EXECUTIVE INSIGHTS

The Quest for Clean Concrete: Why Carbon Capture Should Be Front and Center

Concrete manufacturing accounts for roughly 7%[1] of global carbon dioxide emissions, primarily from cement production. About 40% of cement's CO2 generation comes from the combustion process in the cement kilns. The rest of it is a result of calcination, a necessary part of the production process.[2]

Overall construction activities account for around 10% of global CO2 emissions.[3] This implies that concrete is responsible for a staggering 70% of all construction-related CO2 emissions globally.

Given how important concrete is to overall building costs and footprint, the industry has taken steps to develop more environmentally friendly solutions. But a new and significant one is emerging: carbon capture, utilization and storage (CCUS). We'll show you why in a moment. First, let's look at some other options that are available or in development today.

Alternatives to CCUS

Alternative fuels. The cement industry can meaningfully reduce emissions from the combustion process by replacing traditional fuels like pet coke, coal and natural gas with alternative fuels like biomass and various types of waste. Alternative fuels currently account for nearly 30% of the cement industry's fuel consumption in the EU[4] and 15% to 20% in the U.S.[5] (although as many as 70% of kilns are estimated to use some level of alternative fuel). Austria — to name one country — has reached a substitution rate of around 80%,[6] making it clear that the industry has significant room to increase alternative fuel adoption globally.

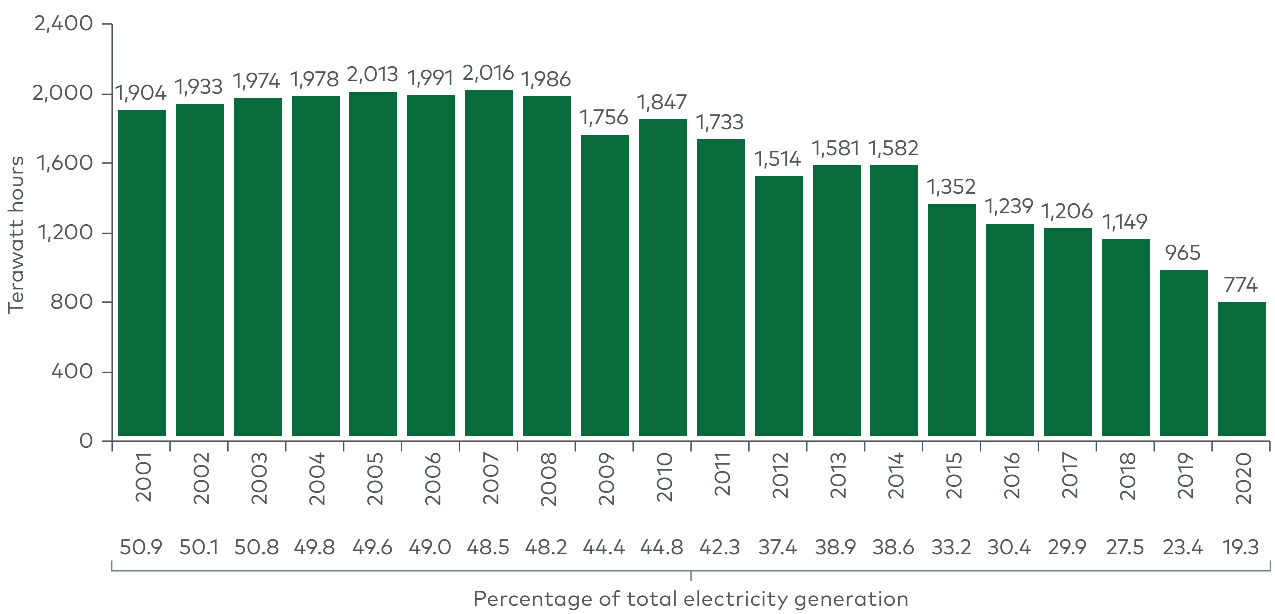
Despite the progress that cement makers and public authorities are making, however, adoption has been relatively slow and is likely capped by access to feedstock.

In Europe, biomass and other types of waste that can be used as alternative fuels are typically routed to incinerators. Like cement kilns, these require continuous supply to operate and, increasingly, methanization plants. In other parts of the world, the availability of biomass and waste from agricultural and forestry sources is limited (e.g., much of the Middle East). Finally, plastics recycling further cuts into potential feedstock availability.

