cement and concrete will be available to the contractor and the purchasers of the building to enable the carbon footprint to be determined and also to show the source of the materials used in construction as well as monitor the energy performance of buildings during their life. Digitalisation can also help improve aggregates grading and optimise admixtures.

Digitalisation, improved mix design and new admixtures can **reduce cement in concrete by 5% in 2030 and 15% by 2050.**



Low carbon cements and the use of cement substitutes

The use of low carbon cements in concretes will reduce the overall carbon footprint for concrete. Fly ash, granulated slag, silica fume, pozzolan and other cement substitutes can also be added at the concrete manufacturing stage. CO₂ savings for this have already been included in the cement manufacturing stage.

Transport

One of the biggest sources of CO₂ emissions related to concrete production is the transport to the job site and the energy needed to pump the concrete to where it is needed. It is assumed that by 2050 all transportation will be handled by zero emissions vehicles with the move to electric, hydrogen or a combination of both.



How can policy support this transformation?

As well as encouraging the development of markets for low-carbon products mentioned above, policies can also play a leading role to incentivise the use of digitalisation across the concrete industry.

Crucially, policies should be based on a full life-cycle approach, and also look at adequate training of all actors down the value chain.



Policies based on material neutrality and the life-cycle performance of products should be encouraged across all EU legislation. The CO₂ footprint of products should be based on a cradle-to-grave lifecycle approach that goes beyond placing a product on the market and also takes into account the performance of the product during its use and after its useful life.

Delivering carbon neutrality in the building sector will require appropriate skills and new building techniques. The upcoming Sustainable Built Environment strategy should promote cooperation between architects, local authorities and engineers. It should foster skills and training to deliver energy-efficient designs and lower-carbon concrete mixes.

Innovation in action

Example of research project aiming to reduce CO₂ emissions

Solidia

Solidia offers solutions that could lower emissions related to cement manufacturing by 30-40%. As well as technology to cure with CO₂ rather than water, trapping the CO₂ in the concrete resulting in a 50% lower CO₂ footprint. These types of concrete would require specialised curing chambers and would thus only be suited to precast operations.



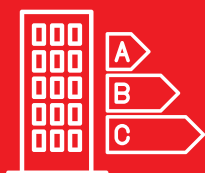
04. Our 2050 Roadmap: The 5C Approach

Construction

The built environment of tomorrow will have sustainability at its core. Sustainability in its three pillars: built structures will need to be safe, durable and affordable (social pillar), need to respond into the quest for CO₂ and energy-efficiency (environment pillar) and construction and renovation will need to remain a key driver for growth and jobs (economic pillar), as strongly emphasized in the Renovation Initiative launched under the Green Deal.

Concrete ticks all these boxes and is clearly instrumental to tackle the needs of the construction sector. Concrete is one of the most versatile and cost-effective building materials. It offers a working life in excess of 100 years, provides fire resistance, and is able to reduce energy consumption for heating and cooling by 25%. This opens significant opportunities to reduce emissions not only for concrete itself, but for the overall construction sector.

How can we reduce emissions in construction?



Energy efficiency in buildings

Currently 72% of CO₂ total emissions related to an average building come from the energy used during its working life². Buildings that leverage the thermal mass properties of concrete can cut energy use by 25% and up to 50% during the peak demand periods. Examples include a multi-story social housing project in Mühlgrundgasse, Vienna, residential passive house building in Lärkträdet in Vara, Sweden and The Edge, multi-story office in Amsterdam. Thermal mass can also be incorporated into re-use of buildings where thermal mass is added to the concrete structure being refurbished for a new building use.

Concrete used in buildings

Research is currently underway to look at ways of reducing embodied carbon of construction materials. This, however, must be done ensuring that it does not lead to premature structural failures and guarantees the durability and working life of a structure. Early research has shown that, by using efficient structural design, we can reduce embodied carbon by up to 30% for certain types of buildings. Improvements in building construction can also be realised using 3D printing.

