

#madewithcement

# Building carbon neutrality in Europe

Engaging for  
concrete solutions





# Introduction

Europe has an ambitious vision, a vision of a carbon neutral future, a vision that integrates energy intensive industries as well as the construction sector and its entire value chain. Cement, which binds concrete together, is at the heart of solutions to turn this vision into reality. These solutions span over the entire life cycle of the cement and concrete value chain: from raw materials to production, use, re-use, and recycling. As part of our effort to move towards a carbon neutral construction sector, we have taken stock of our progress since the publication of our 2050 Low Carbon Roadmap in 2013 and mapped routes to a resource efficient and carbon neutral built environment.

# Strong Foundations

Over the past decades, continuous improvements in Europe have seen the energy used in cement manufacturing reduced by about 30%. Five years ago, the European cement industry published its Low Carbon Roadmap outlining how we can reduce CO<sub>2</sub> emissions intensity by 32% (compared to 1990 levels) by 2050 with conventional technologies and potentially by 80% if breakthrough technologies become widely available.

We evaluated where we are on our journey to 2050 and wanted to explore additional avenues to accelerate our progress and the transition towards our objectives.

## 1 REPORT OUR PROGRESS TO DATE

Identify where we are, compared to the targets set in our 2013 Roadmap; what reductions we have achieved, which technologies have helped us getting there and, more importantly, how we will meet our future targets.

## 2 ASSESS OUR ROADMAP AGAINST SCIENCE BASED TARGETS

The roadmap pre-dates the Paris Agreement. We, therefore, initiated the process of having it assessed using several Science Based Target (SBT) methodologies, thus ensuring compatibility with the objectives of the Paris Agreement, the 2°C Scenario.

## 3 INCLUDE THE COMPLETE VALUE CHAIN

The European Union is defining its long-term vision for a modern and low carbon European economy. It aims at leveraging opportunities brought about by the low carbon transition, including exploiting synergies across strategic value chains. Given its global impact and significant potential to contribute to reaching the objectives of the 2°C Scenario, the global construction value chain is a major driver of the low carbon transition. Carbon neutrality in the built environment requires a collaborative approach across the construction value chain, looking beyond individual sectors and subsectors and focusing on how lifecycle performance can be implemented broadly so as to accelerate results. The cement industry is uniquely placed to achieve step-changes in the way we build, use innovative and low carbon solutions, and integrate a circular model into construction practices, whilst building durable buildings and infrastructure.

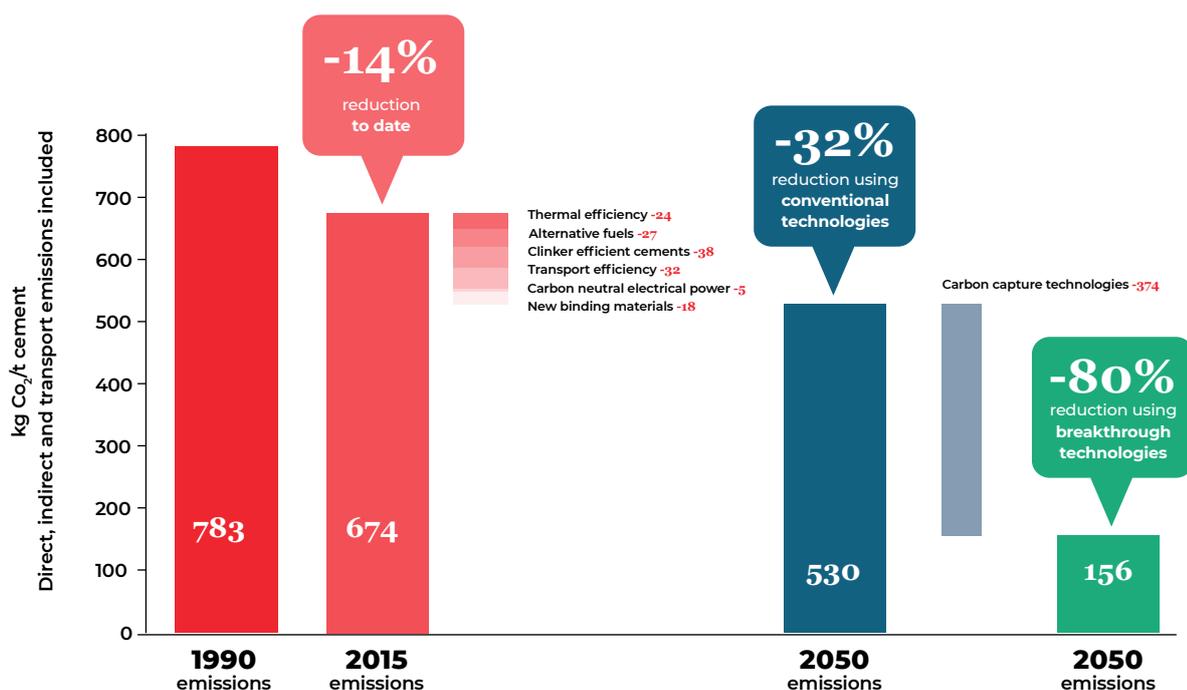
# Our progress on the road to 2050: We are on track!

In cooperation with the European Cement Research Academy (ECRA), CEMBUREAU performed an assessment of where the European cement industry stands on its way to achieving its 2050 targets assuming that the same amount of cement will be manufactured in 2050 as in 1990. The assessment is based on 2015 data ("Getting the Numbers Right" (GNR) database) and the progress was evaluated for the specific technologies identified in the 2013 CEMBUREAU Low Carbon Roadmap.

The graph describes the technology-specific reduction potentials over three time periods:

1. **1990-2015:** what has been achieved (based on GNR 2015);
2. **2015-2030 and 2030-2050:** linear projection of remaining reduction potentials;
3. **2030-2050:** breakthrough technologies applied.

## CO<sub>2</sub> REDUCTION MEASURES: 2050 PERSPECTIVE



Source: ECRA and CEMBUREAU own calculations

Note: Other technologies (e.g. electrical efficiency, alternative raw materials) not displayed as long term reduction potentials are severely limited

## Overall progress towards the 2050 target set in the 2013 CEMBUREAU Low Carbon Roadmap

2050 TARGET	ASSESSMENT (ON THE BASIS OF 2015 DATA)
<p><b>32%</b></p> <p>CO<sub>2</sub> emission reduction using <b>conventional technologies</b></p>	<p>Close to 14% emission reduction to date, with substantial progress achieved in thermal efficiency and alternative fuels.</p> <ul style="list-style-type: none"> <li>• <b>Thermal efficiency:</b> 3.690 MJ/t of clinker (1,6% ahead of the linear pathway towards 2050).</li> <li>• <b>Fuel substitution:</b> 40,6% (15,2% ahead of the linear pathway towards 2050).</li> <li>• <b>Clinker substitution rate:</b> 76,4% (1,7% behind the linear pathway towards 2050).</li> <li>• <b>Transport emissions:</b> Progress has been made, but the real change will come when electric/hybrid drive trains become available for heavy goods vehicles (HGVs).</li> <li>• <b>Electricity use:</b> Demand has not been reduced, mainly due to the power requirements of new systems needed to reduce emissions. Decarbonisation of power generation and shifts in grinding technologies will contribute to real reductions.</li> </ul> <p>More details, including on novel cements, are outlined in the accompanying clinker and cement progress sections.</p>
<p><b>80%</b></p> <p>CO<sub>2</sub> emission reduction using <b>breakthrough technologies</b></p>	<p>Several breakthrough technologies such as carbon capture and storage, and reuse (CCS/CCU) are under development.</p> <p>Technology is now available at demonstration scale and the cement industry is involved in several promising research projects. With the right co-financing framework, it is expected that these technologies will become commercially available after 2030. Education and training of the value chain will be necessary before these technologies will become widespread and commercially viable.</p> <p>Some technologies are at a more advanced stage, but rely on a shift in market acceptance and demand. These could benefit from an increased legislative focus on demand-pull policies as well as standards and building codes providing the necessary quality assurance.</p>

