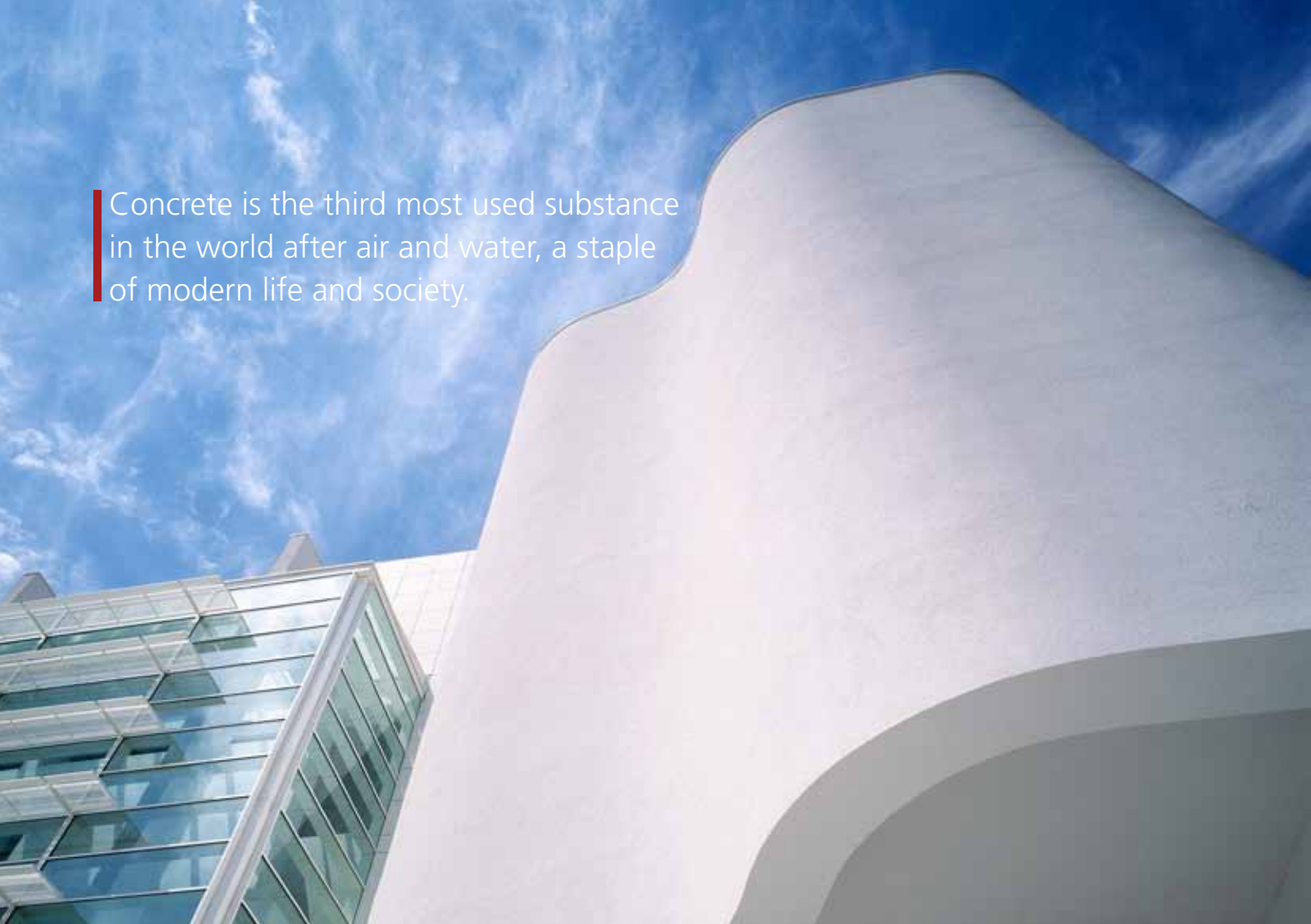


# The role of CEMENT in the 2050 LOW CARBON ECONOMY

## Executive Summary



THE EUROPEAN  
CEMENT ASSOCIATION



Concrete is the third most used substance in the world after air and water, a staple of modern life and society.

# CONCRETE ACTION for 2050

**Concrete combines simplicity, durability, strength, affordability and infinite ability to be moulded. It provides the solid foundations and essential built environment for society. Concrete is the third most used substance in the world after air and water, a staple of modern life and society.**

The special ingredient or glue which makes all this possible is a rather ordinary-looking grey powder called cement. Globally, cement production accounts for around 5% of man-made CO<sub>2</sub> emissions. The industry recognises this responsibility and embraces its commitment to reduce this markedly, especially by contributing to the circular economy. In the roadmap, we focused on what can be done to reduce CO<sub>2</sub> in cement production using today's technology, and will speculate on what could be achieved by 2050.

