Strengthening Sustainability *in the Cement Industry*

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Growing global concerns over climate change are putting an increasing focus on sustainability. This report is part of an occasional series on sustainability in industry which examines the opportunities and challenges facing various industrial sectors and the role that the International Finance Corporation can play to support their efforts and contribute to a greener planet.

Concrete literally holds the modern world together. The material and its binding agent cement comprise a key ingredient in the buildings and roads essential for development and in infrastructure critical to sustainable growth.

The cement industry also generates about 7 percent of the world's greenhouse gas emissions. While manufacturers have reduced emissions in recent decades, the industry must accelerate these efforts considerably if it is to meet its goal of achieving carbon-neutral concrete by 2050.

Decarbonization by the cement industry will require collaboration with policy makers, financial institutions such as the International Finance Corporation (IFC), and end users in the built environment. The complex path to achieving net-zero manufacturing underscores the challenges facing high-emissions industries as they seek to reduce their carbon footprint and build a circular economy.

Sector Background

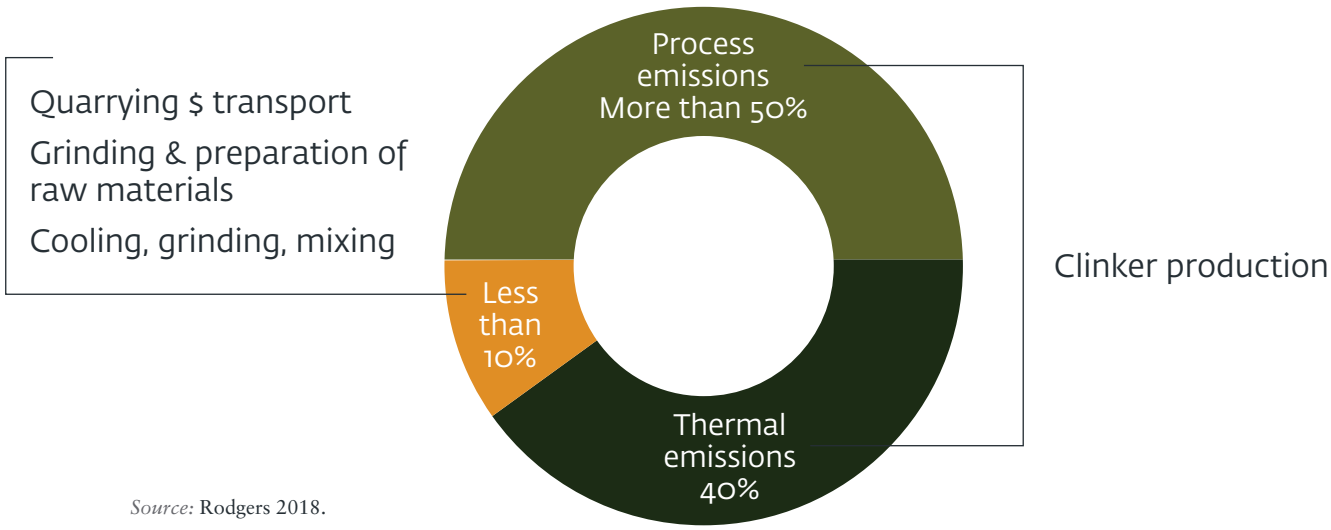
As the most widely used construction material, concrete is indispensable to the construction of many things that make up modern society, from highways, buildings, and bridges, to dams, power plants, and water and sewage pipes. The material is so ubiquitous because it is durable, fire- and water-resistant, and cheap to produce. It can be formed into almost any shape when newly mixed and achieves high strength for a long time once it sets. Cement is part of the future of development and urbanization.

Thus, it is critical for the industry to reduce its carbon emissions. Cement is made by fusing limestone and clay in temperatures up to 1450°C. The process produces gray, rock-like balls called clinker (which is then ground into cement), in chemical reactions that emit large amounts of carbon dioxide. The production of clinker accounts for about 90 percent of the CO2 emissions of cement production (please see graphic below).