# Alignment with the 2°C Scenario of the Paris Agreement

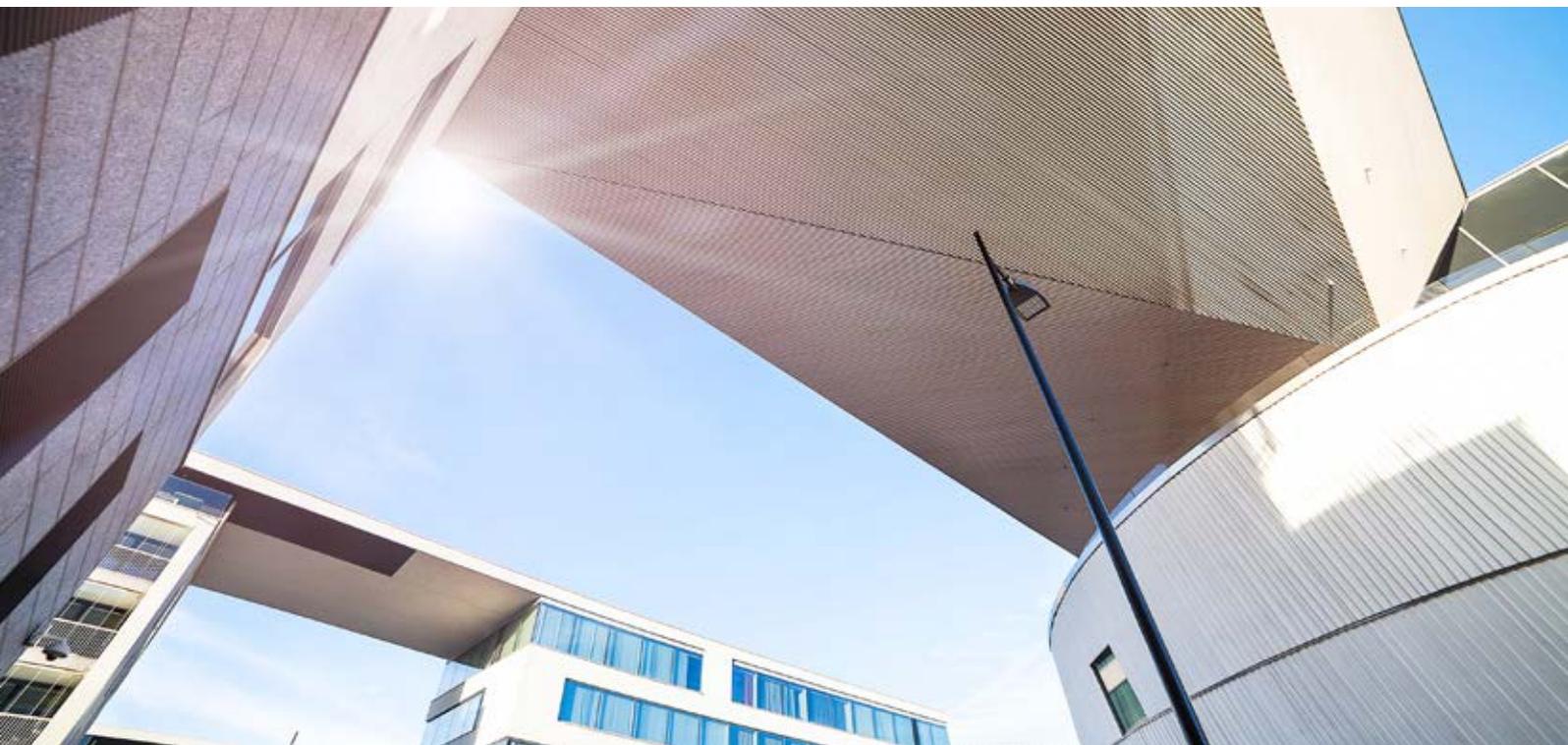
## CEMBUREAU Roadmap... ...Science Based Targets Assessed

CEMBUREAU has asked PwC (PricewaterhouseCoopers) to assess the extent to which the greenhouse gas (GHG) emission reduction targets set for the European cement industry are sufficient to meet the temperature goals adopted in the Paris Agreement, i.e. limit global temperature rise this century to well below 2°C.

Responding to CEMBUREAU's request, PwC has **applied an empirical approach using several established Science Based**

**Target (SBT) methodologies** in order to compare their outcomes with the targets set in the CEMBUREAU Low Carbon Roadmap.

The preliminary assessment indicates that **the CEMBUREAU Roadmap is compliant with a number of SBT methodologies** in its 2050 perspective and is therefore a robust instrument to guide the cement sector towards achieving the Paris Agreement objectives.





## ...more ambitious than the global scenarios

The European cement industry has taken an active role in the development of the International Energy Agency's (IEA) **"Technology Roadmap for Low Carbon Transition in the Cement Industry"** in partnership with the World Business Council on Sustainable Development (WBCSD), the Cement Sustainability Initiative (CSI). In 2009, the first sectoral low carbon technology roadmap for the cement industry was published, identifying the existing and upcoming technological levers to mitigate CO<sub>2</sub> emissions from the sector and paving the way for other sectors to follow. In 2018, the cement industry was the first sector to have its original technology roadmap updated, integrating new technologies.

Our assessment shows that **the 2013 CEMBUREAU Low Carbon Roadmap is more ambitious than the 2018 IEA scenarios**, in particular when it comes to fuel substitution and breakthrough technologies. Clinker substitution for the European region remains a challenge.

Because of Europe's decarbonisation agenda, there is lower availability of clinker substitutes, such as slag from the steel sector and fly ash from the power sector, compared to other regions of the world. More importantly, differences in cement qualities, stemming from varying requirements for performance and durability of construction across the world, make a direct comparison of clinker-to-cement ratio in different regions of the world challenging.

Looking from the entire construction value chain's perspective, cement quality and performance in concrete are also a complicating factor in comparing clinker-to-cement ratios at a global scale.

