Greening the concrete jungle—how to make environmentally friendly cement

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Credit: AI-generated image (disclaimer)

Cement is the world's most widely used material apart from water, largely because it is the key ingredient in concrete, the world's favourite building material.

But with cement's success comes a huge amount of greenhouse emissions. For every tonne of cement produced in Australia, 0.82 tonnes of CO_2 is released. That might not sound like much, especially when compared with the 1.8 tonnes emitted in making a tonne of steel. But with a global production of more than 4 billion tonnes a year, cement accounts for 5% of the world's industrial and energy greenhouse emissions.

The electricity and heat demands of cement production are responsible for around 50% the CO_2 emissions. But the other 50% comes from the process of "calcination" – a crucial step in cement manufacture in which limestone (calcium carbonate) is heated to transform it into quicklime (calcium oxide), giving off CO_2 in the process.

A report published by Beyond Zero Emissions (BZE) (on which I was a consultant) outlines several ways in which the sector can improve this situation, and perhaps even one day create a zero-carbon cement industry .

Better recipes

The cement industry has already begun to reduce its footprint by improving equipment and reducing energy use. But energy efficiency can only get us so far because the chemical process itself emits so much CO_2. Not many cement firms are prepared to cut their production to reduce emissions, so they will have to embrace less carbon-intensive recipes instead.

The BZE report calculates that 50% of the conventional concrete used in construction can be replaced with another kind, called geopolymer concrete. This contains cement made from other products rather than limestone, such as fly ash, slag or clay.

Making this transition would be relatively easy in Australia, which has more than 400 million tonnes of fly ash readily available as stockpiled waste from the coal industry, which represents already about 20 years of stocks.

These types of concrete are readily available in Australia, although they are not widely used because they have not been included in supply chains, and large construction firms have not yet put their faith in them.

Another option more widely known by construction firm is to use the so-called "high blend" cements containing a mixture of slag, fly ash and other compounds blended with cement. These blends have been used in concrete structures all over the world, such as the BAPS Shri Swaminarayan Mandir Hindu temple in Chicago, the foundation slab of which contains 65% fly ash cement. These blends are available everywhere in Australia but their usage is not as high as it should due to the lack of trust from the industry.

It is even theoretically possible to create "carbon-negative cement", made with magnesium oxide in place of traditional quicklime. This compound can absorb CO_2 from the air when water is added to the cement powder, and its developer Novacem, a spinoff from Imperial College London, claimed a tonne of its cement had a "negative footprint" of 0.6 tonnes of CO_2. But almost a decade later, carbon-negative cement has not caught on.

Capturing carbon

The CO_2 released during cement fabrication could also potentially be recaptured in a process called mineral carbonation, which works on a similar principle as the carbon capture and storage often discussed in relation to coal-fired electricity generation.

This technique can theoretically prevent 90% of cement kiln emissions from escaping to the atmosphere. The necessary rocks (olivine or serpentine) are found in Australia, especially in the New England area of New South Wales, and the technique has been demonstrated in the laboratory, but has not yet been put in place at commercial scale, although several companies around the world are currently working on it.

Yet another approach would be to adapt the design of our buildings, bridges and other structures so they use less concrete. Besides using the high-performance concretes, we could also replace some of the concrete with other, less emissions-intensive materials such as timber.

Previously, high greenhouse emissions were locked into the cement industry because of the way it is made. But the industry now has a range of tools in hand to start reducing its greenhouse footprint. With the world having agreed in Paris to try and limit global warming to no more than 2℃, every sector of industry needs to do its part.

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