As an industry, however, we will not focus only on the solutions we provide, but also continue to act responsibly to manufacture with maximum care. The roadmap explores different routes and possibilities for achieving a substantial reduction in CO<sub>2</sub> emissions in cement production. Moreover, their impact will not

be limited to reducing CO<sub>2</sub> emissions, but can also lead to a meaningful decrease in other greenhouse gas emissions, as well as energy and use of natural resources. We are confident that a combination of parallel routes will result in a sustainable cement industry in Europe.

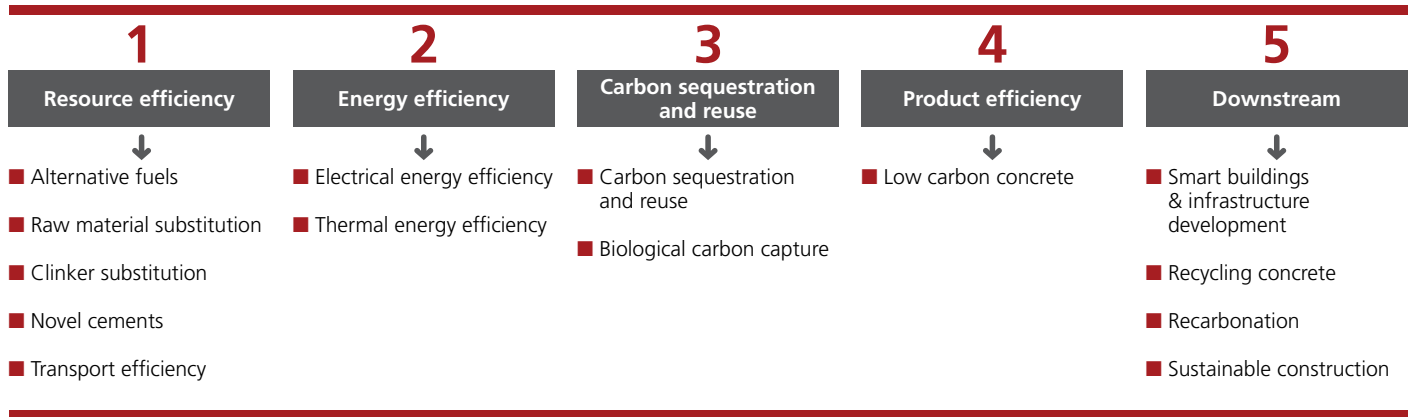
# A LOW-CARBON EUROPEAN CONCRETE and CEMENT SECTOR in 2050

**The roadmap presents a vision for the sector whereby the cement carbon footprint could be reduced by 32% compared with 1990 levels, using mostly conventional means. It also describes potential levers for how this could be further increased by the application of emerging new technologies, such as carbon capture and storage (CCS). Subject to specified policies and technological prerequisites, a potential reduction of up to 80% may be envisaged.**