Overall, the European trade group Cembureau estimates that alternative fuel penetration could reach 60% by 2050. For cement's total CO2 emissions in Europe, that represents a reduction of around 12% over a long period of time, which is significant but fails to address the fundamental chemical emissions from the decomposition of calcium carbonate.

Cementitious materials. Another effective way to reduce emissions from concrete is to substitute cement with CO2-free hydraulic binders. But blast furnace slag, the most efficient type of cementitious material, is already widely used and sought after.[7] And in developed countries, the availability of fly ash — a byproduct of coal power plants and the most widely used type of cementitious product — is running into feedstock constraints due to coal power phaseouts (see Figure 1).

Figure 1
Coal electricity generation in the US (2001-2020)



Source: U.S. Energy Information Administration; L.E.K. research and analysis

While fly ash is under supply pressure, other cementitious materials are likely to be less impacted. Slag, a byproduct of steel production, is less affected, as steel production is not expected to fall in the same way as coal production, although slag is more expensive. One example of a company using slag is Hoffman Green Cement in France, which leverages different processes (relying on flashed clay and slag) to lower cement emissions by 80%-85%. Silica fume, CCFs (calcium carbonate fines) and natural pozzolans also provide alternatives. Cement producers, particularly those with integrated concrete production, are aggressively pursuing traditional and new cementitious materials to deliver low carbon concrete. However, even these cementitious materials still need to be blended with cement and the resultant low carbon blended cements have different curing times and workability characteristics. As a result, they are not the complete solution. Additional levers must be pulled.

Innovative solutions. A number of new technologies and production processes have received significant investments in recent years, with the promise to drastically lower cement's emissions. For example:

- **Solida** (U.S.) is showing very promising results. The company has developed an alternative to portland cement that uses less limestone, water and energy. It also sequesters carbon during the curing process to produce precast concrete with emissions up to 70% lower than those of traditional processes.

- **CarbonCure** (Canada) produces equipment to inject liquid carbon dioxide into concrete during mixing for both precast and ready-mix applications, sequestering CO2 and resulting in concrete with greater compressive strength.

- **CarbonBuilt** (U.S.) is working on scaling its technologies to produce precast concrete with less traditional cement (using calcium hydroxide and fly ash instead) and cured with gaseous CO2 emissions, sequestering carbon without expensive purification and compression.

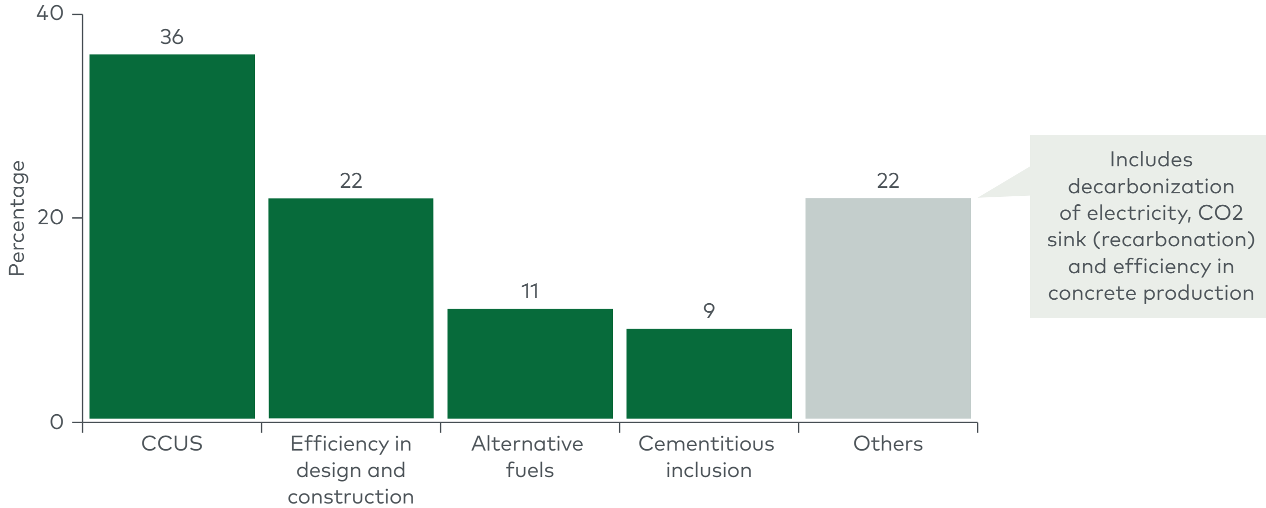
- **CarbiCrete** (Canada) develops precast concrete that is carbon negative by completely replacing cement with slag that is then cured with CO2 to form calcium carbonates, removing the CO2 from the atmosphere. The entire process uses existing cement-making equipment.