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# **Cooperation holds the key to a carbon neutral built environment**



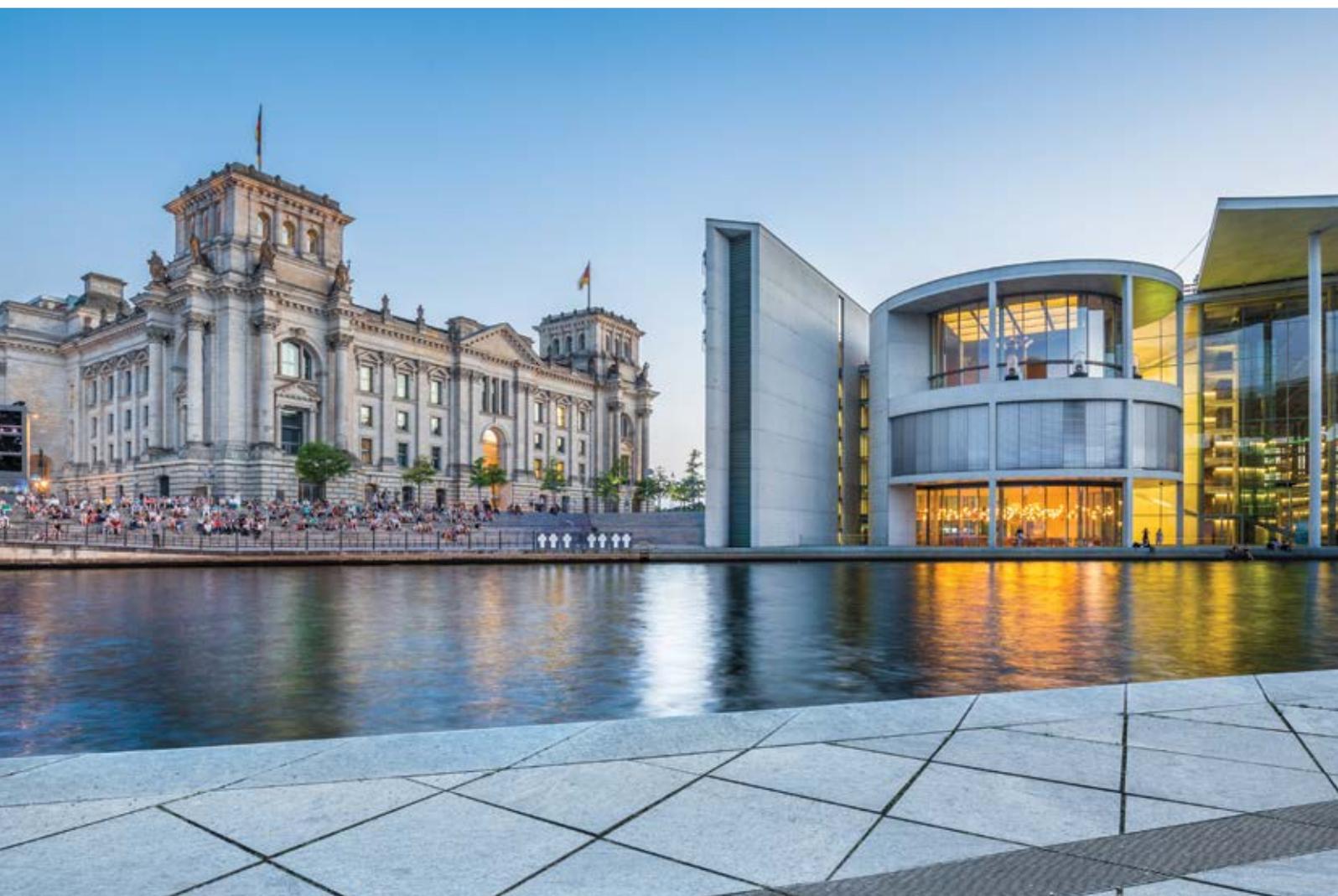


# Concrete: the cornerstone of infrastructure

Concrete is crucial to building Europe's carbon neutral future. Be it the foundations and towers of wind turbines, large hydro or tidal power projects, energy efficient buildings, new transport infrastructure or projects aiming at adapting to climate change, concrete delivers performance, resilience, and durability.

However, this does not mean we will rest on the laurels of previous achievements or the unique qualities of concrete. We know that to achieve a carbon neutral built environment, we can do more along the value chain.





# Going down the whole built environment value chain

It is necessary to consider how cement and concrete solutions can effectively contribute to a carbon neutral Europe; how we can change the way we build; how technological low carbon innovations can be adopted across the construction value chain, and how we can improve concrete re-use and recycling.

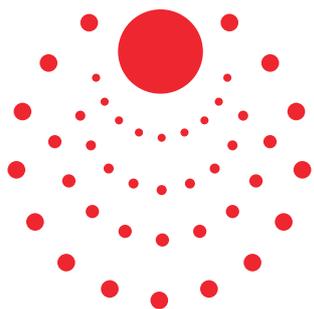
Europe's industry, including the construction sector, should be carbon neutral, circular, and yet remain competitive. This is not an easy task, especially in a globalised world. This is why we want to look beyond our factory gates, focusing on how a material-neutral and lifecycle performance-based approach that considers the whole value chain can yield tangible results.



# The 5C approach: Call for a Concerted Effort

The European cement industry shares the vision of a carbon neutral construction sector in Europe. However, there are no silver bullets or a single solution available at this time. This is why a concerted effort is needed: from architects to specifiers, from regulators to standards agencies, from material manufacturers to builders and users. All actors working together in the value chain can build a carbon neutral future!

To this end, we want to launch and engage in a constructive debate along the key elements of our value chain. We call this framework – **the 5C approach**: clinker, cement, concrete, construction & built environment, and (re)carbonation.



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Such a combination of actors and value chain elements will help turn a low carbon vision into reality. Our aim is to go beyond our direct emissions and explore a variety of solutions for a carbon neutral future.



# The Power of Policy

European policy will play a central role in overcoming hurdles and creating a low carbon, circular, and competitive European construction sector. Progressive policies will be needed to ensure that low carbon cement production and the use of low carbon innovation are viable. It will require a policy framework and normative framework that:

- **Secures a level playing field with other regions and across industrial sectors;**
- **Is material neutral and based on lifecycle performance;**
- **Integrates both the supply and demand sides;**
- **Supports the development of breakthrough technologies and solutions, including through large-scale demonstrators.**



## The 5C Approach

# Exploring concrete solutions for a carbon neutral future





1

# Clinker

Clinker is the backbone of cement production. It is essentially a mix of limestone and minerals that have been heated in a kiln and have been transformed by this heat. When limestone is converted to clinker, CO<sub>2</sub> is released (also known as process emissions).

A substantial amount of heat is needed to start and sustain the chemical reaction, leading to further CO<sub>2</sub> emissions (also known as combustion emissions). The clinker is finely ground and mixed with gypsum and often with alternative raw materials to make cement.

Over the past decades, the cement industry has invested heavily in four main levers to reduce direct CO<sub>2</sub> emissions:

#### • THERMAL EFFICIENCY

Cement kilns have become highly energy efficient as older plants are being upgraded or replaced.

The energy intensity of cement manufacturing is influenced by regional characteristics such as raw material moisture content and burnability, fuel types, plant size distribution, and cement standards. Because of these variables, especially a higher thermal substitution rate, CEMBUREAU has projected an energy consumption of 3.300 MJ/tonne clinker by 2050.

#### • FUEL SUBSTITUTION

Fossil fuels have been substituted with pre-processed waste, including biomass, of which mineral content also partially replaces primary raw materials. This increased use of alternative fuels and materials is aimed at reducing CO<sub>2</sub> emissions linked to our thermal energy needs as well as the use of primary natural resources. Waste streams that are non-recyclable through conventional processes (such as used tyres, certain types of plastics, and chemicals) are co-processed in cement kilns in plants across Europe. By 2030, the average substitution rate could be as high as 60%. In some countries, it is already today more than 90%. This makes the European cement industry the global frontrunner in the use of alternative fuels and materials.

