# Profiles

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## $CO_2$ abatement in the cement industry

Cement manufacturing, cement production is an energy- and carbon-intensive process and therefore a major contributor to global anthropogenic $CO_2$ emissions. World cement production has been increasing steadily over many decades amounting to around 2.31 Gt in 2005. This represented an increase of almost 300% from the 1970s production levels and almost double the total production in 1990.

$CO_2$ emissions in cement manufacturing derive from two sources: fossil fuel combustion and the calcination of the principal limestone raw material. Over 50% of the $CO_2$ emissions in cement production results from calcination, and around 40% of the $CO_2$ result from combustion of the fossil fuels that supply the energy for calcination. Indirect $CO_2$ emissions due to the use of electricity that is generated by fossil fuel combustion account for about 5% of the total emissions. In 2000 the cement industry emitted around 1.4 $GtCO_2$ (direct and indirect), which accounted for ~5% of the global anthropogenic $CO_2$ emissions or 3% of the global anthropogenic greenhouse gas emissions. In 2005, the total $CO_2$ emissions from cement production increased to 1.9 Gt, which was almost 8% of total global $CO_2$ emissions.

The technology roadmap for the cement industry developed by the IEA described the possibility of reducing total $CO_2$ emissions in the cement industry by 18% by 2050. The roadmap envisages four levers for carbon emissions reduction from cement manufacturing: energy efficiency, alternative fuel, clinker substitution and carbon capture and storage (CCS). In addition, extensive research is being carried out to develop innovative low-carbon cementitious materials as alternatives to the traditional Ordinary Portland Cement (OPC).

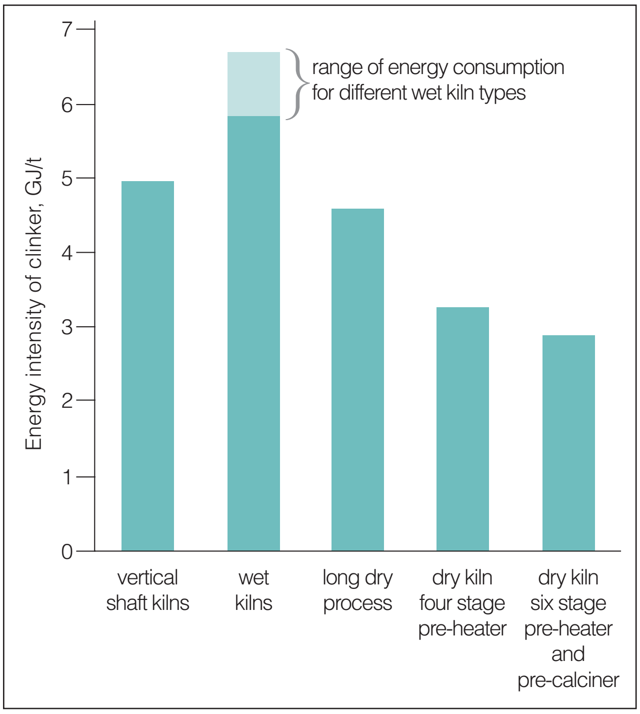
### Improving energy efficiency

Clinker production is the most energy-intensive step, accounting for around 80% of the energy used in cement manufacturing. Improving the energy efficiency in the clinker production process can reduce the energy consumption, associated costs and $CO_2$ emissions. The total energy consumption of a cement plant consists of mainly two parts: combustion of fossil fuel to provide the process heat required for calcination (thermal energy) and electricity to run the machinery (electrical energy). Today's state-of-the-art cement kiln process uses the dry kiln processes with multistage cyclone preheaters with an integral pre-calciner and this process is the most energy efficient. Over the past two decades, cement manufacturers have achieved greater energy efficiencies resulting in a significant reduction in unit-base $CO_2$ emissions in cement production. Apart from adapting to the best kiln process, other measures such as reducing the heat loss from the kiln system, improving the kiln combustion system and optimising the kiln operation using process control and management system, and waste heat recovery for power generation can all contribute to increased energy efficiencies and lower direct $CO_2$ emissions.

