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Reducing GHG Emissions in the Cement Industry

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Issue

Cement production is an energy intensive process using fossil fuels that account for 5% of total global man-made CO_2 emissions.[i] In Metro Vancouver, two cement plants (Lehigh Hanson – Delta, and Lafarge Canada – Richmond) supply 85% of cement consumed in the province and contribute 13% of Metro Vancouver's GHG emissions, and 3% of the provincial total.[ii] Significant heat energy is required to sustain high temperatures, as cement production is a fossil fuel intensive process. For example, in Metro Vancouver 88% of the energy for cement production in 2008 came from coal and petroleum coke.[iii] Given the percentage of GHGs produced by cement production it is imperative to examine the technological and policy approaches available to reduce the industry's CO_2 emissions.

Background

According to the Cement Technology Roadmap and the Canadian Cement Industry Sustainability reports, the cement industry has identified four key approaches to reduce their CO_2 emissions that may require appropriate incentives to overcome barriers to implementation.

1) Thermal and electrical efficiency occurs via retrofits and can provide a cost advantage to the producer through lower energy costs. Efficiency increases over time with new plant technology and by upgrading old plants but it can also be influenced by local energy prices, For example, Indian companies invest strongly in efficiencies because of high-energy prices and low coal availability. A major limitation of increased thermal and electrical efficiency is the high cost associated with retrofits.[iv] New facilities may implement more stringent energy efficiency standards, but upgrades to older facilities can be very expensive. For example, Lehigh Hanson implemented a lighting power management system with variable frequency drive technology in 2008, but it is unclear to what extent this has resulted in improved plant efficiency.

2) The use of **alternative fuels** involves replacing conventional fuels (mainly coal and petroleum coke), with alternative fuels such as natural gas and biomass.). The Canadian cement industry primarily uses coal (54.8%) and petroleum coke (30.2%)

to fuel its production, but fuel use varies substantially between provinces. Alternative fuel use is around the national average in BC at 12% compared with 0% in Alberta and 34.3% in Quebec.[v] Mixed fuels can be 20-25% less carbon intensive than coal, and cement kilns are particularly well-suited for alternative fuels.[vi] An example of this is the Lafarge Plant in Richmond, which in partnership with Urban Wood Waste Recyclers has created an engineered fuel that includes waste wood from construction and demolition.[vii]

3) Clinker substitution partially replaces the main component of most types of cement, with supplementary cementing materials such as ground blast-furnace slag, fly ash, volcanic ash, calcined clay and limestone, to reduce associated CO_2 emissions**.**[viii] In 2008, the Canadian average clinker to cement ratio was 0.83. There are well known varied effects of substitutes on strength, durability, and workability that are optimal for different end uses. Five non-technical barriers have been identified by the industry that will influence whether clinker substitution is implemented or not. These are: 1) regional availability of substituting materials, 2) increasing prices of substitution materials, 3) the properties of the substitutes and the intended application of the cement, 4) national standards for ordinary Portland cement and composite cements, and 5) acceptance of composite cements by construction contractors and customers.[ix]

4) The final technological innovation for the cement industry is **carbon capture and storage** (CSS). CCS is a new technology, not yet proven at the industrial scale, but potentially promising. CO_2 is captured as it is emitted, compressed to a liquid, then transported in pipelines to be permanently stored deep underground. In the cement industry, CO_2 is emitted from fuel combustion and from limestone calcination in the kiln.[x] These two CO_2 sources may require industry-specific capture techniques that are low-cost and efficient. The economic framework will be a decisive factor in the development of CCS in the cement industry. Furthermore, a political agreement is required to limit the risks of carbon leakage between jurisdictions. For example, the EU has proposed a carbon tariff to prevent such carbon leakage.

Recommendations

The Cement Technology Roadmap and the Canadian Cement Industry Sustainability Report both recommend policy measures to promote a cleaner and more energy efficient cement industry. Many of these are aimed at facilitating the growth and effectiveness of the four key technological advances listed above. However, appropriate policy measures will be additionally important for implementation. Measures most relevant to the BC context include:

Increasing energy efficiency
Government can help to improve financial and fiscal conditions to attract the capital investment needs to further modernize the industry. Steps to strengthen and broaden the energy efficiency of co-generation programs will also lead to a more energy-efficient cement industry.