Recent studies point out that a more efficient use of concrete in buildings and other construction projects can reduce the concrete used in these structures. The chart for 2030 includes a 5 to 10% and for 2050 a 10 to 30% reduction in concrete use in structures. These reductions have not been included in the savings as they may well be offset by increased demand for concrete in projects to protect against flooding, infrastructure projects for mass transport systems and for increased renewable energy.



² WorldGBC-Bringing Embodied Carbon Upfront – pg16



Design for Adaptability and Disassembly

Office building structures are often designed for multiple use, so an office block can be converted to an apartment building if the demand for office space in the area declines. Some buildings have been designed using concrete structures that can be adapted to the needs of the tenant, resulting in a mixed-use building. The durability and longevity of concrete perfectly lend themselves to such adaptations to the changing needs of the market. For older buildings there is a move towards re-using the concrete structure of a building rather than demolishing it entirely.

In this context, our sector is also keen to explore the “design for deconstruction” model where a building is conceived at origin with the objective to disassembly at end of life. The approach allows materials and components to be removed easily and to be re-used to construct a new building.



How can policy support this transformation?

The European Green Deal rightly puts an emphasis on the construction sector and the idea of circularity in buildings.

It is critical that ambitious policies are set up in this field.



A more circular approach to buildings is key to reduce emissions. Policies should maximise the different properties of construction materials including their durability, recyclability, thermal mass or re-carbonation potential.

Innovation in action

Some examples of research projects aiming to reduce CO₂ emissions

Perfcon

This is a research project to look at more efficient use of concrete in building design

Technical University of Vienna

The multi-story building of the Technical University of Vienna (TUV) has a positive energy footprint by using thermal mass and solar panels



05. Our 2050 Roadmap: The 5C Approach (Re) Carbonation

In addition to reducing emissions, carbon neutrality can also be reached through greenhouse gas emissions removal through carbon sinks, as recognised in the European Climate Neutrality Law. Cement and concrete have here a key role to play through a process called re-carbonation, which effectively transforms European cities into carbon sinks.

Re-carbonation is the process whereby concrete re-absorbs some of the CO₂ that was released during clinker production. It is a process that occurs naturally in all concrete structures, permanently trapping the CO₂. Thanks to re-carbonation, cities effectively act as carbon sinks, allowing further reduction of emissions in the full cement and concrete value chain.

How can we reduce emissions through re-carbonation



Re-carbonation in the built environment

In the built environment, re-carbonation occurs naturally in all concrete infrastructure. According to research by IVL³, 23% of process CO₂ emissions of cement used, is being captured annually which equates to a 8% saving of total CO₂ emissions for the cement manufactured.

Enhanced re-carbonation of recycled concrete

Re-carbonation increases after demolition of a concrete building. The recycled concrete aggregates have a higher surface area and can absorb more easily CO₂ within the concrete paste (cement, water and sand) from the ambient air. Initial research has shown this can be accelerated by using the exhaust gases from a cement kiln which have a higher CO₂ content and are also at a higher temperature increasing the CO₂ captured up to 50% of process CO₂ emissions⁴. Separating the aggregates from the recycled concrete and grinding the cement paste also enables higher CO₂ capture with the added advantage that the resulting material can be used as a clinker replacement in cement or as an additive in concrete.



³ IVL Research Paper

⁴ Fastcarb Research



Carbonation of natural minerals

Natural minerals such as olivine and basalt when crushed can also be re-carbonated when exposed to air or kiln exhaust gases. Up to 20% process CO₂ emissions can be absorbed. Once carbonated these materials can be used as clinker substitutes.⁵

How can policy support this transformation?

Re-carbonation has a significant, untapped potential



Concrete absorbs CO₂ during its lifetime – the EU should fully use this untapped potential. The re-carbonation of built concrete products over their life cycle should be recognised in CO₂ emissions accounting, carbon footprint methodologies, and CO₂ certification removal schemes.

Innovation in action

Example of research project aiming to reduce CO₂ emissions

Fastcarb

Uses a reaction chamber in which exhaust gases from the kiln pass over crushed recycled concrete resulting in up to 50% CO₂ capture within the concrete paste.

⁵ Reco2de Research





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