Globally, the industry registers the highest emissions per revenue dollar among similar, hard-to-abate sectors, producing 6.9kg of CO2 per dollar compared to 1.4 kg for iron and steel, and 0.8 kg for oil and gas.

A surge in cement production in recent decades has contributed to the sector's high emissions. In 2020, production totaled an estimated 4.1 billion metric tons, triple that for 1995, although in recent years demand has remained relatively stable. Five countries account for nearly three-quarters of the world's cement production, led by China

The production of "clinker" accounts for most of the CO2 emissions of cement production



Source: Rodgers 2018.

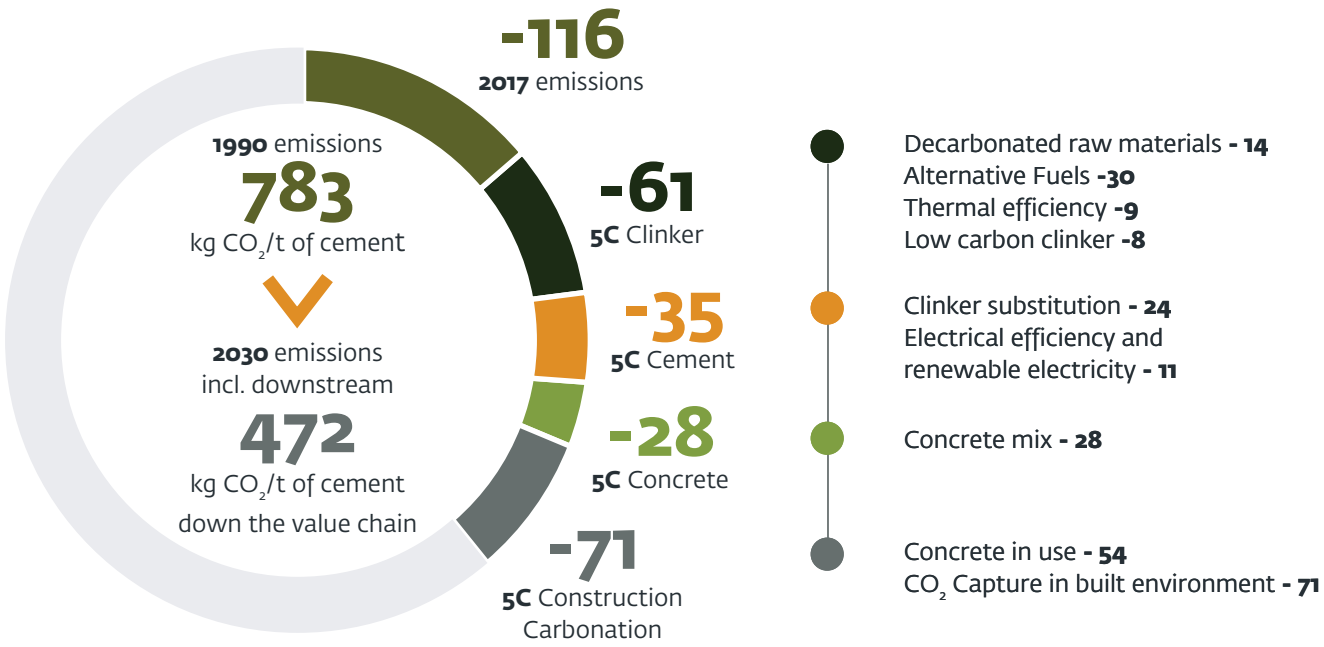
with a 57-percent share, followed by India, Vietnam, the United States, and Indonesia. Most of the increased production up to now has been driven by China's industrialization and infrastructure build-up, but as demand drops there, future increases are expected to come from India, South-east Asia, and Sub-Saharan Africa.

Pressure on the industry to decarbonize has intensified as concern grows over climate change and countries race to meet obligations under the Paris Agreement. If cement manufacturers are to meet the rising demand for low-carbon materials, they must step up adoption of circular business models and clean energy, redesign their products, better utilize waste streams, and reallocate capital flows to finance the transition to green production.

Sustainability

The cement industry has decreased its emissions significantly over the past three decades but progress has slowed in recent years. Advances have occurred largely through incremental change, although some producers have been experimenting with innovative technologies. In 2021, the industry announced an ambitious plan for getting to net zero carbon by 2050.

