NO OFFSETS REQUIRED

The concrete industry is developing a roadmap to net-zero carbon – and there will be no grey areas, writes Claire Ackerman

Decarbonising concrete has been a focus of the industry for 30 years. It has been reporting on its efforts since the Kyoto protocol in 1990 – which is why 1990 is the benchmark for the carbon indicators in the Concrete Industry Sustainable Construction Strategy. First launched in 2008, the strategy represents a commitment from 10 different sub-sectors to work to an agreed reporting framework. The latest report, the 12th, is based on performance data from 2008 to 2018 and the headline statistic is that the embodied carbon of a standardised mix of concrete is now 72kg per tonne, a reduction of 30% from the 1990 baseline.

The original strategy set a range of targets for 2012, which were subsequently updated with new ones for 2020. As we reach that milestone, the concrete industry will set out a revised strategy for beyond 2020, with the aim of achieving net-zero carbon. At The Concrete Centre, we want to make the journey as easy as possible for designers, but – let's be honest – it is complex. So the next four pages don't contain all the answers, but they do explain some of the key components of the solution.

The first challenge in reaching net-zero carbon is to understand what puzzle you are trying to solve. Are you looking at carbon at a product level, or carbon at a building or structure level? They obviously work together, but the levers for change are very different, so they are best explained separately. Then there is the carbon comparison for the first life of a building versus its many potential uses over a whole lifetime, which is covered on pages 3-9.

Decarbonising cement and concrete

The majority of the embodied carbon in concrete comes from cement, an ingredient that plays an important role in properties such as fire resistance and durability. For over 20 years, the UK cement industry has been replacing fossil fuels with renewable, low-carbon sources. Through fuel switching and the use of by-products from other industries, carbon dioxide emissions per tonne of cement have fallen by 29% since 1990.

A 2019 study by the University of Cambridge Institute for Sustainability Leadership (CISL), ▶

INNOVATION IN ACTION

Low-carbon cements

In 2018, the Mineral Products Association (MPA) initiated a project to develop new low-carbon multi-component cements for UK concrete applications, forming a partnership with Hanson, BRE and Bison Precast with the aim of saving carbon through the increased and more efficient use of low-carbon cement. Recent research has shown that materials such as ground granulated blast-furnace slag (GGBS), fly ash, calcined clay and powdered limestone can work together effectively in a multi-component cement. Combinations such as cement-GGBS-limestone, cement-fly ash-limestone and cement-calcined clay-limestone potentially enable greater rates of cement replacement – in current tests, 65% has been achieved. The project is testing the performance of a range of concretes (22 new cements in 50 concrete mixes) and the results will be used to support standardisation of low-carbon multi-component cements in British standard BS 8500. The project is due to be completed in 2021 with the new materials available to the market soon after. The research and demonstration are part-funded by the government under the Department for Business, Energy and Industrial Strategy's (BEIS) £9.2m Industrial Energy Efficiency Accelerator programme, which is managed by the Carbon Trust assisted by Jacobs.

Industrial fuel switching

Switching from fossil fuels to hydrogen and plasma energy could also reduce carbon emissions in cement and lime production. In 2019, a BEIS-funded feasibility study found that a combination of 70% biomass, 20% hydrogen and 10% plasma energy could eliminate fossil fuel CO_2 emissions from cement manufacturing. Now BEIS has awarded £6.2m to the MPA to test that theory. The groundbreaking project will involve trials at sites operated by Tarmac and Hanson Cement, one focusing on electrical plasma energy with biomass, the other on hydrogen and biomass.

Carbon capture

"Direct separation" is a new type of carbon-capture technology, in which the pure CO_2 released from limestone as it is heated is collected separately from the furnace exhaust gases. In a five-year, EU-funded programme that began in 2016, the LEILAC (Low Emissions Intensity Lime And Cement) project has been testing its application to the cement and lime industries at the HeidelbergCement plant in Lixhe, Belgium. The pilot unit has undergone two years of extensive testing in a standard operational environment, in order to demonstrate that the technology can work at scale across the industry. LEILAC will also deliver a techno-economic roadmap for implementation and share knowledge with industry partners.

LEFT All of the in-situ concrete at Nicholas Hare Architects' University College London Student Centre includes 50% GGBS

Photo: Alan Williams

published by Material Economics, found that it was possible for the cement sector to be net-zero carbon by 2050, although it also estimated that zero-carbon production will cost more than current practice.