Increasing alternative fuel use
In order to reach substitution rates in line with Europe, Canadian cement manufactures are going to need a mix of supportive policies that promote the use alternative fuels and biomass.. In addition, waste management legislation and local waste collection networks need to be strengthened so that energy rich materials are diverted from landfills to be harnessed in the production of alternative energy.

Increasing clinker substitution

The most significant barrier to clinker substitution is outdated industry standards that favour traditional cement composition. Developing new, and revising existing, cement standards and codes would allow more widespread use of blended cement. Standards should be based on performance rather than composition. In conjunction with revised standards, further R&D should be conducted to determine which processing techniques have the greatest potential for improved energy efficiency.

Facilitating the implementation of CCS
According to the IEA's Cement Industry Roadmap 2009, CCS is a promising approach, but requires an accompanying regulatory framework, international collaboration, government support for funding of pilot projects, the development of transport networks and storage sites, and a government and industry partnership to educate and inform key stakeholders. Presently, Canada is leading the way in the development of CCS and has already started to capture CO_2 from the St. Mary's Cement Plant in southwestern Ontario in order to grow algae. An adjacent industrial algae production facility harvests the algae, which provides an alternative source of fuel for St. Mary's cement kilns.[xi]

Conclusions

In order to increase efficiency and reduce emissions in the cement industry, cost estimates will need to be associated with each technology in order to better assess industry needs and to provide appropriate policy incentives. It is worth noting that 35% of the total emissions associated with cement industry come from the combustion of fuels in the kiln, and that the remaining 65% are GHG emissions from processing raw materials, primarily the conversion of calcium carbonate ($CaCO_3$) to slaked lime (CaO). Much of the preliminary analysis focuses on the first 35%. Partnerships with a willing industry and the fostering of new technology companies could help to address the remaining 65% of emissions and help to position BC as a global leader in sustainable cement production.

Further Reading

A number of low-carbon or carbon-negative cements are currently being developed or are in demonstration and testing. These include:

Calera: http://www.calera.com/
Calix: http://www.calix.com.au/
Novacem: http://novacem.com/
Geopolymer cement: http://www.geopolymer.org/applications/geopolymer-cement
C-Crete Technologies:
http://www.globe-net.com/articles/2010/may/20/mit-students-create-green-concrete.aspx

Sources

[i] IEA and WBCSD, 'Cement Technology Roadmap 2009: Carbon emissions reductions up to 2050': http://www.wbcsd.org/includes/getTarget.asp?type=d&id=MzY3NDM

[ii] Cement Association of Canada, 2009, 'Energy Substitution in the BC Cement Sector'

[iii] Cement Association of Canada, 2009, 'Energy Substitution in the BC Cement Sector': http://www.cement.ca/images/stories/energy_substitution_in_the_b.c._cement_sector.pdf

[iv] IEA and WBCSD, 'Cement Technology Roadmap 2009: Carbon emissions reductions up to 2050'

[v] Cement Association of Canada, 2009, 'Energy Substitution in the BC Cement Sector'

[vi] IEA and WBCSD, 'Cement Technology Roadmap 2009: Carbon emissions reductions up to 2050'

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[viii] Simandl, G.J. And Simandl, L. (2008): 'Cement - Reduction of CO Emmissions - Economic Considerations - Supplementary Cementitious Materials'; British Columbia Ministry of Energy, Mines and Petroleum Resources; Geofile 2008-9, poster: http://www.empr.gov.bc.ca/Mining/Geoscience/PublicationsCatalogue/GeoFiles/Documents/GF2008-9/GF2008-9.pdf

[ix] IEA and WBCSD, 'Cement Technology Roadmap 2009: Carbon emissions reductions up to 2050'

[x] IEA and WBCSD, 'Cement Technology Roadmap 2009: Carbon emissions reductions up to 2050'

[xi] Pond Biofuels, 2010, 'Technology': http://pondbiofuels.com/Technology/Technology.html