Case #9. HeidelbergCement, Climate Change and Concrete Sustainability

HeidelbergCement is one of the world's largest integrated manufacturers of building materials and solutions, with leading market positions in aggregates, cement, and ready-mixed concrete. Around 53,000 employees at more than 3,000 locations in over 50 countries.

In November 2021, Dr. Dominik von Achten, Chairman of the Managing Board of HeidelbergCement, was part of the official delegation accompanying German Federal President Frank-Walter Steinmeier on his state visit to Norway.. HeidelbergCement is currently building the world's first full-scale carbon capture facility at a cement plant. The facility located at the Brevik cement plant of the Norwegian subsidiary Norcem will be operational in 2024 and capture 400,000 tonnes annually or 50% of the plant's emissions.

As part of the state visit, Dr. Dominik von Achten participated in a roundtable event at the Norwegian classification society DNV on the topic "Energy Transition – From Fossil Fuels to Renewables." Dr. Dominik von Achten underlined HeidelbergCement's strategic focus on Carbon Capture and Utilisation or Storage (CCU/S), and the ambition to decarbonise the company until 2050 at the latest: "We are excited to be part of this pioneering project together with the Norwegian government. It enables us to further progress on our path towards carbon neutrality, thus reducing the carbon footprint of the building materials industry."

Brevik is one of several cement plants where HeidelbergCement is currently testing different technologies and solutions to substantially reduce CO2 emissions. "The experience from Norway will be highly important when we aim to implement carbon capture at a large scale in other cement plants," said Dr. Dominik von Achten: "We target CO2-reductions of up to 10 million tonnes with several CCU/S projects already underway by 2030.

- The Brevik CCS project is part of the Longship programme supported by the Norwegian government for full-scale carbon capture and storage.
- Brevik CCS is the first industrial-scale CCS projects to develop an open-access infrastructure to transport and store significant amounts of CO2 from across Europe.
- Norcem will capture 400,000 tonnes of CO2 per year and transport it by ship to an onshore terminal on the Norwegian west coast.
- From there, the liquefied CO2 will be transported by pipeline to a storage site under the North Sea, for permanent storage.

In October 2021, **HeidelbergCement's British subsidiary Hanson UK** and its partners in the **HyNet North West** consortium, which aims to create the world's first low-carbon industrial cluster in the region of North West England and North Wales, were chosen for funding under the British government's carbon capture, usage and storage (CCUS) "cluster sequencing process." HyNet's proposed hydrogen and carbon capture and storage (CCS) project will play a critical role in the UK's transition to net zero greenhouse gas emissions by 2050 and the fight against climate change.

It also gives Hanson the confidence to invest in a carbon capture plant at its Padeswood cement works, which will connect to the planned HyNet CO2 transport and storage system.

"Yesterday's announcement is great news for HeidelbergCement, and a well-deserved recognition for the HyNet consortium and our colleagues working on CCS in the UK as part of this collaborative project. Cutting CO2 emissions is a key priority for us, and we are delighted to add our Padeswood cement works to our growing range of CCS activities, as a key part of our pathway to reaching net zero", says Dr. Dominik von Achten, Chairman of the Managing Board of HeidelbergCement.

HyNet will reduce regional CO2 emissions by up to 10 million tonnes – including up to 800,000 tonnes from Hanson's Padeswood plant – every year by 2030; the equivalent of taking four million cars off the road. The project, led by Progressive Energy, is being developed by a consortium of regionally located partners including Cadent, CF Fertilisers, Eni UK, Essar, INOVYN (part of the INEOS Group) and the University of Chester as well as Hanson.

In June 2021, **HeidelbergCement AG** announced plans to turn one of its cement plants in Sweden into what it claims will be the world's first carbon-neutral site for cement production. Heidelberg expects the carbon-capture project at the plant to be fully operational by 2030.

Heidelberg will build a carbon-capture facility next to its plant in Slite, Sweden that will allow it to capture up to 1.8 million metric tons of carbon dioxide a year, equivalent to the plant's total emissions. The company also intends to increase the use of greener fuels such as biomass, it said.

Heidelberg has also announced plans for an additional carbon capture plant in Norway that will remove 400,000 tons of carbon annually. However, **the question is whether Heidelberg and others should voluntarily press forward with aggressive carbon capture or wait for regulations to force the necessary CCS implementation industry-wide, making for a level playing field for Heidelberg and others.**

Cement

Cement is a vital source of strength in infrastructure, second only to water as one of the most used substances in the world. In particular, the cement industry is the building block of the construction industry. Few construction projects can take place without utilizing cement somewhere in the design. It is also a source of high carbon emissions, generating more than 6 billion tonnes of carbon, 6 percent of annual global totals.