#### • CLINKER SUBSTITUTION AND NOVEL CLINKERS

The effort in reducing the amount of clinker in cement is progressing well and the clinker to cement ratio has been reduced to 76,4%.

The uncertain sustainable availability of clinker substitutes is the main constraint. CEMBUREAU has projected the clinker to cement ratio at 70% by 2050.

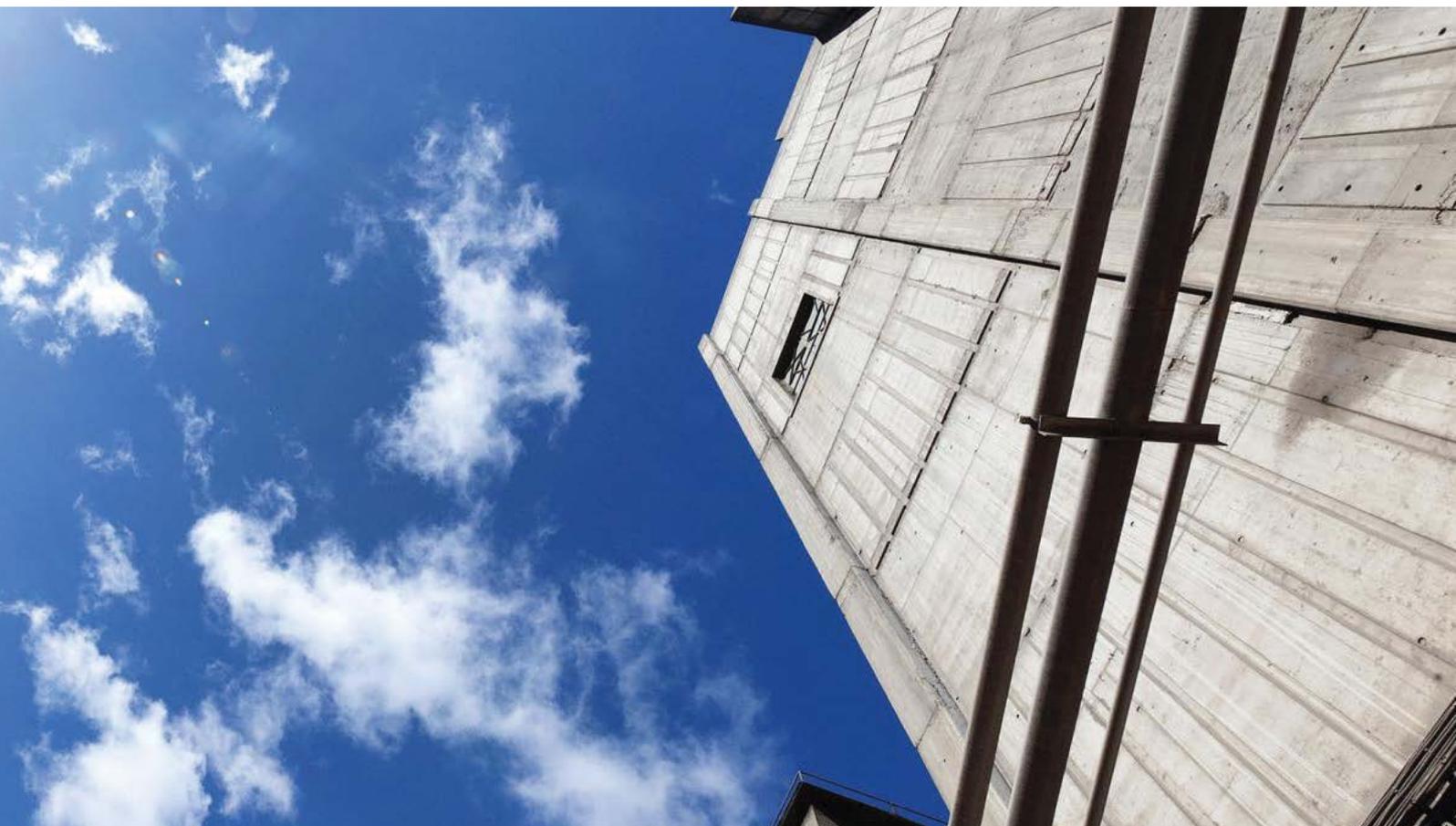
#### • CARBON CAPTURE

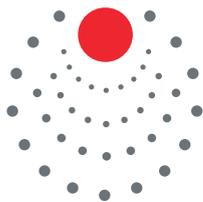
The key breakthrough would be carbon capture. Since the majority of the emissions related to cement production are process emissions, the pure CO<sub>2</sub> could be captured and stored or put to use. CO<sub>2</sub> captured during cement production can become a raw material for new fuels, carbon fibres and chemicals or, ideally, construction materials. In fact, through the development of multiple capture technologies and its strong focus on both storage and reuse, the European cement industry is a leader in research and piloting capture breakthrough technology.

However, the R&D efforts and market deployment of these technologies (if the demonstration and pilot projects prove to be successful) require significant investments and large-scale demonstrators to mobilise the value chain and ensure market acceptance and demand (without which commercial viability cannot be achieved). The cement industry will require the support of public funding for the deployment of such technologies. This could take the form of co-financing for the inception phase.

## • POSSIBLE BREAKTHROUGH TECHNOLOGY

- New types of clinker are being tested. They are produced at a temperature of about 1.200°C, which is roughly 250°C lower than the sintering temperature used in ordinary clinker manufacturing. The resulting process, if successful, would emit 30% less CO<sub>2</sub>.
- In Norway, the innovation project ELSE, a one-year collaborative project launched in April 2018, examines the possibility and the conditions for partially electrifying the cement production process. As a result, it should be feasible to assess if electrification of cement production is technically and economically viable. The conclusions will give insights into what potential is in the use of CO<sub>2</sub>-neutral energy in the combination with CO<sub>2</sub> capture. Last, but not least, the project will assess whether these goals are realistic.
- CemZero is a project conducted in Sweden which looks into feasibility of electrifying cement production, focusing on the calcination process, by 2030. This could result in an emission reduction of around 5 % of Sweden's total emissions.





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## How can policy help?

### **Encourage and facilitate increased alternative fuel use and alternative raw materials (waste co-processing in cement kilns)**

- Recognise its position in the **waste management hierarchy** as a combination of simultaneous energy recovery and material recycling.
- Cooperate with the cement industry to develop a methodology for assessing the **proportion of municipal solid waste being recycled through co-processing** and thereby contributing to recycling targets.
- Ensure a **level playing field among users of waste-derived fuels**
  - for the use of biomass waste by removing subsidies that favour one industry over another,
  - in relation to GHG emissions and related carbon pricing mechanisms.
- Develop and promote sets of **guidelines on alternative fuel use** inspired by international best practices and to ensure operators have adequate processes in place for quality control for material acceptance, traceability, and impact monitoring.

