CONCRETE STEPS TO A GREENER PLANET: UK'S PIONEERING ROLE IN CEMENT INNOVATION

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Reforming the cement and concrete industry may not be the most obvious priority in addressing climate change. Yet, the magnitude of its impact is enormous, and is commonly overlooked. Concrete is the most widely used substance on Earth, second only to water. Its production is responsible for nearly 10% of global carbon emissions – surpassing those from global aviation by more than twofold.

But the barriers to addressing this challenge are profound. Economically, the cement and concrete industry is highly commoditized, characterized by its ubiquity and reliance on abundant, low-cost resources, allowing cheap, localised production. The primary differentiator among manufacturers is not the product itself, but its cost.

Moreover, the construction sector, which drives cement demand, tends to be risk-averse, and rightly so. Recent examples such as the legacy of Reinforced Autoclaved Aerated Concrete (RAAC) in crumbling schools and hospitals underscore the dangers of low-performing alternative materials and processes. This has led to a conservative regulatory framework, which poses a barrier to the adoption of low-carbon concrete solutions. Globally, regulations and certifications mandate the use of specific, carbon-intensive ingredients in cement and concrete, focusing on prescriptive standards rather than performance outcomes.

Despite these challenges, a new generation of entrepreneurs is leading a quiet revolution in the cement and concrete industry. They are pioneering innovative processes, techniques, and materials that offer the promise of zero or even negative emissions, whilst maintaining or improving cost efficiency and performance. Remarkably, many of these innovators are thriving within the current market conditions, without the need for sweeping regulatory changes to achieve economic viability.

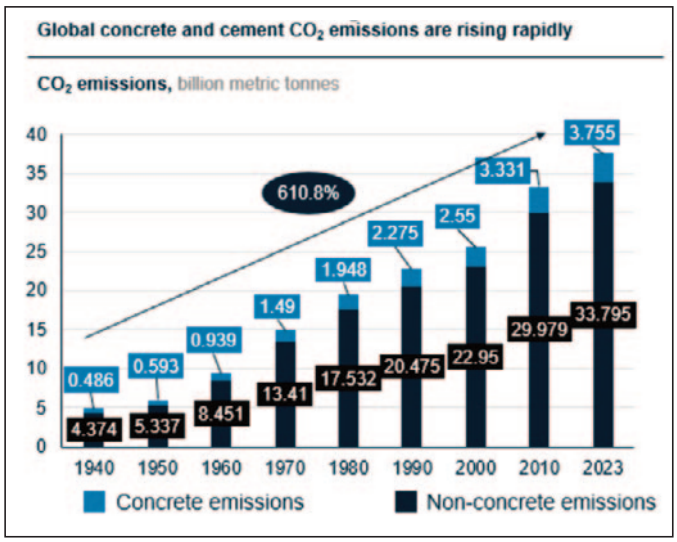

Figure 1: Concrete and cement emissions. *Source: Carbon Limiting Technologies and the Clean Growth Fund*

Even more promising is the fact that the UK is at the forefront of this transformation. With strategic interventions by Parliament, the UK has the opportunity to secure a leadership position in this emerging market.

For example, a ground-breaking development comes from researchers at Cambridge University's Department of Engineering, who have discovered a method to recycle cement from demolished concrete buildings. They founded the startup Cambridge Electric Cement (CEC), which has recently received £2.25 million from private equity investment from UK venture capital firms, and national media

attention via the recent May article in the BBC, "*UK breakthrough could slash emissions from cement.*"

The beauty of their technology is that it can decarbonise cement and steel simultaneously.

When recycling steel, you have to run both steel and a substance called "flux" through the furnace. On the other end, you receive high-grade recycled steel and a byproduct material called "blast furnace slag." What the chemists at CEC discovered is that if you use recycled cement building demolitions as the flux, the resulting slag is *chemically equivalent to Portland cement* and can be used as a 1:1 replacement of traditionally-produce cement: compliant with all the strict regulations and certifications that the industry employs.

