

# The use of alternative fuels in the cement industry and their emission impacts

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Alternative fuels are a well-established aspect of cement kiln operation worldwide. On the available figures, the replacement of traditional fossil fuels with alternative fuels has reached on average 14% fuel replacement. This outcome has been achieved with no adverse impacts upon the cement kiln emissions and is a consequence of the unique characteristics of the cement manufacturing process.

Concrete is cited as the most consumed product on earth after water. Concrete comprises around 15% by weight of cement. Cement is the vital ingredient. It is the glue that holds together the sand and aggregate that forms concrete.

Cement production consumes large quantities of raw materials and fuels and produces significant quantities of carbon dioxide. The production of 1 tonne of cement consumes around 1.6 tonnes of raw materials and 0.1 tonne of coal and produces 0.8 tonne of carbon dioxide. As a consequence carbon dioxide emissions from cement kilns comprise approximately 5% of global emissions. Under the auspices of the World Business Council the Cement Sustainability Initiative (CSI) was developed which is a global effort by 25 major cement producers with operations in more than 100 countries who believe there is a strong business case for the pursuit of sustainable development in the cement sector. Collectively these companies account for around 30% of the world's cement production and 60% of cement production outside China. The cornerstones of this initiative is the development and promotion of the use of Alternative Raw Materials and Fuels derived from waste. The expressed aim is to convert waste that has significant calorific value into a cement kiln fuel or reuse waste streams that have a suitable chemistry as raw material replacements.

Data available from the CSI for 2012 shows the replacement of traditional fossil fuels with alternative fuels had reached around 14% amongst the member companies. This outcome represents around 14 million tonnes per annum of waste. The principal components of the alternative fuel stream were biomass and solid shredded waste each comprising around 25% of the alternative fuel consumption. The biomass comprises timber waste, rice husk and a range of other materials such as grape marc, olive pips etc. The solid shredded waste also known as RDF/SRF/PEF is largely derived from Commercial and Industrial waste, Municipal Solid waste and Construction and Demolition waste.

The use of solid shredded waste has grown to the point that the classification, sampling and testing of the material in Europe is now the subject of a European Standard EN 15359 2011 and is freely traded within the European Union. The export of solid shredded waste from the UK has grown from nothing in 2010 to over 2 million tonnes in 2014. This growth in trade has been driven by changes in the UK regulatory environment a lack of capacity to absorb additional volumes within the UK and the capacity of cement kilns and waste to energy plants in mainly northern Europe to accept additional material.

In Australia, ResourceCo supplies 20% of the fuel requirements of Adelaide Brighton Cement at Birkenhead in South Australia with solid shredded waste derived from Commercial and Industrial Waste and Construction and Demolition waste. ResourceCo also has a processing operation in Malaysia that supplies 15% of the fuel requirements of Lafarge Kanthan Works. The feed material to

this kiln is solid shredded waste derived from Municipal Solid waste and Commercial and Industrial waste. Approximately 80% of the fuel is sourced from Australia and 20% is sourced locally.

It has been a feature of the Adelaide Brighton operation and the Lafarge operation that the change in fuel has had no adverse impacts upon the emissions to the environment and this finding is consistent with cement kilns around the world using alternative fuels. In the case of Lafarge Kanthan the use of solid shredded waste also known as PEF has resulted in a reduction in Nitrous Oxide emissions of around 20% and a reduction in Carbon Dioxide emissions of approximately 20,000 tpa.

This outcome is not surprising given the inherent nature of the cement manufacturing process. The species that are emitted from a cement kiln and that are of interest to a regulator can be broadly divided into the classifications of Dust, Nitrous oxides, Organics, Acid gases and Metals.

**Dust:** The particulate emissions from a cement kiln bear no relationship to the fuel being used but are purely a consequence of the type of dust collector that is used and the standard to which it is maintained and operated. Given the fact the process is counter current ie the gas flow is the opposite to the material flow the dust that leaves in the cement kiln stack is the fine component of the raw material input comprising typically limestone and clay.

