Cement production decarbonisation options appraisal

Background

There are many industrial decarbonisation road maps published for the cement industry from organisations including the International Energy Agency (IEA), trade associations such as Global Cement and Concrete Association, Cembureau (Europe) and the Mineral Products Association (UK) all of which identify carbon capture utilisation and storage as an essential part of reaching net zero cement and concrete.

The cement process has two sources of carbon dioxide emissions, CO2 from the combustion process represents about 30-35% of the emissions and the calcination of the limestone (the conversion of calcium carbonate to calcium oxide and carbon dioxide) the remaining 65-70% of emissions.

Unlike other industries, cement production cannot be decarbonised by switching to a decarbonised fuel such as hydrogen or carbon neutral biomass fuel. Carbon capture and storage is the only means of fully decarbonising cement production.

The Padeswood CCS project is part of the UK Government track 1 phase 2 industrial carbon capture projects which are required to be operational before 2030. To meet this deadline carbon capture techniques need to be mature technologies with proven applications at an industrial scale.

Techniques for carbon capture

During the pre Feasibility and Feasibility phases of the Padeswood CCS project potential technologies for carbon capture were assessed, these are summarised below.

Technique	Study phase	Brief description	Decision
Leilac CCS (low emission intensity lime and cement) technology	Prefeasibility	The Leilac process is under development by Calix and has been demonstrated at 1 tph scale at Heidelberg Materials Lixhe plant in Belgium. Leilac is a direct capture technology but at present can only be applied to the calcination process and therefore would not achieve full decarbonisation of the cement process. Current status: Leilac 2 scale up project to 100,000 tpa is currently under development at Heidelberg Materials Ennigerloh plant in Germany.	Not applicable
Oxyfuel technology	Prefeasibility	Oxyfuel CCS has not yet been demonstrated at industrial scale and is more appropriate technology for a new cement kiln. The production of oxygen for the combustion process requires additional electricity which cannot be provided by the current grid connection at Padeswood. The power grid reinforcement is not planned until 2037 at the earliest. Current status: 500 tpd scale demonstration plant is being developed at Mergelstetten in Germany.	Not applicable
Oxycal	Feasibility	Oxycal was technology developed by Heidelberg Materials during the Padeswood feasibility study. It combines oxyfuel combustion in the calciner with amine capture for the kiln. An oxycal pilot plant was recently commissioned in Bulgaria to demonstrate the concept. Technology not demonstrated at scale. Current Status: Trial operation of the Anrav beta 16tph pilot plant started in 2024 to demonstrate the operation of the modified cement process.	Not applicable
Post combustion amine	Prefeasibility	Widely used in other industries already and demonstrated at similar scale on coal fired stations at Petranova and Boundary Dam, construction in progress at HM Brevik plant.	Applicable

Membrane separation	Prefeasibility	Technology only demonstrated at large prototype scale in gas treatment TRL 5/6. No information available on performance with cement kiln gases. Current status: no information available on industrial scale plants in operation.	Not applicable
Cryogenic separation	Prefeasibility	No information on industrial applications to processes other than hydrogen production. Current status: no information available on industrial scale plants in operation.	Not applicable

At present post combustion carbon capture using amine is the only carbon capture technology already proven on an industrial scale in other industries. It is being applied in the cement industry at the Heidelberg Materials Brevik Plant in Norway and will be operational there in 2025. Selecting another technology would require between 5 and 10 years further development to enable carbon capture at the scale required at Padeswood thus resulting in the continued emission of CO2 at around 700,000 tonnes per year until the technology was proven.

Technique	Study phase	Brief Description	Decision
Non pipeline CO2 transport	Prefeasibility	Road (or rail) transport from Padeswood to HyNet would require CO2 liquefaction at Padeswood which requires additional electrical energy and a loading facility. In the case of road transport this would require an additional 28500 vehicle movements to and from Padeswood each year. At present these would all consume diesel and thus not achieve the objective of net zero cement production.	Pipeline transport