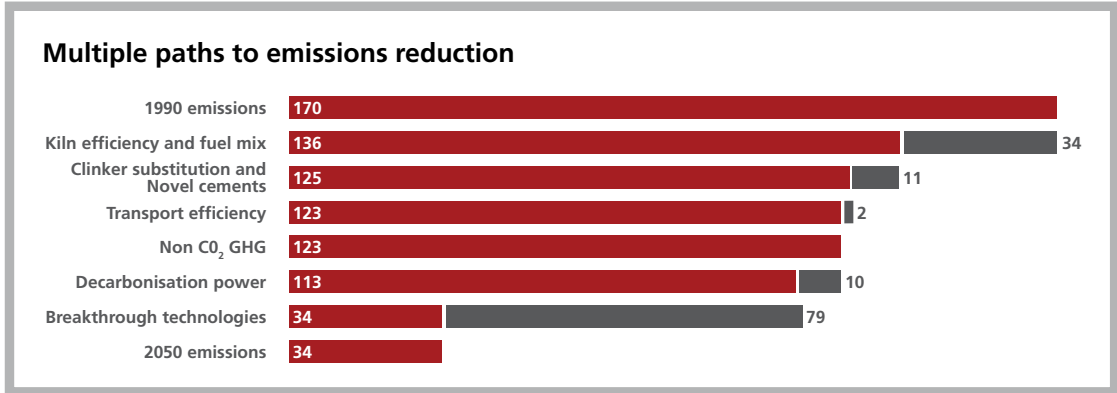
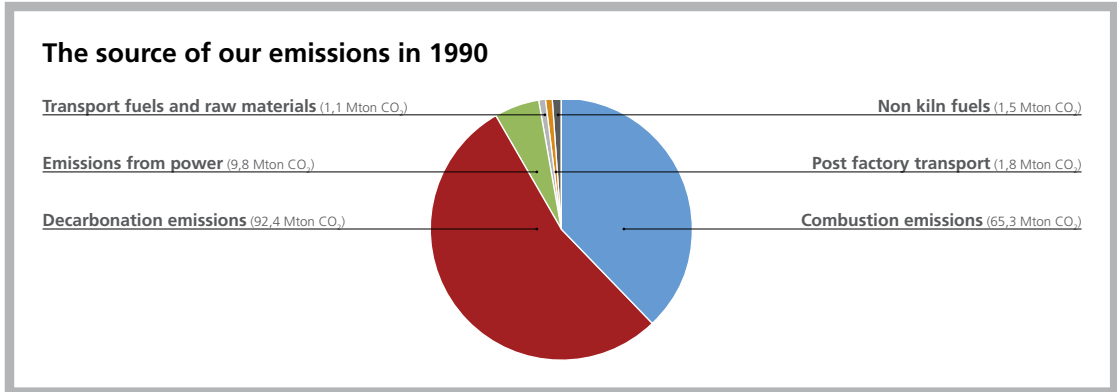
The industry has focused on five routes to achieve these objectives, three of which are considered to be 'under the sector's control'. Potential savings from the other two routes outlined (Product Efficiency and Downstream) do not relate directly to cement manufacturing, so were not included. The sector is committed, however, to investing in innovation that explores new ways for cement and concrete to contribute to a low carbon and circular economy, especially where life cycle emissions of buildings and structures can be meaningfully reduced by intelligent use of concrete. This could increase the overall contribution further.

The sector is committed to investing in innovation that explores new ways for cement and concrete to contribute to a low carbon and circular economy.



Only a combination of different ways to reduce emissions, as set out in each of the chapters below, can achieve substantial reductions.

# Our EMISSIONS




Building blocks and assumptions can be found on [lowcarboneyconomy.cembureau.eu](http://lowcarboneyconomy.cembureau.eu)

## Our unique carbon profile

The cement and lime industries are unique due to the fact that the majority of greenhouse gas emissions are not caused by energy use from fuel combustion, but come from the raw materials themselves. Around 60% of total CO<sub>2</sub> emissions from clinker production are released directly from the processing of limestone. Of the remaining 40%, most originate from burning fuel in the kiln to reach the high temperatures necessary for clinker mineral formation. Indirect emissions from electrical power consumption contribute approximately 6% to overall CO<sub>2</sub> emissions.







The ability to mix fossil fuels like coal or gas with waste materials, biomass and industrial by-products is beneficial both from a resource efficiency and security of supply point of view.



# 1

## FIVE PARALLEL ROUTES: Resource Efficiency

### **Alternative fuels**

Alternative fuels, including a high proportion of waste products, are increasingly being used and now represent almost a third of all fuel in the EU cement industry. The unique process and energy requirements of the cement industry enable use of fuel mixes that would not be suitable for many other industries. This ability to mix fossil fuels like coal or gas with waste materials, biomass and industrial by-products is beneficial both from a resource efficiency and security of supply point of view.

It has been estimated that by 2050, 40% of kiln energy could potentially come from traditional sources, i.e. coal (30%) and petcoke (10%), while 60% of kiln energy could potentially be provided by alternative fuels of which 40% could be biomass. This fuel mix would lead to an overall decrease of 27% in fuel CO<sub>2</sub> emissions.

### **Raw material substitution**

The main raw material used in cement production has traditionally been limestone. Limestone is abundantly available, but over 60% of the industry's CO<sub>2</sub> emissions are caused by transformation of limestone into lime.

Limestone needed to make clinker can be partially substituted by a range of alternative calcium containing materials, including waste and industrial by-products, which are already increasingly being used. Moreover, many of the alternative materials are ashes provided by the combustion of alternative fuels.

At a European level, it is estimated that the clinker-to-cement ratio can be reduced to 70%, resulting in a further CO<sub>2</sub> saving of 4%.



### **Clinker substitution**

Ordinary Portland cement can contain up to 95% clinker (the other 5% being gypsum). The current average clinker-to-cement ratio over all cement types in the EU27 is 73.7%<sup>1</sup>. The use of other constituents in cement and the reduction of the clinker-to-cement ratio means lower emissions and lower energy use. Clinker can be blended with a range of alternative materials, including pozzolans, finely ground limestone and waste materials or industrial by-products. However, varying clinker content has an impact on the type of applications the cement can be used for.