CEMBUREAU Roadmap : CO2 Reduction Along the Cement Value Chain (5 Cs: Clinker, Cement Concrete, Construction, Re-Carbonation).



Source: CEMBUREAU

Reduced emissions. The industry reduced its emissions per ton of cement produced by about one-fifth between 1990 and 2020. Manufacturers achieved these gains mostly by improving energy efficiency in the production process, utilizing waste as a fuel, and substituting clinker with industrial waste, such as fly ash from power generation plants and blast furnace slag from steel plants.

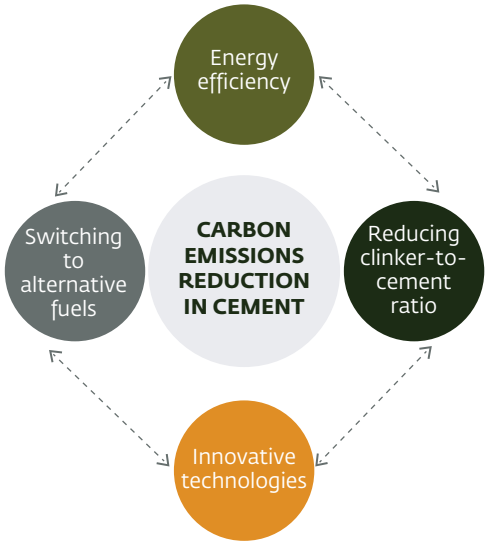
New technologies. Cement companies are piloting a variety of innovative technologies aimed at reducing their carbon footprint. By deploying carbon capture, utilization, and storage (CCUS), they seek to prevent CO_2 from being released, whether by storing it or using it to make chemicals, concrete, or plastics. Supported by the European Union, the LEILAC 2 project will test Calix's Direct Separation technology, which separates 20 percent of a regular plant's process emissions. The project will be implemented at HeidelbergCement's plant in Hanover, Germany, and is set to become operational in 2023. Widespread CCUS adoption, however, will depend in part on the economic viability of sequestering carbon; currently, technologies are in the early stage, with years of development needed before they become commercially viable. Manufacturers are also exploring reducing the ratio of clinker to cement by substituting clinker with less emissions-intensive materials or by using alternative binding materials.

Commitment to net zero. Major industry associations have committed to addressing sustainability issues in the sector. The World Cement Association issued a statement supporting accelerating changes in the industry to achieve full decarbonization through technical development and other measures. CEMBUREAU, which represents the European cement industry, has set a goal of reducing gross CO_2 emissions by 30 percent for cement and by 40 percent down the value chain by 2030. And the Global Cement and Concrete Association has issued a set of sustainability guidelines and an ambitious roadmap for the industry to reduce emissions by 26 percent in the concrete manufacturing value chain by 2030 and to reach net zero carbon by 2050. IFC welcomes the roadmap and is encouraged to see that the industry has committed to producing carbon-neutral concrete by 2050. It remains keen to work with all cement companies in developing markets to help them advance their decarbonization plans in a way that is technically feasible, socially acceptable, and financially sustainable.

Opportunities & Challenges

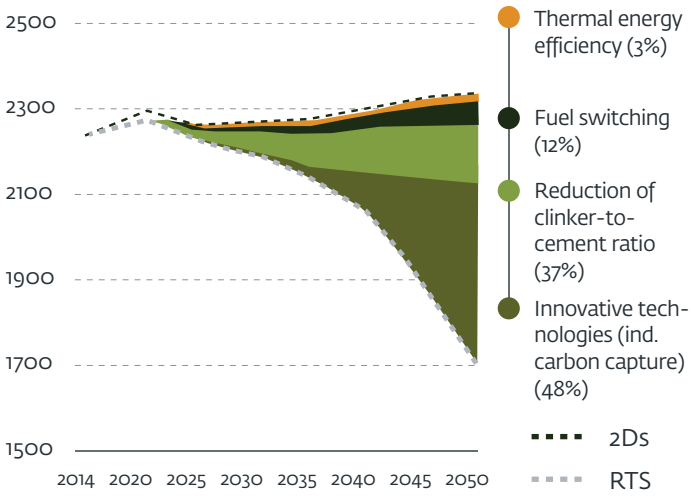
Decarbonization will require transformation across the whole supply chain as well as changes in government policy and in the behavior of end users.