The report identifies four routes for cement and concrete to decarbonise:

- Materials efficiency and circular business models
- Materials recirculation and substitution
- New low-emissions processes
- Carbon capture and storage/use.

Not all of these activities are related to cement and concrete production – some fall under the scope of the designer.

Cement and concrete production

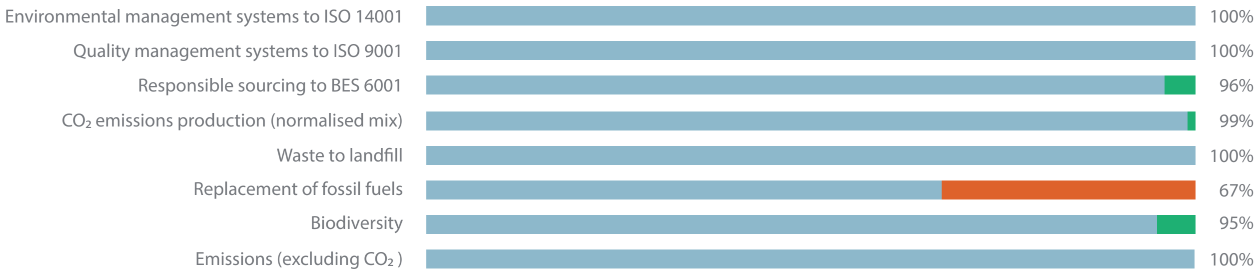
The simplest place to start is with energy use and indirect emissions. As the electricity grid decarbonises, the energy used to produce materials will be less carbon-intensive, reducing the embodied carbon of cement and concrete. The decarbonisation of delivery transport will also have an impact. Concrete is a local material so the overall travel distances are small. As the automotive industry deploys low-carbon vehicles, the costs and emissions profiles for transport will change.

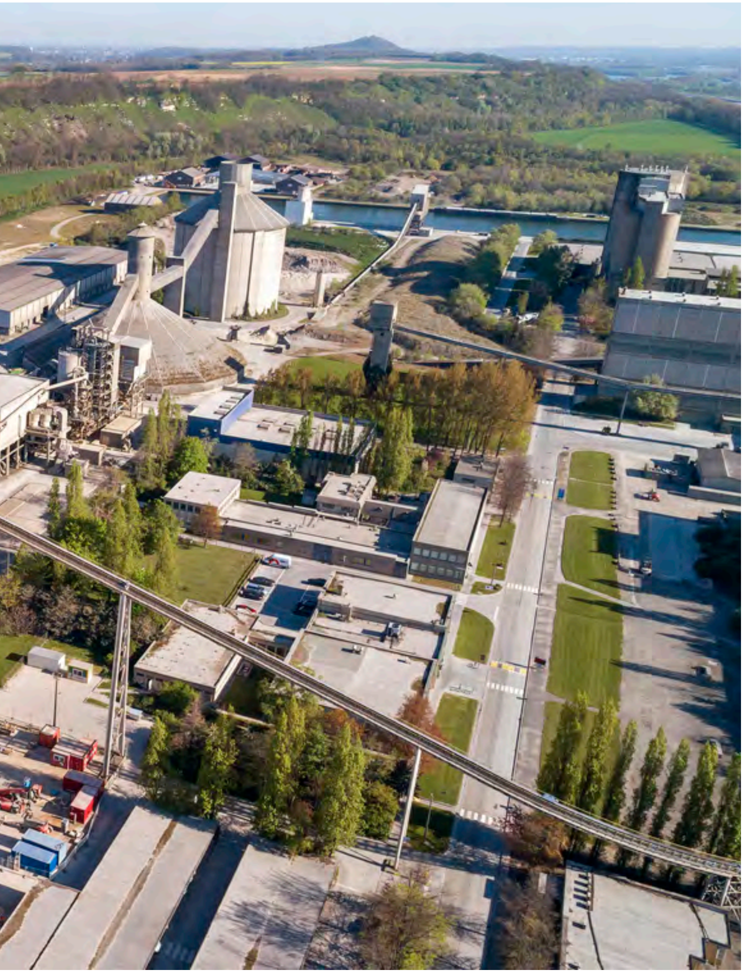
The next energy use category is direct emissions, the energy use that is in the control of the cement and concrete manufacturer – combustion and process emissions. A cement kiln reaches high temperatures, and that requires energy. Here fuel switching is one answer: the industry has already replaced 34% of its fossil fuel use with renewable, low-carbon sources, which include biomass as well as materials from other industries and processes that could otherwise go to landfill. But to reach net zero, a zero-carbon fuel mix is needed, and this will require new technologies. The cement sector has recently been awarded funding by the Department for Business, Energy and Industrial Strategy to test emerging technologies such as hydrogen-based fuels (see box, page 21).