The impact of that finding could be enormous. If scaled up, CEC's cement production process could *significantly* reduce cement production emissions *whilst simultaneously producing recycled steel.*

CEC's process additionally unlocks high value for steel manufacturers. Researchers have already estimated that current steel recycling rates could meet up to a quarter of the UK's cement demand. As the use of electric arc furnaces increases globally, the potential for widespread adoption of electric cement grows, promising a substantial reduction in global cement emissions – exacerbated by the rapid decarbonisation of the grid, allowing arc furnaces to run on clean energy.

There are many other exciting examples in the UK. Cocoon (which also recently raised £4.2m in August), Seratech, and Karbonite are all making cementitious materials out of waste/byproducts from other industrial processes; BioZeroc and Kenoteq have wholesale concrete replacements for certain use-cases; CarbonRe and Converge are using AI to make cement production and use more efficient. And the various startups in the space are not necessarily competitors, technologically at least – each one complements the other and has a role to play in the future.

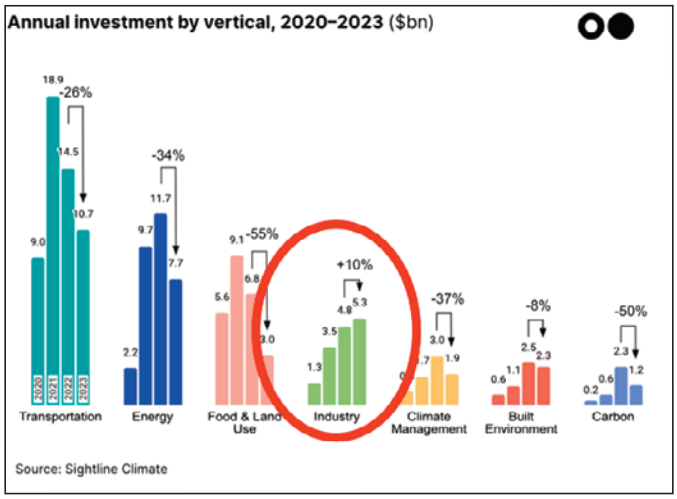

Figure 2: Global cleantech investment by vertical 2020-2023 ($bn). *Source: Sightline Climate*

Their results are catching the eye of investors. "Industry" as an investment area (cement, steel, and similar foundation industries) is the only climate-tech category that saw an increase in investment in 2023. UK funds like the Clean Growth Fund, whose research underpins this article, under the leadership of Beverley-Gower Jones OBE, are at the forefront of making sure British capital is exclusively reaching British innovation in order to drive decarbonisation. The thriving landscape of UK cement innovations proves its investment thesis is built on solid ground. Its sister company, Carbon Limiting Technologies (CLT), is helping make the economic case more appealing. In the case of cement, CLT is supporting Innovate UK's development of an "Advanced Market Commitment" (AMC) for low-carbon cement. Like a common mechanism for funding vaccines, the AMC endeavours to obtain purchase agreements for low-carbon cement before the product is commercially available in order to encourage investment into these startups. Buyers can only consider signing such an agreement if the innovations have extraordinary potential.