Strategies to reduce CO_2 emissions from cement production



Carbon emissions reduction levers can influencethe potential for emissions reductions of other options.
Reference: IEA-CSI,2018.

Direct Co2 emissions from global cement production (Mt/yr)

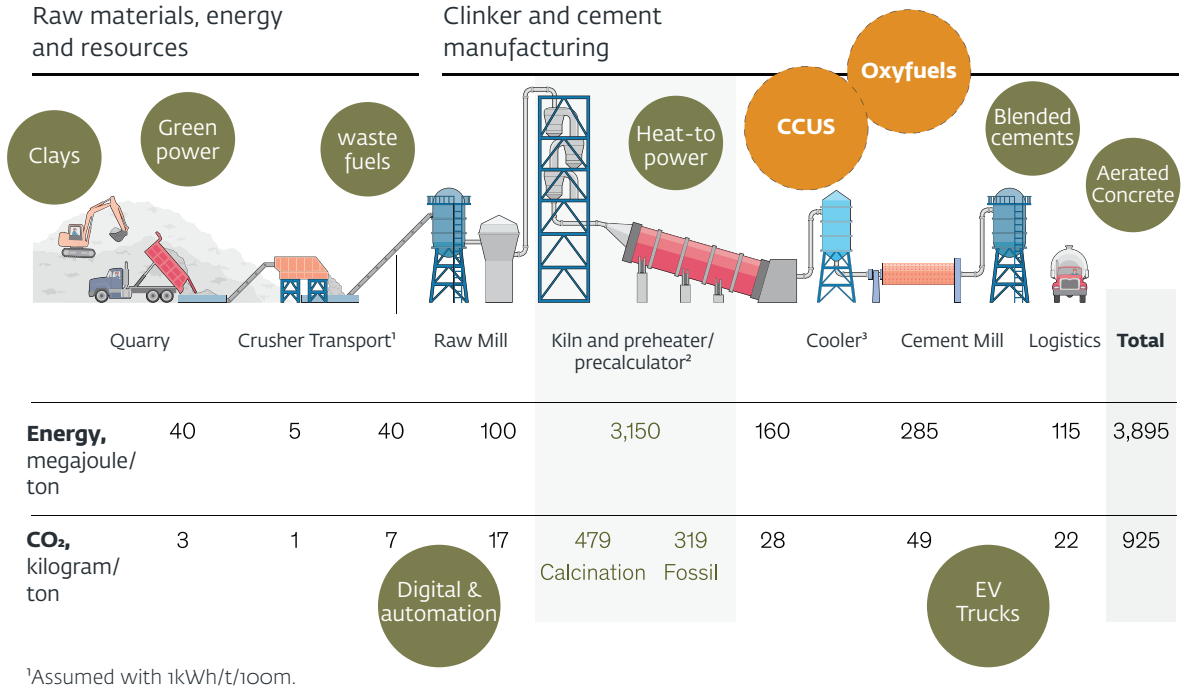


The equivalent of almost 90% of today's direct global industrial CO2 emissions are cumulatively avoided from cement production in the 2DS compared to RTS.

Product design

Support and promote the use and production of blended cements. Blended cements reduce the clinker-to-cement ratio by substituting clinker with other materials such as calcined clay, limestone, fly ash, blast-furnace slag, or silica fume. One challenge is the lack of availability of these materials; the quantity of blast-furnace slag and fly ash is expected to decline as the industries decarbonize. Clays offer another option. LC3 cement, blended from limestone, clinker, and calcined clay, can reduce carbon emissions in the production process by up to 40 percent.