Electric energy efficiency improvements can be achieved through several approaches such as implementing best available technologies and non-technical measures. Grinding processes are the major power consumers in cement plants. Modern grinding technologies can reduce the electricity demand of the raw and finishing grinding operation as well as that of coal milling for fuel preparation, leading to reductions in indirect $CO_2$ emissions. Using modern highly-efficient motors or improving the efficiency of the existing motor system can result in a significant reduction in electricity use and related indirect $CO_2$ emissions. A reduction in the power demand of a cement plant can also be achieved by measures such as improving raw material blending/homogenising, using high efficiency classifiers/separators, efficient transport systems and fans, reducing pressure losses in cyclone preheaters and implementing a slip power recovery system.

### Alternative fuels

Coal, the most carbon-intensive fossil fuel, is the most widely-used fuel in the cement industry. Replacing fossil fuel with biomass and/or waste derived fuels saves energy and natural resources as well as reducing $CO_2$ emissions. The use of wastes as alternative fuels in cement kilns has a number of potential benefits such as the recovery of the energy content of waste, conservation of non-renewable fossil fuels, reduction of overall $CO_2$ emissions, lowering cement production cost and the use of existing




*Energy efficiency of various kiln technologies*

technology to safely treat hazardous wastes, eliminating disposal of such wastes through incineration or landfill. However, there are several technical challenges and some financial barriers to the use of alternative fuels in cement kilns. In addition, the availability and price of alternative fuels may also become a limiting factor to their wider application.

## Clinker substitution

Clinker substitution is the most cost-effective way to reduce $CO_2$ emissions from cement production and has other environmental benefits. The supplementary materials that can be used as clinker substitutes include blast furnace slag, fly ash from coal combustion, and other natural and manufactured pozzolans. Many types of blended and composite cement can be produced depending on the supplementary material used and the clinker ratio. The thermal energy consumption of per unit cement produced decreases with the increased ratio of clinker substitutes in the blended cement. The reduced thermal energy requirements and possibly lower power consumption result in decreases in both direct and indirect $CO_2$ emissions in cement production and in associated costs.

## Carbon capture

The carbon capture technologies potentially applicable for cement manufacture are post-combustion and oxyfuel combustion capture. The chemical absorption process is the leading technology currently used for post-combustion $CO_2$ capture. Carbonate looping using CaO as sorbent, when properly developed, may be suitable for $CO_2$ capture in a cement plant. Other post-combustion capture technologies such as membrane and cryogenic separation processes are under development and are not yet commercially available but may play a key role in the future for $CO_2$ capture at large-scale power or cement plants.

In oxyfuel combustion, fuel is burned in pure $O_2$ instead of air and this results in a flue gas that is composed mainly of $CO_2$ (>80%) and water vapour, which is easily separated at low cost by a condensation process, eliminating the need for costly post-combustion capture systems. However, the major cost and energy penalty of post-combustion processes is traded here for the costly and energy-intensive oxygen production. In addition, to introduce oxyfuel combustion technology into an existing cement plant is extremely challenging.

## Low-carbon cement

Replacing limestone with alternative calcium containing raw materials with less embodied $CO_2$ offers a chance to reduce emissions of both the process related $CO_2$ and the fuel combustion related $CO_2$ in the clinker production. Examples of such decarbonated alternative raw materials include CKD, steel slag, fly ash and other pozzolanic materials, and concrete wastes. Implementing raw material substitution is fairly simple technically and requires low capital investments but the application is subject to the availability of the substituting materials.

A large number of innovative low-carbon cements have been developed or are in development. In many cases, the production of the innovative cements involves chemistry that is completely different from that of OPC production. They offer opportunities to significantly reduce $CO_2$ emissions from cement production. However, due to the well established production and supply chain and the low prices of OPC cement, a significant shift from OPC to innovative low-carbon cement materials is unlikely to happen unless a legal constraint and/or a strong and effective market for emissions trading are established to make $CO_2$ savings financially rewarding.

Each issue of *Profiles* is based on a detailed study undertaken by IEA Clean Coal Centre, the full report of which is available separately. This particular issue of *Profiles* is based on the report:

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