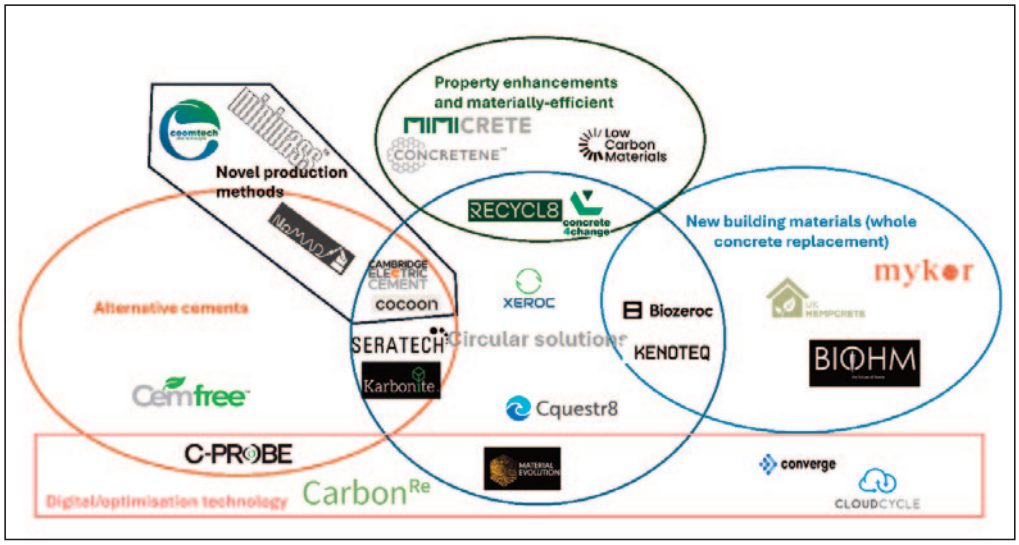

Figure 3: Landscape of UK cement and concrete innovations. *Source: Carbon Limiting Technologies and the Clean Growth Fund*

And they do. To fully grasp the significance of these novel interventions, one must first understand the scope of the issue and the nature of the solutions being developed. Concrete production involves four key components:

1. **Cement (the binder)**
2. **Aggregates (rocks, gravel, sand, etc.)**
3. **Chemical additives (property enhancers)**
4. **An activator (typically water)**

The concrete we use today primarily relies on Ordinary Portland Cement (OPC), which, although comprising just 9% of concrete by mass, accounts for approximately 90% of its total carbon emissions. OPC is a powdery substance, which, when mixed with water reacts chemically to bind the aggregates together to form an extraordinary building material. The carbon intensity of OPC arises from two main factors. First, the production process

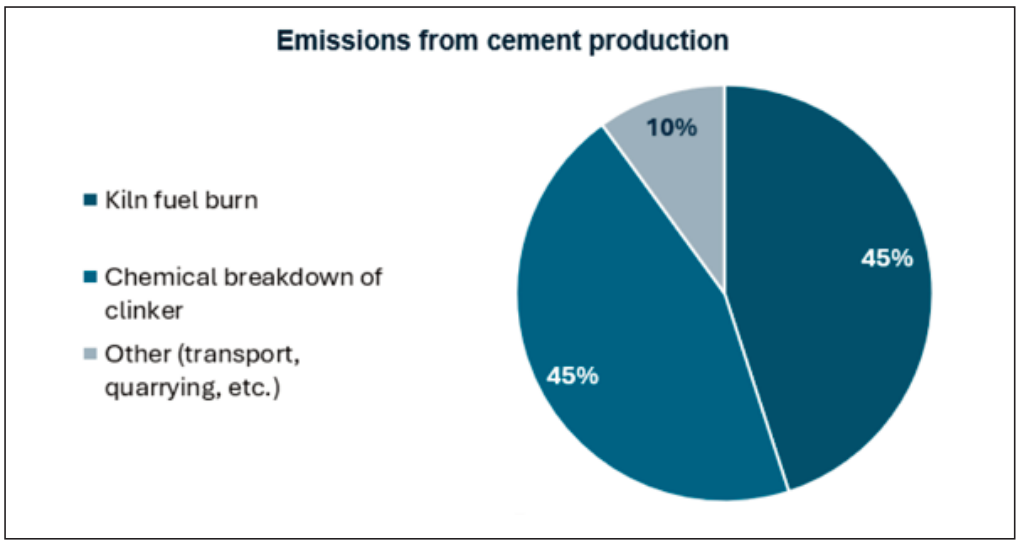

Figure 4: Emissions from cement production. *Source: Chatham House*

involves grinding limestone and other raw materials, then heating them in a kiln to a staggering 1,500 degrees Celsius, a highly energy-intensive process. The second factor is chemical; the breakdown of limestone in the kiln releases CO_2 as a by-product.