## Support the development and deployment of emerging and innovative low carbon technologies for clinker and cement production

- Ensure the cement sector is eligible for **investment mechanisms** that leverage private funding for low-carbon innovative technologies and through the promotion of private-public partnerships (e.g. the EU-ETS Innovation Fund).
- Develop **long-term holistic policy frameworks** that prevent carbon leakage. Investment security and appropriate economic frameworks are prerequisites for the deployment of innovative low-carbon technologies within the EU.
- **Carbon capture and storage, and reuse (CCS/CCU)**
  - **Coordinate regulatory frameworks for CCS/CCU internationally** and cooperate with industry to significantly expand efforts to educate and inform the public and key stakeholders about carbon storage to build social acceptance.
- **Support coordination and demonstration of CO<sub>2</sub> transport networks** on regional, national, and international levels to optimise infrastructure development.
- Foster international cooperation, for example through the **United Nations Framework Convention on Climate Change (UNFCCC)**, to harmonise approaches for **safe site selection**, operation, maintenance, monitoring, and verification of CO<sub>2</sub> permanent storage.
- Recognition of CCU (e.g. mineralisation) climate mitigation potential.





## 2

# Cement

At the scale of the cement industry, even small changes can make a big difference. Doing more with less clinker or making clinker more efficient in cements has been very successful, and research into activating other, less carbon intensive, elements is also looking very promising.

### PRODUCING LOW-CLINKER CEMENTS

The cement industry has been continuously reducing clinker content in cement and replacing it by other active elements such as fly ash, blast furnace slag, pozzolans or limestone to reduce CO<sub>2</sub> emissions.

It is important to highlight, however, that the decarbonisation of the European industry will have an impact on alternative material availability, such as fly ash and blast furnace slag.

In addition, the limited availability of calcined clay in Europe puts a constraint on a further reduction of the clinker content in cement in Europe compared to other parts of the world that have not, as yet, committed to a consistent path towards decarbonisation.

### DEVELOPING INNOVATIVE BINDERS

Apart from clinker substitution through the use of other active elements, more fundamental changes in the raw materials used in cement/clinker are also under development. **More diversified, less carbon intensive raw material mixes and clinker types** are being developed, tested or are already in use today.



Novel materials based, for example, on calcined clay, iron, bauxite instead of Portland clinker can offer a lower carbon and realistic solutions in regions where different raw materials are available. As clinker-based cement provides the durability, safety and strength of concrete, the cement industry is also directing its research into a detailed assessment of the impact of other raw materials on the durability and strength.

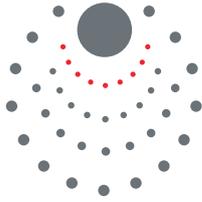
The cement industry is also exploring the potential for **development of low CO<sub>2</sub> binders**. Projects such as Solidia cement, Eco-Binder, Celitement, explore the technologies leading to around 30% lower CO<sub>2</sub> emissions in clinker production by using less limestone, a lower clinker burning temperature, and lower grinding energy requirements.

## **IMPROVING ENERGY EFFICIENCY**

The cement industry is continuously **improving grinding and mixing methods** to improve the performance of different types of cement as well as testing new substitutes and additives. The shift in grinding technology includes wider grinding with vertical roller mills and roller presses, high efficiency separators, optimisation of operating parameters of ball mills, but also R&D on potential future technologies by analysing different concepts for comminution, particle size distribution, transport, and classification of different materials.







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## How can policy help?

### Encourage and facilitate the efficient use of clinker and lowering of the clinker-to-cement ratio

- Provide support for and access to R&D funding for the development of processing techniques and performance testing for potential clinker substitutes.
- Support the CEN work on the development of standards for cement and concrete as well as building codes allowing more widespread use of novel cements whilst ensuring product reliability, safety, and durability at final application.
- Facilitate access to raw materials and enhance waste and by-products recycling policies.
- Ensure traceability/labelling/ethical and responsible sourcing of construction materials.
- Foster the use of low-clinker cements in sourcing and public procurement policies, provided that:
  - It is technically appropriate
  - Clinker substitutes are sustainably available
  - A life cycle approach is applied rather than simply focusing on product footprint or intermediate product impacts.
- Promote training events with experts, research institutes, and the construction sector, to exchange experiences on efficient use of clinker in building products, cement and concrete standards, and environmental and economic impacts.



### **Support the development and deployment of emerging and innovative low-carbon technologies for cement production**

- Reward clean energy investments and provision of flexibility to local energy grids, for example through fiscal incentives or initial support in rendering WHR (Waste Heat Recovery).
- Promote R&D into different existing and emerging grinding technologies and increasing the energy efficiency of this process.

### **Support the demonstration, testing, and earlier stage research for novel cements, and to develop large-scale demonstration projects and technical standards**





## 3

# Concrete

Cement is mainly used as a binder in concrete. One needs to remember that, no matter the concrete type, whether innovative or conventional, it has a low embodied CO<sub>2</sub> compared to most other construction materials such as timber (especially glue laminated timber), steel or bricks. Furthermore, few other materials provide the versatility, resilience, safety, and durability as well as high thermal mass, which makes concrete a highly energy efficient construction material. Thanks to their durability, concrete structures can last 100 years or more, which means resources and emissions are dramatically reduced compared to structural materials with shorter lifetimes. Last, but not least, concrete is 100% recyclable at the end of its life.

Nevertheless, the carbon footprint per tonne of concrete can be further reduced by using low-clinker cement, using it more efficiently, optimising the mix, aggregate packing, and fine-tuning additives, whilst helping to deliver the same performance and strength.



There are efforts underway to further leverage the potential of concrete to lower embodied CO<sub>2</sub> emissions.

- **The use of blast furnace slag or fly ash in concrete**, either as an addition or through a factory-made cement, can significantly reduce the overall greenhouse gas emissions associated with the production of concrete.
- By **using admixtures to optimise mix constituents**, the net improvement in water use and reduction in global warming potential of the concrete can be as high as 10-20%.
- **CO<sub>2</sub> can be used to produce concrete made from recycled aggregates** with additional strength and durability. This is done by exposing the aggregates to very high levels of CO<sub>2</sub> in a controlled curing chamber triggering a chemical transformation that locks the CO<sub>2</sub> in the concrete. These are called carbonatable binders.

These binders are being developed and market-tested for a number of applications. Contrary to traditional hydraulic binders that harden with water, carbonatable binders harden with CO<sub>2</sub> from flue gases at a much faster rate (as little as 1 day).

- Technologies like Solidia can save up to 250 kg CO<sub>2</sub>/tonne during cement manufacturing by using innovative clinker compositions and permanently store up to 300 kg CO<sub>2</sub> in concrete (per tonne cement used). This equates to a CO<sub>2</sub> saving of 50-60% per tonne of concrete.



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## How can policy help?

- Revisit, strengthen, and implement sustainability standards and regulations, such as public procurement policies, that are “material neutral” and take a “whole-life” approach, looking at the performance of the whole building rather than its individual components.
- Adequate training of architects/ engineers on the applicability of lower carbon concrete mixes and efficient design opportunities in buildings and infrastructure.

In addition, carbon neutrality in the built environment requires a collaborative approach across the construction value chain:

- Adequate training of engineers and contractors to use different types of cement and concrete in a meaningful and efficient manner.





## 4

# Construction & built environment

Buildings are responsible for 36% of CO<sub>2</sub> emissions in the EU and 40% of energy consumption. For this reason, one should look at the entire life-cycle of buildings and infrastructure, to constantly drive emissions reductions. In fact, buildings made with cement and concrete can further save CO<sub>2</sub> over their lifetime.