As a result of more than 4 billion tonnes of cement produced globally each year, emissions from cement make up 8% of global CO_2 emissions. If cement were a country, it would be the fourth-highest emitter of CO_2 in the world after China, Russia and the United States.

Currently, 55% of cement production takes place in China with India producing the second most, 8%. Nevertheless, pressure is on European and American cement manufacturers to reduce their carbon footprint and produce cement in a more sustainable manner in keeping with Paris Agreement goals.

Although the cement industry used only one-quarter of one percent of total energy in the U.S. and EU**, it is the most energy-intensive of all manufacturing industries, with a share of national energy use roughly 10 times its share of the nation's gross output of goods and services.** On average, other energy intensive industries' share of energy use is roughly twice their share of gross output. Cement is also unique in its heavy reliance on coal and petroleum coke.

Clinker

To produce cement's main ingredient, "clinker," a mixture of crushed limestone and aluminosilicate clay is roasted in a kiln. At high heat, limestone's calcium carbonate splits into calcium oxide (the desired lime content) and carbon dioxide (the waste). The technology that has changed little over the past 100 years.

CO_2 is emitted during the production process by the burning of fuel to heat the kilns, as well as from the gases released from the limestone during the calcination process. **Decarbonizing limestone causes roughly 60 percent of cement's emissions. The remaining 40% results from energy use to heat the limestone mix.**

For every 10 tonnes of cement produced, six tonnes of carbon dioxide end up in the atmosphere. When every step of the concrete supply chain is taken into account, the industry carbon footprint is among the worst.

Economics of the Cement Industry

The majority of all cement shipments, approximately 70 percent, are sent to ready-mix concrete operators. The rest are shipped to manufacturers of concrete related products, contractors, materials dealers, oil well/mining/drilling companies, as well as government entities.

The domestic cement industry is also regional in nature. The cost of shipping cement prohibits profitable distribution over long distances. As a result, customers traditionally purchase cement from local sources.

To reach net zero in carbon emissions could double the cost for cement, leading to a 30 per cent increase in the cost of concrete, and that could increase the cost of construction by 3 per cent--small, but it is not trivial. It does raise questions about who is going to pay for the increased cost through the supply chain, up to who is going to be willing to pay more for a building made from zero-carbon cement.

To reach net zero, cement makers need to radically reduce their carbon emissions, but, if no one else is doing it, it's hard to be the first one, as the costs are significant, and there are minimal product quality or customer service differences that could make up for increased costs in a competitive marketplace.

Ian Riley, chief executive of the **World Cement Association**, says the industry has already cut emissions by more than a fifth during the past two decades, by traditional means, such as using more efficient kilns, cleaner energy sources for heating the limestone, and making cement with less clinker. The industry can reduce emissions by another 30 per cent using those methods, he estimates, but not all the way to zero. “A lot of the low-hanging fruit has already been picked,” says Riley. “That still leaves 70 per cent of emission that we haven’t addressed — and for that 70 per cent we really need some new approaches.” https://www.iea.org/reports/cement

The problem is getting worse, not better

The direct CO2 intensity of cement production increased 0.5% per year during 2014 18. To get on track with the SDS, a 0.8% annual decline is necessary to 2030. Sharper focus is needed in two key areas: reducing the clinker-to-cement ratio (including through greater uptake of blended cements) and deploying innovative technologies (including CCUS). Governments can stimulate investment and innovation in these areas through funding R&D and adopting mandatory CO2 emissions reduction policies.

OPTIONS FOR REDUCING THE CLIMATE IMPACT OF CEMENT MANUFACTURING

Option 1 in Reducing the Climate Impact of High-Carbon Concrete: Low Emission Fuels

Since 40% of the carbon emission form manufacturing cement comes from the energy use in the kilns to heat the limestone mix. In the short term, this could mean a shift from coal-fired kilns to natural gas, biomass, or electricity generated by win or solar.

Option 2 in Reducing the Climate Impact of High-Carbon Concrete: Material Efficiencies

Adopting material efficiency strategies to optimise the use of cement would help reduce demand along the entire construction value chain, helping to cut CO_2 emissions from cement production.

Lower cement demand can be achieved through actions such as optimising the use of cement in concrete mixes, using concrete more efficiently, minimising waste in construction, and maximising the design life of buildings and infrastructure. Material efficiency efforts have gained increasing support in recent years. While this option is outside the control of Heidelberg or any other cement maker, it would have a positive impact on climate change assuming the alternative construction material were not as carbon intensive as cement.