Some emissions are difficult to abate, and this is true of the process

Sustainable concrete: Progress to 2020 targets based on 2018 performance data

The graph below summarises the 12th progress report on the Concrete Industry Sustainable Construction Strategy. The strategy is underpinned by the international standards ISO 14001 on environmental management and ISO 9001 for quality and performance, and the industry has met its target on both of these, with 100% of sites now certified. It also uses the responsible sourcing standard BES 6001, to which 96% of concrete is certified. The concrete industry is a net user of waste and by-products from other industries, using 271 times more than it produces. The graph is based on a 2008 baseline year for all targets, other than carbon targets, which are based on a 1990 baseline year. For the latest updates on the data, visit sustainableconcrete.org.uk





ABOVE The LEILAC project has been testing the application of "direct separation" technology to the cement and lime industries at the HeidelbergCement plant in Lixhe, Belgium

Photo: Carbon Trust

emissions related to the physical transformation of limestone to Portland cement. One option is lower-carbon clinkers – already other minerals are added to reduce the use of Portland cement clinker and produce lower-carbon cements. New technologies are also in development.

Alternative clinkers can help to reduce process emissions, but adoption of carbon capture, use and storage (CCUS) is needed to eliminate them entirely. CCUS will enable the transition to net-zero carbon of not only the cement and concrete industry, but the steel industry too. For the cement and lime sectors, there is a live demonstration project in Belgium (see box, page 21). There are obviously considerable costs associated with such transformative technology, and collaborative European projects are currently leading the way. The UK cement sector is encouraging the government to support similar projects for the local manufacture of net-zero carbon cement.

The cement and concrete industry is developing a roadmap to net-zero carbon, which will include the potential application and associated costs of a number of enabling technologies. Implementation of these technologies is not all within the control of the industry, though we want to collaborate to accelerate progress. One thing that the industry can control is the first principle of the roadmap: it will not rely on offsetting.

Concrete and carbon in the built environment

The other group of enablers that are vital to achieving net-zero carbon concrete and a net-zero carbon built environment are designers and the wider construction industry, through material specification, design, use and reuse of buildings. The construction industry represents 7% of the UK's economy yet 10% of its CO_2 emissions, and it directly influences 47% of the total when the operational emissions from the built environment are included. If buildings were designed to use less material, be more energy-efficient in use, last longer, be more easily repurposed, and then were recycled at end of life, the UK could reduce its carbon emissions considerably. There are many ways in which this can be tackled using concrete.

Designers can use concrete in myriad ways in the built environment, and each application can be specified with a different balance between performance and carbon. There are material-efficient design solutions, there are energy strategies that can use concrete's thermal mass, and there are flexible design choices that enable buildings to be used and adapted in many ways over their lifetime, to make the most of concrete's durability.

Guidance from The Concrete Centre is available to enable designers to:

- specify low-carbon concrete
- design using material-efficient design solutions such as post-tensioned concrete, ribbed slabs and offsite construction
- use the thermal mass of concrete to save energy
- optimise the whole-life carbon investment of concrete buildings.

We are also working to share lessons learned and new innovations on:

- reuse and refurbishment of existing structures
- new cements
- carbonation, the process by which concrete absorbs carbon naturally, and new carbon-cured products in which this natural process is accelerated.

It should not be forgotten that this is just part of the story. No other product offers so much in terms of strength, durability, thermal mass, fire resistance and resilience, all of which will be essential for adapting to the climate change that is already unavoidable. The Concrete Centre is committed to working with industry, designers, contractors and clients to achieve the best carbon result now and to support investment in new technologies to deliver a carbon-negative future. ●

More information about the Concrete Industry Sustainable Construction Strategy is available at sustainableconcrete.org.uk. A range of guidance documents on low-carbon design published by The Concrete Centre can be downloaded from concretecentre.com/publications

THROUGH FUEL SWITCHING AND THE USE OF BY-PRODUCTS FROM OTHER INDUSTRIES, CO_2 EMISSIONS PER TONNE OF UK CEMENT HAVE FALLEN BY 29% SINCE 1990