To meet the 2°C Scenario of the Paris Agreement by 2050, the building sector, as a whole, needs to move towards full carbon neutrality. The Global Alliance for Buildings & Construction identified several levers available to achieve this, including: nearly-zero energy buildings (nZEBs), deep renovation, better building management, and production of low-carbon energy. Cement and concrete have a very significant role to play in each of these.

## CONCRETE FOR EFFICIENT HEATING AND COOLING

Conventional buildings use 150-200 kWh/m<sup>2</sup>/year. By contrast, today's concrete buildings, thanks to thermal mass, long-lasting air-tightness, and other measures, can be designed to use 50 kWh/m<sup>2</sup>/year or less<sup>1</sup>. "Thermal mass" refers to concrete's unique ability to store energy and release it over a daily cycle, leading to reduced energy for heating and cooling, and more comfortable indoor spaces. Thermally activated concrete, where heating or cooling is delivered through pipes embedded in the concrete, further enhances the thermal mass effect. Though the benefits of thermal mass vary according to the type of building and where it is located, it can lead to savings of between 5% for heating and 20% for cooling. In the case of thermally activated concrete, almost twice as much energy can be saved.

<sup>1</sup>THERMAL MASS. The smart approach to energy performance by CEMBUREAU (2015)

As Europe decarbonises its electricity supply by moving to renewable sources, and as buildings become increasingly heated and cooled by efficient, electrically driven heat pumps rather than gas, concrete offers the best way to take advantage of this low-carbon energy. This is because, as well as making buildings more energy efficient, the thermal mass of concrete buildings can be used to store energy and better match fluctuating renewable energy sources to demand. This is known as “demand response”.

A study by The Concrete Initiative<sup>2</sup> showed that the flexibility provided by the thermal mass of buildings could lead to significant savings both at the level of the electricity grid (e.g. by a reduction of the need for excess capacity to cover demand peaks up to 50%) and at the level of individual buildings, with a resulting higher penetration of renewable energy and CO<sub>2</sub> emission reductions (up to 25% CO<sub>2</sub> savings per structure).

## **CONCRETE STRUCTURES TO LAST**

When it comes to renovation of existing buildings, concrete is the material of choice. Thanks to its durability, concrete structures can last several renovation cycles without the need to be rebuilt. This being said, it is worth remembering that overall renewal of the building stock to make it more energy efficient also includes rebuilding – which in many cases can be the preferable option from an economic, energy efficiency, and social point of view.

## **SMART CONCRETE**

The final lever, “better building management” includes both user behaviour and automation & controls. As in the example above, “smart” (automated) control of heating and cooling through thermally activated concrete,

in communication with the smart electricity grid, is one of the best ways to manage supply and demand, and fully use all renewable energy produced.

## **CONCRETE FOR RENEWABLE ENERGY PRODUCTION AND LOW-CO<sub>2</sub> TRANSPORT SOLUTIONS**

The description of whole-life CO<sub>2</sub> savings of concrete buildings above can also be applied to its use in infrastructure, thanks again to its durability and resilience. Concrete bridges and tunnels reduce emissions from vehicles, while much CO<sub>2</sub>-saving renewable energy infrastructure such as dams and wind farms would not be possible without concrete.

## **INNOVATIVE CONCRETE SOLUTIONS**

If the construction sector is to become carbon neutral, technology and innovation for construction and use of the built environment need to play an important role. This is why, in addition to the more conventional contribution to reducing life-cycle emissions described above, the cement and concrete sector continues to innovate to increase the life-cycle CO<sub>2</sub> savings.

For example, like other European industries and services, the construction sector could be expected to be transformed by digitalisation. From greater precision thanks to industrialised production and 3D printing, to supply chain optimisation thanks to the integration of chips, carbon emissions in the construction sector will be driven down further.

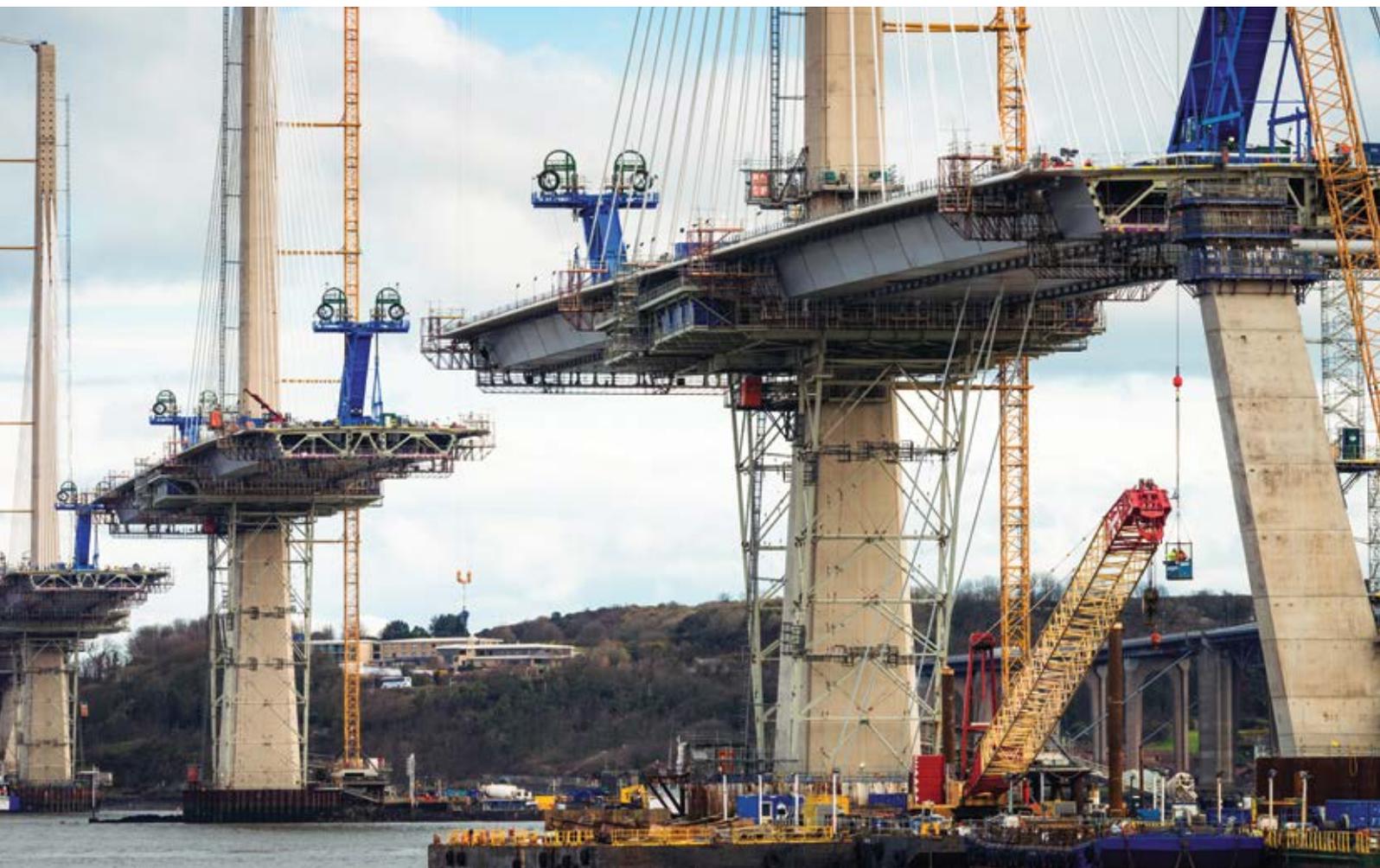
In addition, when thinking of the life of a building, architects also innovate to develop designs that allow for greater modularity of a construction.