Option 3 in Reducing the Climate Impact of High-Carbon Concrete: Clinker Substitution

To reduce emissions from the cement manufacturing process, the second option is to change the composition of cement. Conventional clinker can be partially substituted for alternative materials that include volcanic ash, certain clays, finely ground limestone, ground bottle glass, and industrial waste products—namely blast furnace slag (from manufacturing iron) and fly ash (from burning coal). These materials leapfrog the most carbon-emitting, energy-intensive step in the cement production process.

The average global rate of clinker substitution could realistically reach 40 percent and avoid up to 440 million tons of carbon dioxide emissions annually. Standards and product scales will be key for realizing the opportunity of alternative cements.

To reach net zero, the problem is that in a competitive cement marketplace, if no one else is doing it, it's hard a company to be the first one.

Option 4 in Reducing the Climate Impact of High-Carbon Concrete: Carbon Capture, Utilization, and Storage (CCUS)

Because carbon dioxide emissions cannot be totally eliminated by changing to alternatives to clinker, in order to meet the goals of the Paris climate accord and avoid the rising costs of polluting due to increasing regulation and remain competitive in a low-margin marketplace, the cement industry could accelerate the adoption of carbon-capture-and-storage (CCS) or, as it is sometimes called, carbon-capture-utilization-and-storage (CCUS) technology.

When it comes to reducing the carbon output of the cement sector, there's good news: the CO_2 concentration in exhaust from cement plants is very high, which makes it easier to capture the carbon. 90%+ of the CO_2 can be captured and stored using existing technology, but at significant cost. As in the steel sector, the cost of developing more effective technology could make early adopters less competitive until it is uniformly utilized across the industry.

The financial challenges to decarbonize their businesses could also be heightened if the costs associated with the future regulation put industry profitability at risk, especially if these costs cannot be passed on to customers.

Option 5 in Reducing the Climate Impact of High-Carbon Concrete: Technological Innovation

Globally, the energy intensities of thermal energy and electricity have continued to decline gradually as dry-process kilns – including staged preheaters and precalciners (considered state-of-the-art technology) – replace wet-process kilns, and as more efficient grinding equipment is deployed.

The global thermal energy intensity of clinker is estimated to have fallen to about 3.4 GJ/t in 2018, representing annual average drops of 0.5% since 2014. Fossil fuels continue to provide the majority of energy in the cement sector, with bioenergy and biomass-based wastes accounting for only 3% of thermal energy used in 2018.

In the SDS, the thermal energy intensity of clinker production declines by 0.7% per year to a global average of 3.1 GJ/t, and the electricity intensity of cement production falls by 0.3% to 85 kWh/t.

Heidelberg Sustainability Commitment (*from the Heidelberg website*)

"For us, sustainability means integrating economic, ecological, and social goals into our business strategy. In this context, we have defined the fundamental principles of our sustainability strategy in six action areas along the value chain and published them in our Sustainability Commitments 2030:

- Driving profitability and innovation
- Achieving excellence in occupational health and safety
- Reducing our ecological footprint
- Enabling the circular economy
- Being a good neighbour
- Ensuring compliance and creating transparency

Within the framework of "Beyond 2020", we are significantly pushing our ambitious climate goals. **We want to achieve our original target for 2030 of a 30% reduction in specific net CO2 emissions compared with 1990 already by 2025.**

By 2030, we intend to reduce our specific net CO_2 emissions to below 500 kg per tonne of cementitious material. This corresponds to a further decrease of more than 15% compared with 2019.

We will achieve these goals by using proven techniques and measures such as maximising the use of alternative fuels, optimising the product mix, or improving the efficiency of our plants. To this end, we have defined specific measures for all plants worldwide. **We aim to offer CO2-neutral concrete by 2050 at the latest.**

To achieve this, however, tried-and-tested techniques and measures alone are not sufficient. We are therefore researching and testing several new technologies such as the capture and use storage (CCUS) of CO2 and are intensifying the circular economy in order to reduce CO2 emissions in the long term.

The Quest for "Green" Cement: Heidelberg is Not Alone

The quest for 'green' cement draws big name investors to $300bn industry. Start-ups and venture capitalists are joining concrete makers in trying to solve the hardest problem of carbon emissions.

Among the start-ups, Solida Technologies and others trying to produce low-carbon cement are attracting some of the most prominent tech investors, such Bill Gates' Breakthrough Energy, Amazon's Climate Pledge Fund, as well as venture capitalist John Doerr, of Kleiner Perkins. More than $100m in venture funding has gone to cement start-ups from July, 2020 to June 30, 2021.