**Nitrous oxides:** While NO<sub>x</sub> can be formed in a cement kiln from atmospheric nitrogen and the nitrogen in the fuel, it can also be destroyed depending upon the combustion conditions. The formation of NO<sub>x</sub> in a cement kiln is largely driven by the peak flame temperature in the main burner. The production of NO<sub>x</sub> by this mechanism can be offset by a phenomenon known as reburn in the kiln calciner where combustion of the fuel can produce conditions that destroy a portion of the NO<sub>x</sub>. It has been found in many kilns that the burning of a secondary alternative fuel can produce these conditions and this phenomenon has been observed with the burning of PEF in the Lafarge Kanthan kiln.

**Organics:** The major concern with organic emissions is typically dioxins and furans (PCCD, PCCF) and Volatile Organic Compounds (VOC, TOC). The presence of additional chlorine in the system in the plastics component of PEF raises the question of whether there will be an increased risk of emissions of dioxins and furans. In the cement kiln system the principal determinant of the dioxin and furan emission is the cooling rate of the gas from the preheater exhaust temperature of 360 degrees C to under 200 degrees C and not the chlorine concentration in the gas stream. It is the time the gas spends in this temperature window that determines the dioxin and furan emission. The cement process raw milling system provides the ideal quenching system to avoid dioxin and furan formation, with limestone at ambient temperature being contacted with the hot preheater gases. Volatile Organic Compounds present in the kiln stack emissions are exclusively a consequence of the incomplete combustion of the organic components in the raw materials burning at relatively low temperatures (350-450 degC) and, as a consequence, forming a range of organic compounds. The fuels burn at such high temperatures with enough oxygen and for sufficient time that combustion is complete.

**Acid gases:** The components that can potentially form acid gases are chlorine, sulphur and fluorine. Although there is additional chlorine entering the system with PEF and there is the potential to form HCl from hydrogen radicals from the fuel combustion, the chlorine has a greater affinity to form compounds with potassium and sodium which remain trapped in the system until they reach an equilibrium and exit with the cement clinker. Similarly, any sulphur in the system preferentially reacts with potassium and sodium and then calcium and exits the system with the clinker. Fluorine behaves in a similar fashion. These effects can be likened to the process that takes place in a lime scrubber

**Metals:** The major impact on metals emissions from a cement kiln is the dust release from the emission control device. This dust comprises the raw material and the metal component of the raw material is essentially what comprises the metal emissions. The research arm of VDZ, the German Cement Industry Association has estimated the contribution the metals in fuels make to the stack emissions. For the eight refractory or non-volatile metals (Sb to V) the contribution is 0.0005%. For the semi-volatile metals (Cd and Pb) the contribution is 0.002%. For the volatile metals mercury and thallium the outcome can be unpredictable but is estimated at 0.02% for thallium and up to 100% for mercury. Thallium is an extremely rare metal. Mercury must be managed to low levels but for all the other metals present in fuels the impact upon emissions is so low as to be immaterial

While the preceding discussion deconstructs the emissions profile of a cement kiln and examines the conditions within the process that reinforce the observation that changes in fuel type have no adverse impact upon emissions there are also references available in the scientific literature that support this conclusion.

One of the best documented studies was conducted by the University of Lisbon on the cement kilns operated by Secil a Portuguese cement company<sup>1a,b</sup>. The work noted that *“One important conclusion is that the use of different alternative fuels has no impact upon the level of emissions and as the whole process was carried out within the control of the community, it was a consensual deduction.”*

The use of alternative fuels by the cement industry is a means of improving the sustainability of that industry by reducing its impact upon virgin resources in the form of fuels and raw materials, reducing carbon dioxide emissions as well as providing a better solution for waste management. The overwhelming evidence is that these outcomes can be achieved without any additional adverse impact upon environmental emissions.

#### References

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