One or more of these companies may have cracked the green cement code. But a number of hurdles are still to be cleared, from technological validation to scalability and availability of the alternative materials used in the process (e.g., slag). There's also the matter of ensuring solutions are cost competitive with existing offerings.

CCUS: Reality vs. perception

The limitations of alternative fuels and cementitious materials explain in large part why the Global Cement and Concrete Association (GCCA) highlights CCUS as the single-largest future contributor to a realistic net-zero outlook for cement (see Figure 2).

Figure 2
GCCA's path to net zero by 2050



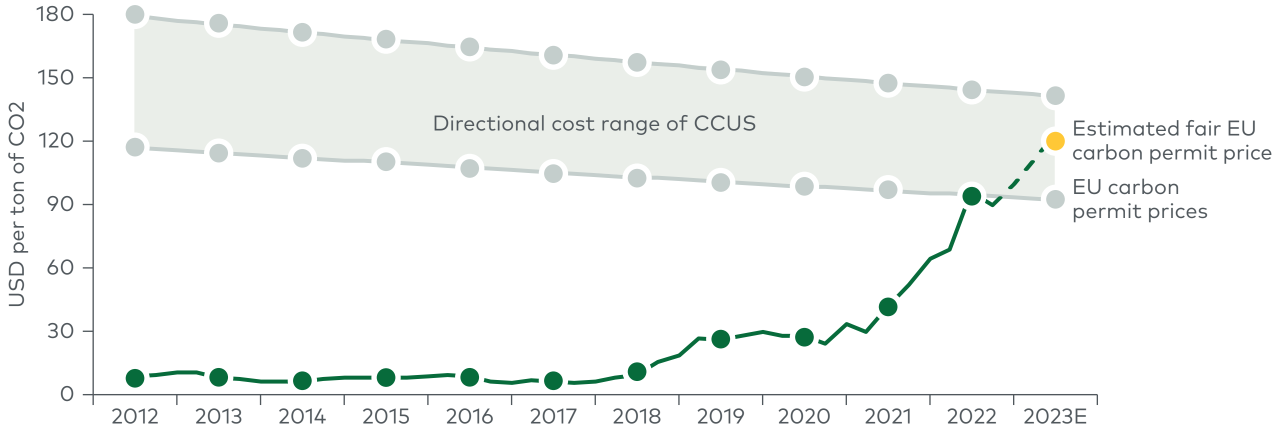
Source: GCCA; L.E.K. research and analysis

CCUS has been used in oil recovery for decades. Since 2017, approximately $30 billion in capital has been allocated among 30 CCUS projects, with another 40 projects recently announced in the U.S. alone.[8] CCUS projects also have been ramped up specifically for cement applications, particularly by Heidelberg in Norway and Canada.

While some industry participants view the economics and technical challenges of CCUS as barriers too high to overcome in the medium term, there are clear signs that CCUS will be viable more quickly than previously expected.

For one thing, the sharp increase in the value of European carbon credits is making CCUS an increasingly viable option. After years of lingering in the $10-$30 range, EU carbon credits nearly reached $100 in early 2022. Berenberg Bank, a leading forecaster in that market, places the current fair value of EU carbon credits above $120.[9] This puts it well within the $50-$150 cost per ton of CO2 associated with CCUS (see Figure 3).