The Public Policy Landscape

While some promising policies have been introduced in recent years, greater policy ambition is needed to decarbonise cement.

According to the **International Energy Agency (IEA)** , The direct CO2 intensity of cement production has increased 0.5% per year over the past seven years. To get on track with the UN's Sustainable Development Goals, a 0.8% annual decline is necessary to 2030.

Governments can stimulate investment and innovation through funding R&D and adopting mandatory CO2 emissions reduction policies. https://www.iea.org/reports/cement

One challenge for all the "green" cement start-ups is that at present, large cement companies have few financial incentives to reduce their emissions. Europe is an exception, where cement companies have to buy allowances to cover their CO2 emissions and can save money if they produce less. But in many other countries, such as the US, policies are not in place yet to encourage cement makers to pay for greener alternatives. "It isn't so much that there are regulations today [that require emissions cuts]," says Riley. "It's just at some point, the social license to operate, will depend on [producers] doing something like this."

Heidelberg and the other largest cement makers are also racing find low carbon solutions in anticipation of tighter rules that could be imposed on them by governments worldwide.

In Europe, the mandate to develop cement standards within the **European Committee for Standardisation** was recently widened to allow possible low-carbon alternatives to ordinary Portland cement clinker that rely on different raw materials or mixes.

Also in Europe, the cement sector is covered by the EU emissions trading system. While allowance prices have increased in the past couple of years, it does not appear that the scheme is yet having a large impact on the sector's emissions. A higher price will likely be needed to curtail total sectoral emissions, regardless of whether production increases. A faster reduction in available allowances planned for phase 4 (2021-30) may help with this.

Nevertheless, further policy efforts in all countries will be required to achieve the necessary cement sector decarbonisation.

Increased support for RD&D is needed from governments, particularly to advance the large-scale demonstration and deployment of technologies that have already shown promise. Public-private partnerships can help, as can green government procurement and contracts for difference that generate early demand and can enable producers to gain experience and bring down costs.

Governments may also need to develop or modify regulations to facilitate technology uptake. For example, shifting from prescriptive to performance-based design standards (e.g. within building codes) would stimulate uptake of lower-carbon blended cements and cements that include alternative binding materials.

Policy makers can promote CO_2 emissions reduction efforts by adopting mandatory reduction policies, such as a gradually increasing carbon price or tradeable industry performance standards that require average CO_2 intensity for production of each key material to decline across the economy and permit regulated entities to trade compliance credits.

While a considerable proportion of cement production is not exposed to cross-border competition, measures will be needed to help ensure a level playing field if the strength of policy efforts differs considerably from one region to another. Governments can extend the reach of their efforts by partaking in multilateral forums to facilitate low-carbon technology transfer and to encourage other countries to also adopt mandatory CO_2 emissions policies.

Improving the collection, transparency and accessibility of cement subsector energy performance and CO_2 emissions statistics would facilitate research, regulatory and monitoring efforts (including, for example, multi-country performance benchmarking assessments).

Released in 2018, the Technology Roadmap: Low-Carbon Transition in the Cement Industry provides an update of the Cement Technology Roadmap 2009 and outlines a strategy for the cement sector to decouple cement production growth from the related direct CO2 emissions.

CASE QUESTIONS

1. **(9) Diagram the most likely, best case and worst case scenarios for how the future will evolve for Heidelberg?**

- **By "draw" I mean a diagram as in the example in Module 9 and Exhibits 9.1 and 9.2.**
- **Your scenarios begin at the end point of the case. DO NOT include past history of the case in your scenario. This is a common error of students in presenting scenarios.**
- **The boxes of a scenario diagram show events, actions and decisions by actors. They do not contain actors, as in power diagrams.**
- **The arrows showing the interconnectedness of events, actions and decisions. They imply causality and/or the passage of time.**
- **Further, a forecasted outcome or end point is required. The scenario is how you get there!**
- **In sum, I am looking for the chain of actions and events that result in the three possible outcomes! Each should be represented separately.**
- **Finally, I would like to you provide a probability assessment for each of your endpoints, i.e., probability of the most likely scenario developing, the worst case developing or the best case developing. (You may wish to assess each step along each scenario if you wish. It may be helpful in assessing the end point probability, but is not required.)**

2. **(6) With appropriate reference to your scenarios, would you recommend Heidelberg hold to its gradual timetable for moving toward green cement production, including waiting for regulations to force the necessary CCUS and other operational changes to be implemented industry-wide, making for a level playing field for Heidelberg and others. (Note the targets Heidelberg has set for itself from its website.) (maximum 150 words)**