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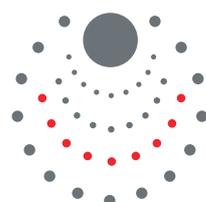
<sup>2</sup> Structural Thermal Energy Storage in Heavy Weight Buildings –Analysis and Recommendations to Provide Flexibility to the Electricity Grid (2016) by 3E for CEMBUREAU

This means that a building could be adapted to new uses through its lifetime. Consequently, building elements, or even entire buildings, could become modular and re-usable. The use of solutions that reduce the amount of needed materials, reduce waste, and increase material efficiency, can be expected to increase. Concrete proves to be a material of choice for that purpose.

- Several pilot projects in Austria have demonstrated the effectiveness of using concrete to store excess energy produced when renewable energy was available thus taking full advantage of renewable energy peaks – allowing buildings to run year-round for virtually no heating costs!
- Concrete wall panels were re-used in the rehabilitation of the Kummatti housing estate in Raahe in Finland resulting in 36% savings in construction costs.
- Housing in Mehrow near Berlin includes reuse of precast concrete elements, from unwanted buildings that have been constructed using “Plattenbau” construction technique, for the construction of new houses. The project resulted in 30% reduction in costs and substantial reduction of the building's CO<sub>2</sub> footprint.



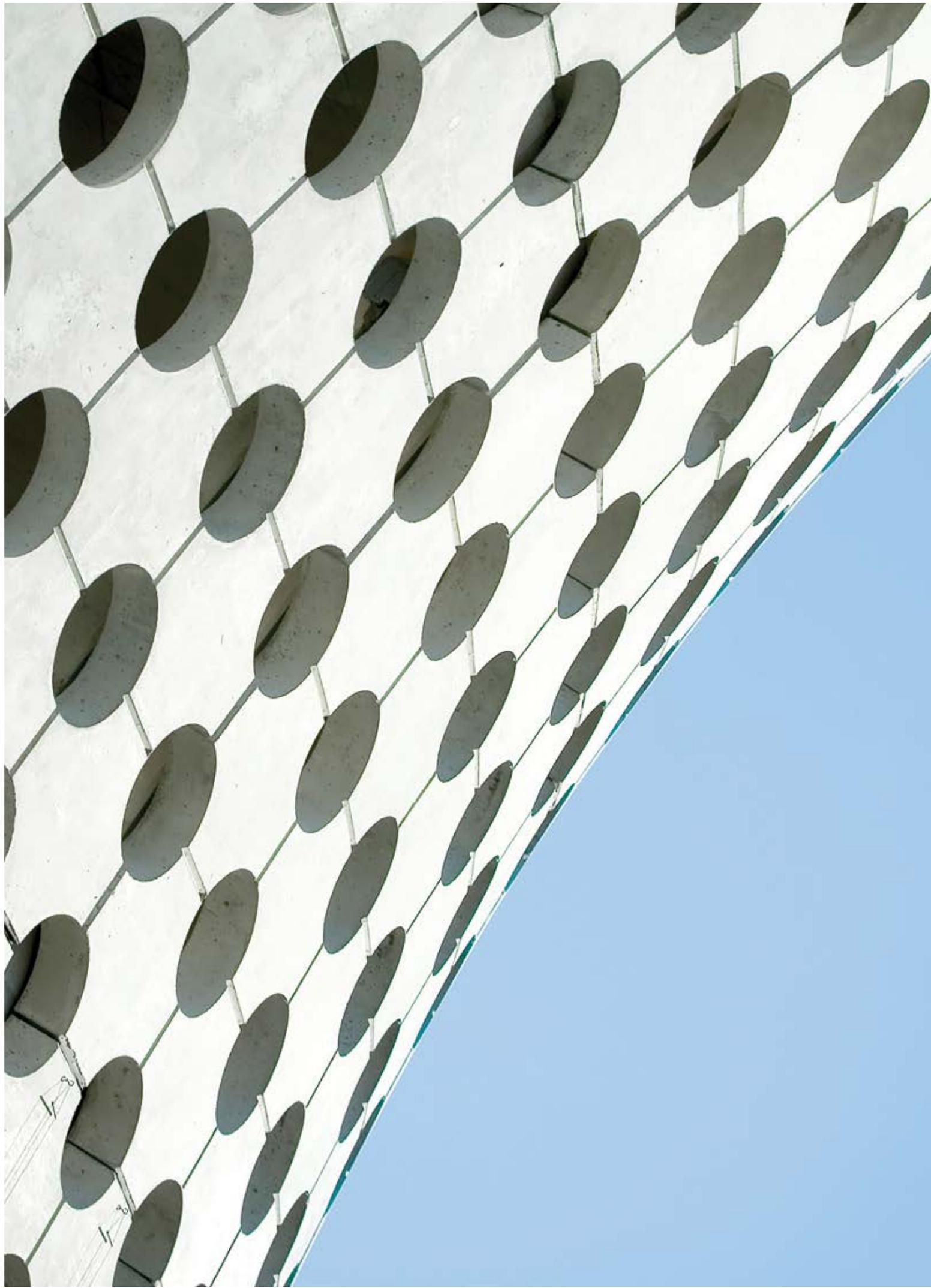




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## How can policy help?

- Continuously focus on driving down energy use by buildings in Europe through the implementation of the Energy Performance of Buildings Directive (EPBD) at national level, including accounting for thermal mass in energy performance calculations.
- Revisit, strengthen, and implement building regulations and specifications aiming at achieving carbon neutrality of the built environment over its entire life-cycle, including use phase and end-of-life of buildings and infrastructure applications.
- Take advantage of structural thermal energy storage when designing an integrated, smart, and decarbonised energy grid and building stock.



## 5

# (Re)Carbonation

A little-known fact about cement is that it is a carbon sink!

### A NATURAL REACTION

Hydrated cement used in concrete or mortars naturally absorbs CO<sub>2</sub> during its lifetime, a process known as (re)carbonation, thus removing carbon from the atmosphere. This permanently locks CO<sub>2</sub>, providing a stable long-term CO<sub>2</sub> storage solution. The process can even boost concrete strength by increasing the density of its pore structure. During the life of a built structure, up to 25% of the process emissions related to the production of the cement can be absorbed.

The Intergovernmental Panel on Climate Change (IPCC) recognises the phenomenon of (re)carbonation for carbon removal, even though it is currently not considered in the countries' GHG emissions inventories. Recent studies have shown that it is possible to make robust calculations of the amount of CO<sub>2</sub> absorbed by the building stock as a whole.

The cement industry is currently working on developing a suitable global methodology. It would allow a country to account for the CO<sub>2</sub> removal thanks to concrete carbonation.

### DESIGNING FOR PERMANENT STORAGE

Concrete in the built environment offers opportunities for permanent storage of carbon. CO<sub>2</sub> uptake by (re)carbonation is a natural process for concrete surfaces exposed to air. Reinforced concrete is designed so that carbonation happens slowly during the life of the structure (in order to avoid corrosion of reinforcement bars), and at a greater rate after demolition and crushing. However, innovative design for recycling of building elements as well as improved handling of construction and demolition waste could maximise the (re)carbonation potential.