There are numerous opportunities for greening the cement production process



	Quarry	Crusher	Transport[1]	Raw Mill	Kiln and preheater/ precalculator[2]		Cooler[3]	Cement Mill	Logistics	**Total**
Energy, megajoule/ ton	40	5	40	100	3,150		160	285	115	3,895
CO_2, kilogram/ ton	3	1	7	17	479 Calcination	319 Fossil	28	49	22	925

[1]Assumed with 1kWh/t/100m.
[2]Assumed global average, data from the Global Cement and Concrete Association, Getting the Numbers Right 2017.
[3]Assumed reciprocating grate cooler with 5kWh/t clinker.
[4]Assumed lorry transportation for average 200km.

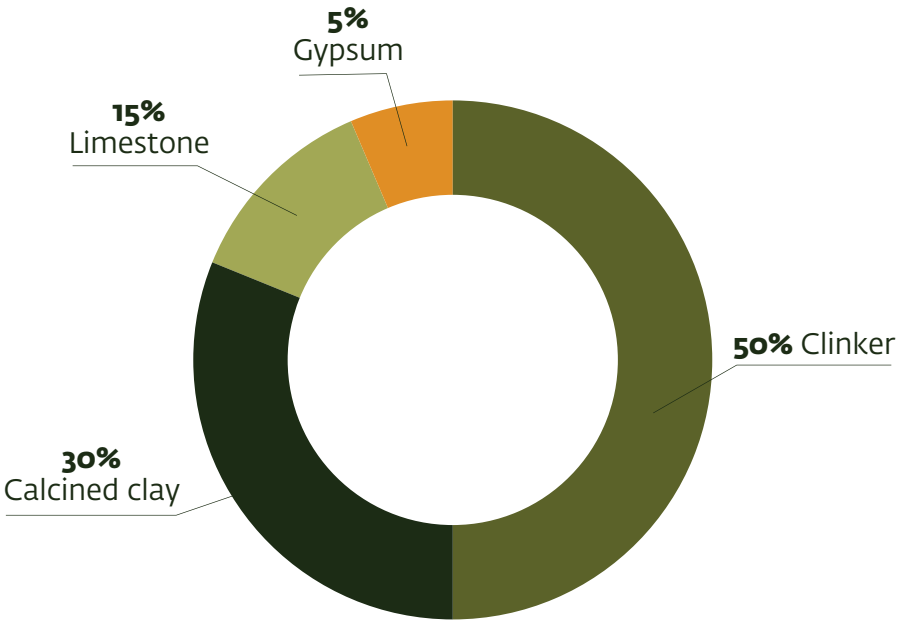
Source: Czigler et al. 2020.

Manufacturing process

Improve energy efficiency and decarbonize electrical energy. Ways to boost energy efficiency include integrating waste heat recovery systems, which can reduce overall plant electricity needs by 30 percent, and investing in state-of-the-art equipment, such as multistage preheaters with inline calciner and high-efficiency coolers that can reduce kiln heat requirements. Companies should increase their use of clean electrical energy, whether by developing on-site, renewable power generation from solar, wind, or integration with battery systems, or buying clean energy, such as from hydro power plants.

Increase use of alternative fuels to heat kilns. Alternative fuels only supply about 8 percent of total thermal energy used in cement production globally, but offer strong potential. Use of alternative fuels can reduce cement emissions while tackling disposal of waste and by-products from other industries. Adoption requires investments in technology and equipment to turn waste into fuel and incorporate it into the manufacturing process, but producers face no technical limitations to increase the

LC3: A New Type of Cement



Source: LC3-Project 2021.

share of alternative fuels to 95 percent. Ultimately, green hydrogen offers a promising, mid- to long-term solution, contingent on availability and prices, which currently are very high.

Leverage digitalization and AI to accelerate sustainability. These technologies can provide cement producers with new tools to drive decarbonization. They include AI-based optimizations, Internet of Things connectivity, and efficiency-oriented applications.

Value Chain

Enable a truly circular value chain. Building materials account for half of the solid waste generated every year worldwide—an amount that by 2025 is expected to reach 2.2 billion tons per year globally, equivalent to 6,000 times the weight of the Empire State Building. One way to reduce the amount of waste and introduce circularity into the value chain is by recycling construction and demolition waste (C&D waste) to produce concrete. Other solutions include introducing new materials that can be easily deconstructed and reused in other buildings once the original building is torn down, and expanding the use of carbon calculators such as EC3 to give visibility to the embodied carbon emissions in a construction

project at the design and procurement phases. This would allow building owners, green building certification programs, and policy makers to assess supply chain data to establish requirements and set embodied-carbon limits at the project stage.

