CO2 capture from cement production

Results in Brief

Carbon capture for the cement industry

Cement’s CO2 emissions can only be mitigated with carbon capture technologies. An EU team evaluated the options.
Climate change, also called global warming, is already starkly evident. The main cause is CO2 released into the atmosphere from human activity.

One significant contributor is the cement industry, responsible for approximately 6-7% of emissions. Most of the industry’s carbon pollution derives from the chemical reaction fundamental to the product. The raw ingredient, limestone, is mostly calcium carbonate, which forms calcium oxide when heated, in the process releasing large amounts of CO2.

Changing to renewable energy sources will make little difference in this case, so the bulk of any potential emissions reduction must come from carbon capture and storage (CCS) technologies. These prevent carbon released via industrial processes from entering the atmosphere. Yet, retrofitting existing cement plants with new technologies is not a simple matter.

The EU-funded CEMCAP project compared CCS options available to the European cement industry. The team assessed five candidate technologies according to suitability for different types of plants. The project compared the technologies technically and economically, plus established a framework making the comparison possible. Pilot-scale testing confirmed the feasibility of all capture technologies.

Candidate technologies

The team tested all but one of the candidates in a laboratory that replicated industrial conditions. The exception, clinker cooling, was tested at a working cement plant. This process involves cooling of clinker, which is the main constituent of cement, with CO2 instead of air.

Researchers also tested three post-combustion technologies. The chilled ammonia process removes CO2 from exhaust gases using an ammonia solution. A second method, called membrane-assisted CO2 liquefaction, combines a plastic membrane which separates CO2 with a CO2 liquefaction process. The final candidate technology, calcium looping, adds calcium oxide to exhaust gas, to form calcium carbonate with the CO2. The team tested two versions of calcium looping.

All tested technologies were more energy efficient than the amine capture method used for reference, although oxyfuel was most efficient. Researchers found that post-combustion technologies are easier to retrofit to existing plants, while integrated technologies (e.g. oxyfuel with calcium looping) are most difficult to retrofit.

“We found no clear winner among the capture technologies,” emphasises project
leader Dr Kristin Jordal. “All CO2 capture technologies investigated in CEMCAP are technically feasible, and either ready to move forward towards on-site testing or already proceeding in that direction.” The optimal capture technology will always be case-specific, depending on location and other factors.

Further testing and uptake

Building on CEMCAP, new EU project **CLEANKER** will progress calcium looping towards full on-site demonstration. Similarly, the European Cement Research Academy will fund a demonstration of oxyfuel capture at plants in Austria and Italy. For the other technologies tested by CEMCAP, no plans for further demonstration currently exist.

Although the project proved all candidates feasible, much remains to be done before industrial implementation could be possible. The core problem is that all CCS processes add 50-90 % to the costs of manufacturing cement.

“At present, there are no business cases for CO2 capture in onshore Europe,” says Dr Jordal. Europe furthermore lacks any infrastructure for CO2 transport and storage as well as an appropriate legal and regulatory environment. “Therefore, no one is currently capturing CO2 from cement plants, although Norcem cement aims to if the Norwegian government covers some costs.”

Without a business case, commercial cement producers are unlikely to adopt CCS voluntarily. The European Commission may have to legislate for compulsory use of the technologies. If so, CEMCAP will have helped simplify that process.

**Keywords**

CEMCAP, CO2, cement, capture technologies, oxyfuel, calcium looping, pollution, CO2 liquefaction, chilled ammonia process, CCS
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