

Reduced Emission Cement: Cradle to Grave Material Applications and Accounting

Summary

After water, concrete is the largest global commodity, and a key to development. The production of cement, the binding agent in concrete, releases 8% of global CO₂ emissions, with some re-use as fill. These emissions are expected to increase by 50% by 2020 and more than double by 2050. We will develop a process based on oxygen combustion and concrete recycling that increases material efficiency with evaluation via life cycle analysis (LCA) providing cradle-to-cradle energy and material analysis.

Oxygen combustion replaces combustion air with produced oxygen. Converting cement plant involves isolating the kiln from the atmosphere, recycling exhaust gases as thermal ballast and producing oxygen on site and more. The primary concern is ensuring that the cement produced is consistent with existing standards and the kiln can sustain the new conditions. Many of the ancillary unit processes, such as fuel pre-processing and raw material drying, can be optimized for efficiency and safety. The presence of high purity gases also makes novel processes, such as onsite gypsum production, feasible. Furthermore, the kiln would produce a wet stream of CO₂ that can be purified and potentially captured via anti-sublimation, a novel CO₂ capture technology.

We propose to investigate the recovery of calcium ions from the waste concrete via leaching with subsequent carbonation using atmospheric CO₂. The result will be precipitated calcium carbonate suitable as filler in paper or recycled kiln feed. In combination with the CO₂ capture, the cement plant will be a significant source of negative CO₂ emissions.

As part of the life cycle analysis, direct and indirect emissions reductions will be tabulated to investigate the strategic value of concrete in the urban environment, advanced production methods and proactive recycling methods. In particular, the process modifications to the oxygen combustion process will be tabulated with various carbon capture methods. The LCA will also compare the proposed changes to the best available technology for producing Ordinary Portland Cement.