There is a need to ensure that all the cement manufactured is safe and durable as it will be used in structures that are made to last at least 50 years or more. Thus, high durability of the final product concrete is a key property for sustainable construction.

There is some uncertainty regarding the future availability of clinker substitutes (for example fly ash supplied by coal fired power plants) as well as the impact of environmental policy and regulation.

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### **Novel cements**

The European cement industry is highly innovative with large scale research centres in several countries and hundreds of patents filed each year. A number of low-carbon or very-low-carbon cements are currently being developed. While some daunting hurdles and validation of product properties remain, there is ultimately the exciting prospect of entirely new types of cement.

<sup>1</sup>Source: For the purposes of meaningful reporting, the definition of cement used in the GNR database differs slightly from that in common use. In this document, cement and cementitious products are considered equivalent.

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There is a future for new or novel cement types, but given the early stage of their development, it will take quite some time before large-scale production becomes a reality. Furthermore, they are likely to be used in non-structural niche applications for the foreseeable future. Nevertheless, a 5% share of total cement production for novel cements has been included, namely 11 million tonnes. Novel cements will still require energy for their production and will not be zero carbon products. The exact potential carbon reduction is not known at this time but for many of the more promising technologies, it is estimated to be around 50%, which has been applied in the modelling for the expected 5% of total cement production.

### **Transport efficiency**

Cement is a heavy product and so are its raw materials. The industry is continuously working on solutions to reduce transport related emissions and expects to make significant progress on reducing emissions related to heavy haulage by mixing water and land based transport modes as well as improving transport efficiency.

If the share of road transport is reduced to 50% by 2050, with both rail and water representing 23% each, combined with innovation in the transport sector, it has been estimated that transport related emissions can be halved.



In a bid to increase its competitiveness, the European cement industry continuously strives to reduce power consumption and will continue to do so.



# 2

## FIVE PARALLEL ROUTES: Energy Efficiency

### **Electrical energy efficiency**

Cement production requires electric power at several stages, from crushing of raw materials over clinker production and cement grinding.

Continuous improvements to the production process will lower the amount of electricity used. Replacing older plants with more modern and efficient technologies and continually modernising existing plants will result in improved electrical performance. However, deploying Carbon Capture technology could increase electricity consumption by 50-120%.

The model included in this roadmap assumes a total decarbonisation of the power sector by 2050 and all measures that will be taken to reduce our electricity consumption do not have an impact on the carbon profile of the calculations. Nevertheless,

the European cement industry continuously strives to reduce power consumption and will continue to do so.

### **Thermal energy efficiency**

Cement manufacturing requires raw materials to be heated to 1450°C and is thus rather energy intensive, even if thermal energy only accounts for approximately 35% of the cement industry's CO<sub>2</sub> emissions.

Continuous improvements to production facilities have almost halved our energy use since the 1960s. Most European plants now use state-of-the-art technology and the few remaining older wet kilns will be replaced by more modern plants and concentration of production in fewer, larger, plants will lead to further reduced energy consumption.



Taking into account the increased use of alternative fuels, average thermal energy consumption per tonne of clinker is expected to reach 3.3 MJ/tonne by 2050.

Under optimised and regular conditions, the best energy efficiency today – around 3,300 MJ/t clinker – can be achieved with preheater kilns with precalciners (PH-PC)

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# 3

## FIVE PARALLEL ROUTES: Carbon sequestration and reuse

### **Carbon Sequestration and Reuse**

Even with the most efficient processes, a part of the CO<sub>2</sub> emissions linked to cement production cannot be avoided. The possibility of carbon capture is currently being evaluated in several large scale integrated CCS (Carbon Capture and Storage) projects in the power sector and the initial results show currently available technologies could capture 90% of CO<sub>2</sub> emissions.

Captured carbon could be transported to a storage site or used in other production/downstream processes e.g. to grow algae as biomass that can be used as a fuel.

Carbon capture would increase production costs by 25 to 100%, require substantial investments and the use of additional electricity. CCS is only realistic if the

CO<sub>2</sub> transport infrastructure and storage sites are suitable and approved for that purpose.

Carbon capture in the cement industry is still at the research & development stage. Nevertheless, the potential of CCS looks promising. In order to achieve an 80% reduction in CO<sub>2</sub> emissions by 2050, taking into account all other measures, and without any other breakthrough technology, 85% of all clinker production would have to be equipped with carbon capture technology, which amounts to 59% of all plants since carbon capture would be deployed at larger plants.