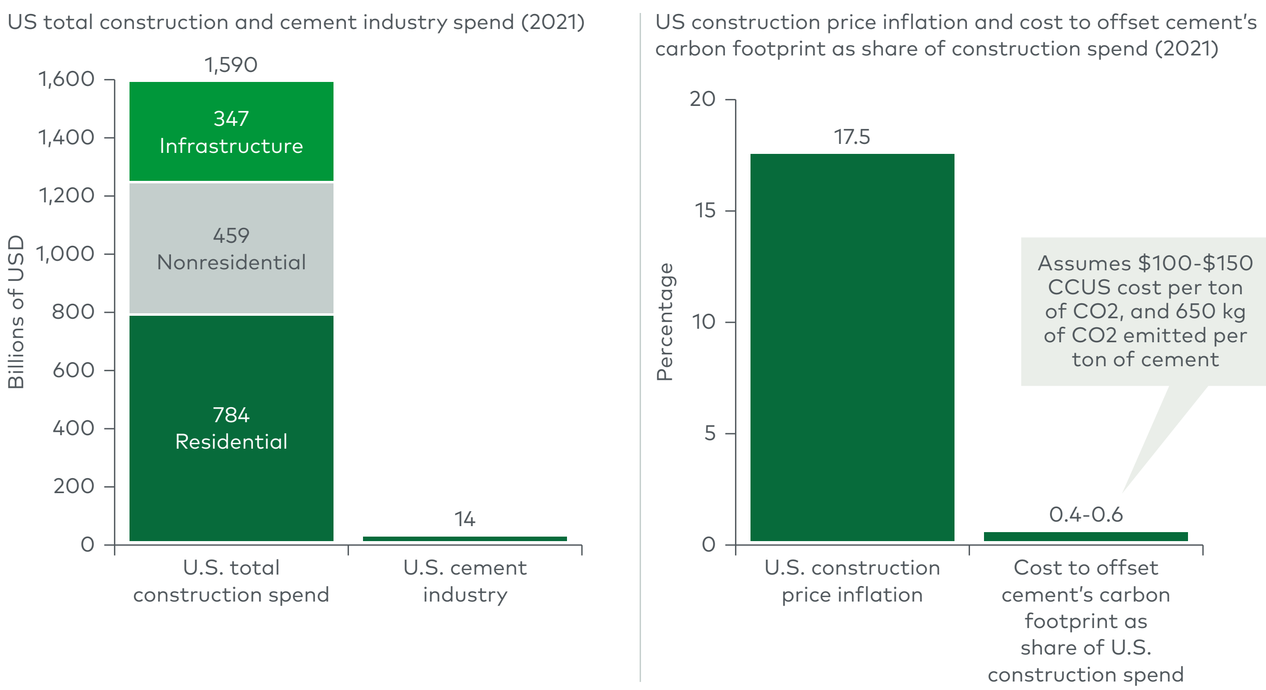
Figure 3
EU carbon permit pricing relative to CCUS (2012-2023E)



Source: Ember Climate; Berenberg; L.E.K. research and analysis

In addition, at the current CCUS cost, offsetting cement's entire carbon footprint would only marginally increase total construction costs despite being a major change for the cement industry. To see how, let's assume a CCUS cost of roughly $100 per ton of CO2. At that price, the U.S. could offset the carbon footprint of its cement industry for around $7.1 billion. This, in turn, would increase total construction spending by a mere 0.4%-0.7%. Compare that to the 17.5% price inflation that the industry sustained in 2022 (see Figure 4).

Figure 4
Construction spending vs. cost to offset carbon footprint



Source: U.S. Census Bureau; L.E.K. research and analysis

An attractive solution for the industry

Concrete's disproportionate contribution to construction-related carbon dioxide emissions has prompted the cement industry to ramp up well-known mitigation measures. Given the limitations of these measures, however, industry participants and public authorities should prioritize and investigate CCUS as a realistic alternative. Surging carbon prices in Europe make CCUS particularly attractive. Notwithstanding the high cost of carbon capture relative to today's clinker cost, the cost relative to the overall construction cost is a very small price to pay.

For more information, please contact industrials@lek.com.

Endnotes

[1]https://www.linkedin.com/pulse/co2-emission-from-cement-industry-whats-best-estimate-claude-lorea/

[2]https://www.greenconcrete.info/downloads/11_ConcreteCO2.pdf

[3]https://globalabc.org/sites/default/files/inline-files/2020%20Buildings%20GSR_FULL%20REPORT.pdf

[4]https://www.cemnet.com/News/story/169021/experiences-with-alternative-fuels.html

[5]https://www.zkg.de/en/artikel/zkg_Development_of_alternative_fuels_in_the_U.S._cement_industry_3302670.html

[6]https://www.cemnet.com/News/story/169021/experiences-with-alternative-fuels.html

[7]https://www.lek.com/insights/ei/capitalising-opportunities-cementitious-materials-disruption

[8]https://www.lek.com/insights/ei/carbon-capture-utilization-and-storage-strategic-imperative-reach-net-zero

[9]https://anchor.fm/chris-dark/episodes/2-3-Carbon-Credits---A-New-Asset-Class--with-Lawson-Steele-e1c0vns

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