Cementing Australia's Future: Carbon impacts of cement production in the context of domestic and international decarbonisation policy and impacts for upstream and downstream industries

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Australia produces more cement than any other construction material, which is then used as concrete in the construction of significant infrastructure projects like bridges, tunnels, dams, and large buildings. In 2018-2019, Australia produced 10.4 million tonnes of cement and 5.6 million tonnes of clinker, with an average annual cement production growth rate of 3% since 2013/14 FY. The cement industry is responsible for contributing an estimated $15 billion AUD to the national accounts. This is forecast to grow due to significant state and national investment in large scale infrastructure projects, particularly in the freight and transport sectors.

Cement production consists of several steps which convert minerals into clinker and then into cement to be used as concrete. This process is energy intensive and identified as contributing 8% of global CO2 emissions. The starting point of cement begins with limestone which is extracted from the ground. This is then moved into the carbon intensive production of clinker which is heated at temperatures of 600-900°C in the kiln to induce the combination of complex chemical reactions (IPCC Guidelines). Once clinker is formed, it is then ground to a fine powder, and mixed with gypsum to create the most common form of cement known as Portland cement (IPCC Guidelines).

As we look beyond the COVID-19 pandemic, focus has begun to "re-shift" back to areas of resilience; across economic, social, and environmental systems with particular attention to climate change resilience and decarbonising our heaviest polluters. This has most recently been witnessed in the European Union through the proposed Carbon Border Adjustment Mechanism (CBAM) which places a carbon price on imports of a targeted selection of products to prevent 'carbon leakage' and help ensure they meet the EU's proposed greenhouse gas reduction measures and have specifically identified cement as a carbon emission intensive production. This indirectly places both political and economic pressure on Australia's cement production industry through potential cost implications on exports as well as indirect pressure to "green our production processes" and improve our emission targets in line with the European Union.

In this study we conducted a high-level cradle-to-gate Life-Cycle-Analysis (LCA) to calculate nationwide cement industry carbon emissions using the Intergovernmental Panel on Climate Change (IPCC) guidelines to help determine the potential cost impacts from the European Union's CBAM proposal if adopted in Australia. To gain an understanding of the impacts that such a policy change may incur to both upstream and downstream industries, we used the calculated CBAM cost impacts as inputs into an input/output model for Australian domestic production and supply. Whilst calculating carbon emissions from Australia's cement industry is not new, or novel, our study raises this timely subject in the context of international policy development, supply chain impacts as well as other mechanisms for managing emissions in a critical Australian industry.

There are four steps when conducting a life cycle analysis:

1. Identify the goal and scope of the LCA
2. Inventory analysis
3. Impact assessment, and
4. Interpretation of the results.

The goal of the LCA is to identify the amount of life cycle emissions and consumed energy that is contained during pre-construction, construction before being distributed to consumers. The LCA scope considers a cradle-to-gate approach which includes the initial resource extraction to being in the hands of the consumer, which includes scope 1 and 2 emissions. Scope 1 emissions are calculated from direct emission factors that are emitted per unit of activity during the emission release which includes initial manufacturing processes, mining and onsite disposals. Scope 2 emissions are calculated from the indirect emissions of the generation of the electricity purchased and consumed during the production. These are emissions such as burning fuels and power from power stations.

Our approach involves calculating the LCA of clinker and cement total production across Australia, with data sourced from Cement Industry Federation to calculate the GHG emissions. The formula used in this paper is recommend within the IPCC Guidelines to calculate scope 1 and scope 2. The results are displayed from 2010 to 2019 annually in GHG emissions tonnes. The preliminary results showed that, in 2018-2019, Australia produced 5.7 million tonnes of clinker and 10.2 million tonnes of cement which resulted in 8.9 million tonnes of GHG emissions. Scope 2 emissions includes electricity used in the state and the emission factor for electricity comes from the IPCC Guidelines. The preliminary findings were calculated to show the comparative carbon emissions from cement production with state-by-state emission factors to identify carbon intensive state from cement production. Under these assumptions, we find that the GHG emissions of cement to be 9.2 million tonnes in 2018-2019. This year was used as a benchmark as the industry had not yet been impacted by Covid-19.

As the world races to prevent environmental collapse of some of our most vulnerable ecosystems, policy makers are under immense pressure to set targets to achieve net-zero emissions. In Australia, the safeguard mechanism is used to reduce large scale emission outputs from its largest emitters through legislative requirements. The mechanism, however, only applies to facilities that emit more than 100,000 tonnes of carbon within a financial year leaving a significant carbon gap.

One method of reducing carbon emissions in Australia would be to impose a tax, such as the carbon border adjustment mechanism in the European Union. Placing a tax on carbon would effectively increase the price of cement, which in turn may lead to reductions in overall supply. The impacts of this mechanism may then be tested in an Input-Output (IO) Model to show the impacts of this reduction to related industries. While the findings of this analysis are underpinned by a range of the assumptions, such an approach helps quantify the pressures facing Australian policy makers, particularly as climate targets become more prevalent.

An IO model divides the economy into final demand and production, and accounts for the direct and indirect interdependencies within different sectors of the economy. The IO model measures the price impact and ripple effect upstream and downstream to fully consider the effects of the impact.

Therefore, the use of input-output price model analysis shows the effect in response to price changes of the direct and indirect impacts of price changes.

We use the price elasticity of demand for cement to determine the expected change in cement production. Price elasticity of demand is used as a ratio of the percentage of change in the quantity of demanded product to the percentage change in price. A literature review of elasticities found that the range is wide, ranging from -0.60 to -1.60. When taking a mid-point, this suggests that for every 1.00% increase in cost, there would be a 1.20% reduction in cement production.

We calculated results for low, medium, and high elasticities to understand the potential range of impacts to the cement industry. The reduction in cement production will be calculated in the study showing the reduction in production then flows through to impacts in other sections, both negatively where cement is an input and positively where there are replacement effects. This reduction in production has the potential to reduce gross regional product or reduction employment opportunities.

This example uses figures that rely on guidelines and industry data. Australia currently does not have a carbon tax on its intensive emission industries in comparison to other countries that are set on achieving greater environmental outcomes. If Australia were to place a carbon tariff equivalent to the CBAM, this example shows the potentially extensive impacts to other industries. The preliminary findings show that the non-ferrous metal ore mining industry has a high dependence on cement and is the associated industry that would be impacted most. The results in this study further discuss the economic impact of the cement industry and surrounding industries of tariffs on carbon emissions produced in the cement industry.

The cement industry is one of the world’s largest carbon intensive industries which is being globally addressed by policy makers yet is unacknowledged in Australian policy. Calculating the emissions from the cement production is not yet factored into infrastructure assessment frameworks and/or overarching sustainability of projects within Australia. This study provides calculations from global guidelines to calculate the emissions from the Australian cement industry showing the emission intensive outcome to Australia’s production. Adopting a carbon tax may not be the most effective way to encourage a shift in both the production and use or carbon intensive concrete production, but it does demonstrate to policy and decision makers that the concrete industry is a significant carbon producer and needs to be considered in the context of climate policy and how current large scale infrastructure projects are assessed and costed in world where sustainability now carries a ‘value’.