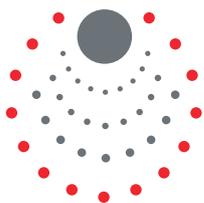


Stockage de CO<sub>2</sub> par carbonatation du béton recyclé

### **FASTCARB PROJECT**

(Accelerated carbonation of recycled concrete aggregate – [www.fastcarb.fr](http://www.fastcarb.fr)) is a collaborative project that brings together several firms and research institutes (21 partners) to:

- optimise the accelerated carbonation process under laboratory conditions in order to obtain a solution which can be transposed to the industrial scale at a reasonable cost, and
- show that the process could be used under industrial conditions (in particular, a pilot test in a cement production plant).



**CLINKER  
CEMENT  
CONCRETE  
CONSTRUCTION  
CARBONATION**

## **How can policy help?**

- As the IPCC recognises the phenomenon of carbonation for carbon removal, countries should use a suitable global methodology to account for the CO<sub>2</sub> removal to calculate the average net emissions of all cements produced.





# Our advances in breakthrough technologies

Find out more on some of research projects and technology demonstrators of potential breakthrough technologies:

- **Norcem CCS:** CO<sub>2</sub> capture demonstrator
- **ECRA:** oxyfuel project (gas CO<sub>2</sub> enrichment for optimising CCS/U)
- **CEMCAP:** CO<sub>2</sub> capture technology
- **CLEANKER:** CO<sub>2</sub> capture using calcium loop processing
- **LEILAC:** direct CO<sub>2</sub> separation



The **ECRA CCS project** aims at demonstrating **oxyfuel technology**, which uses pure oxygen instead of air in combination with flue gas recirculation in order to provide a high CO<sub>2</sub> concentration exhaust gas stream for further capture in two pilot plants, in Austria (Retznei) and Italy (Colleferro).

<https://ecra-online.org/research/ccs/>

For novel cement, main ongoing research projects include:

- **SOLID LIFE:** novel non-hydraulic binder
- **AETHER:** less limestone, lower temperature, less energy cement
- **CELITEMENT:** innovative cement production process
- **ECO BINDER:** insulating concrete systems based on novel low CO<sub>2</sub> binders



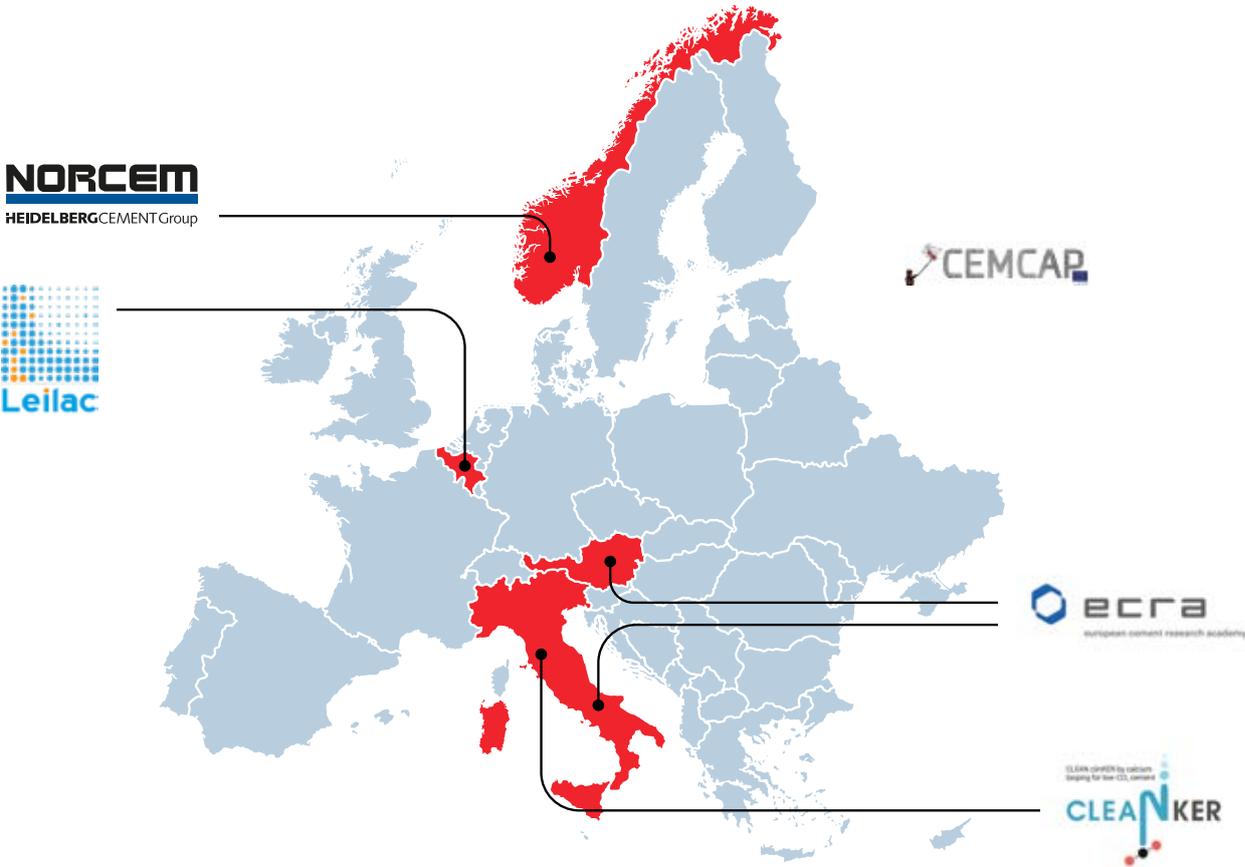
The **Norcem's Brevik CCS project using post-combustion technologies**, a tail-end separation of CO<sub>2</sub> from flue gas, has recently received financial support from the Norwegian government.

[www.norcem.no/en/carbon\\_capture](http://www.norcem.no/en/carbon_capture)



**CLEANKER is looking to advance the Calcium Looping (CaL) process for CO<sub>2</sub> capture.** The core activity of the project is the design, construction, and operation of a CaL demonstration system in the cement plant operated by Buzzi Unicem site in Vernasca (Italy). The CO<sub>2</sub> from a portion of the flue gas of the cement plant is to be captured. It can then be transported to a storage site or reused.

[www.cleanker.eu/home-page-it](http://www.cleanker.eu/home-page-it)



**NORCEM**  
HEIDELBERGCEMENT Group



The cement sector is also joining up with the lime industry to focus on the development of **Direct Separation technology**, which seeks to re-engineer the process flows of a traditional calciners by indirectly heating the material being processed and hence separate the process emissions and enabling pure CO<sub>2</sub> to be captured (**LEILAC project**).

The **CEMCAP Project** is a project funded by Horizon 2020. Its prime objective is **to prepare the ground for large-scale implementation of CO<sub>2</sub>-capture in the European cement industry**. Its focus is to demonstrate oxyfuel and post-combustion capture. In addition, a dedicated clinker cooler for oxyfuel cement plant will be designed and built.

<https://www.project-leilac.eu>

[www.sintef.no/projectweb/cemcap](http://www.sintef.no/projectweb/cemcap)

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N° Editeur: D/2018/5457/October



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Published by CEMBUREAU  
The European Cement Association  
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