Support carbon-cured concrete and recarbonation technologies. Cement products naturally absorb CO_2 from the atmosphere in a process called recarbonation. Several companies are developing technologies to accelerate recarbonation by injecting captured CO_2 into fresh concrete to make carbon-cured concrete. Captured CO_2 can also be used to accelerate the recarbonation of crushed demolition concrete into improved recycled aggregates. An example of this technology is Solidia-Flying carbon capture technology.

Policy

Establish a policy framework to achieve net zero concrete. Many of the decarbonization solutions listed above will require major investments in infrastructure, alternative energy sources, and new technologies, including for CCUS. Cement producers have been reluctant to adopt these approaches on a broad scale without economic motivation or assurance of their technical feasibility. For example, CO_2 pricing is nonexistent in most geographies or prices are too low to pressure cement makers to upgrade their facilities. Virgin concrete generally remains cheaper than recycled concrete. Governments can play a carrot-and-stick role by providing subsidies, policy support, and regulation. The introduction of *carbon pricing mechanisms* would help to create a level playing field in terms of carbon costs and prevent carbon leakage. The establishment of a *competitive secondary-materials market* with green taxes would create demand for waste material, while directives aimed at diverting waste from landfill would improve access to *residual waste streams*. Other ways that government could help include: supporting *carbon capture technology* through R&D and construction of infrastructure to transport and store captured CO_2; and introducing construction regulations and standards and public procurement guidelines to promote green buildings and the use of blended and novel cements.

BOX I: ***IFC Cement Projects***

National Cement Company Ltd (NCCL) (2014–2020). IFC supported NCCL, now Kenya's largest domestic cement producer, to increase its clinker and cement-grinding capacity in the country and introduce new cement capacity through a sister company in Uganda. IFC supported NCCL in two rounds of investments involving both loans and equity. The investments allowed NCCL to tap into the countries' abundant natural resources, strengthening local economies and jobs creation, while lowering carbon emissions in cement production through the use of more efficient technology.

Cimenterie de Lukala S.A. (CILU) (2016). IFC made an equity investment into CILU, the largest cement manufacturer in the Democratic Republic of Congo. CILU has an integrated cement plant in Lukala, near the capital Kinshasa. The project involved an expansion of CILU's cement production capacity, which is expected to help create a reliable domestic supply of cement, support housing and infrastructure development, create jobs, and strengthen the local supply chain.

IFC Role

IFC has a long track record of investing in the cement industry, with more than $4 billion in committed financing in more than 200 projects in emerging markets. IFC seeks to support industry players and provide them with long-term financing, advisory services, and project development capital to implement the best-available technologies and reduce their carbon footprint. IFC also deploys financing and advisory services to support their increased use of alternative fuels. And it is working with manufacturers to convert less efficient plants, such as those using wet or semi-wet production processes, to become more efficient.

Conclusion

Demand for concrete and cement is projected to grow worldwide along with pressure on the industry to further reduce its energy use and CO_2 emissions. Over the last few decades, cement manufacturers have increased their sustainability through incremental changes and some innovation. Going forward, the industry will need to adopt transformational technologies and processes to achieve more substantial gains. The sector also has a key role to play in boosting sustainability in other sectors, specifically green buildings and infrastructure. For the industry to achieve these goals will require collaboration across the value chain and support from governments and international financial institutions. IFC will complement the work of investors, regulators, and end-users to help forward-thinking and innovative players along the pathways leading towards a zero carbon future.

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7. Global Cement and Concrete Association 2021.

8. Calcined clay, or metakaolin, is made by heating a source of kaolinite, found in china clay deposits and some tropical soils, at high temperatures. Calcined clay helps to speed up the reactions that harden concrete, and has been tested and accepted in standards around the world. For more information, see https://gccassociation.org/cement-and-concrete-innovation/clinker-substitutes/calcined-clays/.

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