Energy Efficiency and CO$_2$ Reduction in the Cement Industry

In brief

The most important use of cement is in the production of concrete. It acts as the binder that ‘glues’ the other key ingredients of concrete – sand and gravel. Cement typically makes up about 12% of the concrete mix.

Clinker, the main component of cement, is obtained during the calcination of limestone. The clinker is then ground and blended with other materials into a powder (cement). Most CO$_2$ emissions from cement manufacturing result from the production of clinker. Reducing the clinker content therefore reduces the energy and carbon intensity of the cement produced.

Cement production generates CO$_2$ emissions from two sources: combustion (38%) and calcination (62%). Combustion-generated CO$_2$ emissions are related to fuel use while emissions due to calcination are generated when the raw materials (mostly limestone and clay) are heated and CO$_2$ is liberated from the decomposed limestone.

The technology

Four processes are currently available to produce clinker: wet, semi-wet, semi-dry and dry. Over 90% of cement production in Europe now uses the dry process. The main steps in producing cement are: (a) preparing and grinding the raw materials; (b) producing clinker as an intermediary; and (c) grinding and blending clinker with other products to make cement.

As cement manufacture is a mature technology, no breakthrough technologies are foreseen that will reduce thermal energy consumption to any significant extent. Carbon capture and storage (CCS) may be a viable option to reduce CO$_2$ emissions from cement production.
cement production in the medium term, but improving cement energy and environmental performance in the short term is the main technological challenge. This will be achieved through higher uses of clinker substitutes in cement and increased use of alternative fuels, such as waste and biomass.

A number of energy efficiency measures are already on the table, but their deployment is usually site-specific, making it difficult to assess the overall gains that can be expected.

Ongoing research

Investment in state-of-the-art thermal and electrical efficiency technologies has been a key element of the cement industry’s efforts to reduce its emissions. Co-processing of alternative fuels and raw materials is one way to increase substitution rates of non-renewable materials in the cement industry. Further use of alternative fuels will avoid emissions and ultimately save on fossil fuel use.

In addition, innovative binder technologies not requiring the high-temperature firing of limestone and silica materials are being researched. This research is still at the early stages, and more time will be required to assess the economic viability and suitability of these technologies for the production of durable concrete.

The cement industry is currently researching the considerable potential for carbon capture and storage. However, the viability of CCS has yet to be proven on an industrial scale, as the current technologies (post-combustion and oxy-combustion) can double the price of the cement.

The Industry

Global cement production in 2012 was about 3.6 billion tonnes with China being the main producer, with a 59.3% share. Without taking China into consideration, world cement production was up 1.8% in 2012, compared to an increase of 2.8% in 2011. However, cement production in the EU-27 fell from 195.5 million tonnes (Mt) in 2011 to 156.3 Mt in 2012. The EU-27 share of total world production is now around 5.6%, just over half its share in 2006 (10.5%).

Demand for cement in 2012 was in line with the general economic downturn. Cement consumption dropped compared to 2011 in most CEMBUREAU countries. The overall per capita consumption of cement in the EU-27 is now expected to remain fairly stable, at around 450 kg. This would lead to cement production in Europe of about 234 Mt by 2030.

Barriers

Low energy prices are among the main barriers to the deployment of energy efficiency measures and CO₂ mitigation technologies.

Fact file

- Energy needs accounts for around 40% of the variable cost of cement production. Electrical energy accounts for around 20% of cement energy needs.

- The current European average of electrical consumption by the cement industry is 117 kWh/t cement, most of it (around 80%) consumed for grinding processes, which have energy efficiencies of only 5% to 10%.

- From 1990 to 2010, the global weighted average of electrical consumption of participants in the ‘Getting the numbers right’ project increased from 114 kWh/t cement to 117 kWh/t cement (WBCSD/CSI, 2013);

- Without the adoption of CCS technologies, the specific electricity demand of cement production in 2030 could decrease to about 105 kWh/t cement, compared to 110 kWh/t in 2006.

1 WBCSD/CSI 2013

Globally, cement production accounts for around 5% of man-made CO₂ emissions. The industry recognises this responsibility and embraces its commitment to reduce this markedly, especially by contributing to the circular economy.

European Cement Association (CEMBUREAU)
in the European cement industry. Though high energy prices favour investment in energy efficiency and increased abatement of CO₂ emissions, they may also lead to more imports from non-EU countries – to the detriment of European production.

The market penetration of cement with a decreasing clinker-to-cement ratio will largely depend on the availability of raw materials, the properties of the cement, the price of clinker substitutes, the intended application, national standards and market acceptance.

Due to differences in national applications of the European concrete standard, concrete can often not be used universally. The cement industry therefore needs to promote harmonisation of standards at the EU level.

Needs

The industry needs to continue to promote state-of-the-art technologies, increase the use of alternative fuels, encourage clinker substitution and facilitate the development of carbon capture and storage.

Other critical needs for the cement industry include ensuring predictable, objective and stable CO₂ constraints and an energy framework on an international level. Also, research and development of capabilities, skills, expertise, innovation and international partnerships must continue to be developed.

Among the conclusions of the International Energy Agency (IEA) cement roadmap is that the current options available today, such as alternative fuels and clinker substitutes, are not sufficient to achieve a substantial reduction in CO₂ emissions.

There is a need for new technologies and new types of cement. To achieve this goal, an increase in European RDD&D is required.

Fact file

- Almost three tonnes of concrete are produced in the world per person, twice as much as all other materials together, including wood, steel, plastics and aluminium.
- The total cement production in the EU-27 and Turkey in 2011 was worth about EUR 18 billion (Eurostat).
- CO₂ emissions from the cement industry in Europe peaked in 2007 at 173.6 Mt CO₂, but fell to 157.8 Mt CO₂ in 2008. Emissions have continued to fall since, reaching 122 Mt CO₂ in 2011 (CEMBUREAU).
- The drop in European CO₂ emissions in 2011 (to around 124.7 Mt CO₂) was a direct consequence of a sharp decrease in cement production.
- The CO₂ emissions savings from the use of alternative fuels would be an estimated 23.5 Mt CO₂ in 2030 if current trends in fuel substitution are maintained.
- The production of cement provides an estimated 61,000 direct skilled jobs in the EU-27 and Turkey (CEMBUREAU).

Installed capacity

Three out of the world’s five largest cement producers are sited in the EU-27 and the European cement industry has a 95% share of the European market and 75% of the North American market.

The EU-27 thermal energy consumption for cement production in 2007 was 0.76 EJ (18.1 Mtoe).

Meanwhile, the alternative fuels consumption increased from 3% of the heat consumption in 1990 to almost 18% in 2006 (CEMBUREAU, 2009); if current trends are maintained, the rate of fuel substitution could reach 49% in 2030 with a saving of 7.3 Mtoe in 2030.