To address these emissions, innovators are exploring three primary avenues:

1. **Producing cement with less energy**
2. **Using cement and/or concrete more efficiently**
3. **Substituting OPC with alternative materials or entirely new types of concrete**

The innovations fall into six technological categories, as follows:

A - Alternative cements: new binders that do not produce CO_2 during production

B - New production methods: techniques that significantly reduce energy use

C - New building materials: (whole concrete replacement) alternatives to traditional concrete that do not rely on the same ingredients

D - Property enhancement additives that increase concrete's lifespan or its natural ability to sequester CO_2 as it hardens

E - Digital Optimisation software that optimizes production and use

F - Circular solutions: (re-use, recycling, CCU/CCS) innovative approaches to recycling, reusing, and managing cement and concrete waste

To capitalize on these innovations and transform the cement and concrete industry, with the UK taking a leading role, Parliament should consider the following strategic actions:

1. Advocate for regulatory reform

Transition to performance-based standards in place of prescriptive, ingredient-based regulations. This shift would lower the barrier to entry for new, sustainable materials, making it easier for them to gain certification and market acceptance.

2. Implement public procurement policies

Develop Green Procurement Guidelines that prioritize low-carbon materials in public construction projects. This would drive demand and incentivize the use of sustainable alternatives.

3. Invest in commercial development

Beyond supporting research and development, it is crucial to fund initiatives that advance commercialization. Programmes like Innovate UK and Carbon Limiting Technologies' Advanced Market Commitment can stimulate R&D by ensuring market demand for new products.

4. Encourage collaboration and knowledge sharing

Facilitate partnerships among innovators, investors, policymakers, insurers, and end-users. By bringing these stakeholders together, Parliament can help unblock the paths to implementation of new materials and processes.

To truly revolutionize the cement and concrete industry, it is essential for the House of Commons and the House of Lords, alongside industry, to adopt a forward-thinking approach. Cement should be seen not as a static commodity, but as a dynamic industry ripe with technological innovation. The market and the brightest minds in the UK have already started this transformation. However, without the right support, the journey ahead could be a marathon. Will the government do their part to help make it a sprint? ■

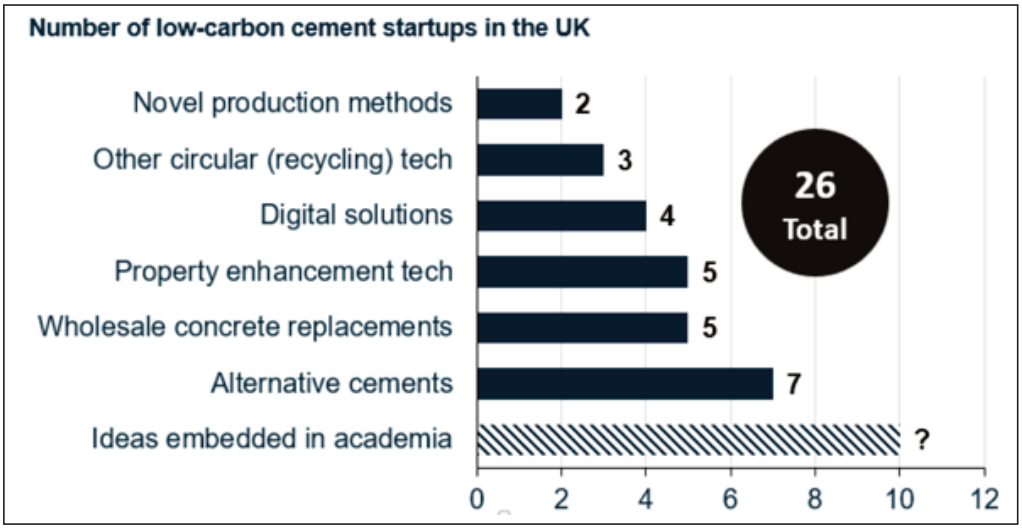

Figure 5: Number of UK cement innovators. *Source: Carbon Limiting Technologies*