### **Biological carbon capture**

A promising alternative to CCS is using algae to 'eat' CO<sub>2</sub> emissions and produce fuel at the same time. Because of their substantial emissions, cement



## Research projects will help to determine the functional and economic feasibility of industrial organic biomass production.

plants would be ideally suited for deployment of this innovative technology. Several projects, including large-scale undertakings in Spain and France, are currently underway to test the technology.

The algae can be harvested and dried (possibly using waste heat from the cement plant), before being used as a fuel for the cement kilns. Alternatively, algae biomass can be processed into third-generation biofuels, bio-plastics or high-value-added compounds like antioxidants, lipids or proteins.

The technology is still at a very early stage of development. Research projects will help to determine the functional and economic feasibility of industrial organic biomass production and how to incorporate this technology into the manufacture of cement.

# 4

## FIVE PARALLEL ROUTES: Product Efficiency

### **Low carbon concrete**

After cement manufacturing, several techniques and processes are used that further improve the environmental performance of concrete. Techniques include using high performance cements to optimise cement use per tonne of concrete, locally sourcing of aggregates, optimising admixtures and concrete composition at the concrete mixing stage.

Modern high strength concretes can reduce the volume of concrete needed to create a specific structure. None of these have been included in the CO<sub>2</sub> reduction model as they do not relate to reducing the impacts of cement manufacturing itself.



# 5

## FIVE PARALLEL ROUTES: Downstream

Cement is never used on its own. It is always mixed with other materials to make plaster, mortar and most importantly concrete. Therefore, the sector looks beyond the factory gates and carries out research and product development to improve the environmental performance of concrete and how to reuse or recycle concrete. None of the potential savings outlined in these sections were included in our calculations.

### **Smart building and infrastructure development**

Today, solutions exist for new buildings to be built with 60% less energy use and CO<sub>2</sub> emissions over the life cycle than conventional buildings constructed 20 years ago.

Technology and new techniques in cement and concrete can help extend the service life of buildings, and improve their energy efficiency performance.

New buildings can be built with deconstruction rather than demolition in mind and parts of buildings could be re-used in their entirety or as modular elements.

### **Recycling concrete**

About 200 million tonnes of construction and demolition waste (C&DW) is generated every year in Europe. Fortunately, at the end of its life cycle, concrete can be recycled thus reducing its environmental impact. The 'zero landfill' goal of concrete can be achieved if the structure is carefully conceived and designed, and if the building undergoes successful renovation or demolition.

Crushed concrete can be used as an aggregate in concrete and the hardened cement fraction in concrete can be recycled to raw material for cement production. Crushed concrete can also be reused as a foundation or backfilling for many applications.

# Concrete buildings can achieve considerable energy savings during their lifetime because of the high level of thermal mass they deliver

## Recarbonation

During the lifetime of a concrete structure (such as a building or road), hydrated cement contained within the concrete reacts with CO<sub>2</sub> in the air. Part of the CO<sub>2</sub> emitted during cement production is re-absorbed by the cement through carbonation, a reaction also referred to as cement recarbonation.

Recarbonation mainly takes place at the surface. Thus, if the structure can be deconstructed, crushed concrete should be exposed to the air to enable the full potential of recarbonation before it is used as a foundation or backfiller.

Studies have been conducted to analyse the recarbonation potential. They show that 5-20% of the CO<sub>2</sub> emitted during the cement manufacturing process is taken up during the service life cycle of concrete, and an additional 5-10% may be taken up during the secondary or recycled lifetime.

## Sustainable construction

Energy consumption of buildings is one of today's major environmental concerns, as buildings account for approximately 35% of total EU greenhouse gas emissions (including direct and indirect emissions from electricity generation).

Concrete buildings can achieve considerable energy savings during their lifetime because of the high level of thermal mass they deliver, meaning that the indoor temperature remains stable even when there are fluctuations in temperature outside.

In the transport sector, which accounts for 20% of total European greenhouse gas emissions, concrete also contributes to reducing CO<sub>2</sub> emissions in a cost-effective way. According to studies, concrete pavements can lower fuel consumption of heavy trucks by up to 6% by reducing rolling resistance between the road and the truck.

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[www.cembureau.eu](http://www.cembureau.eu)

The full Roadmap is available at:  
[lowcarboneyconomy.cembureau.eu](http://lowcarboneyconomy.cembureau.eu)

Comments on this roadmap are welcome and should be sent  
to Jessica Johnson ([aj.johnson@cembureau.eu](mailto:aj.johnson@cembureau.eu))



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