Low Carbon Cements: The Challenges and Opportunities

First Global Future Cement Conference 2011

8 February 2011
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Executive Director
Mineral Products Association
Summary

The Big Picture

Tackling the CO2 challenge

Low Carbon Cements
**Some CO₂ Numbers**

<table>
<thead>
<tr>
<th>Country</th>
<th>million tonnes CO₂</th>
<th>Sector</th>
<th>million tonnes CO₂</th>
</tr>
</thead>
<tbody>
<tr>
<td>World</td>
<td>40,000</td>
<td>Chemicals/Petroleum</td>
<td>3,000</td>
</tr>
<tr>
<td>USA</td>
<td>6,000</td>
<td>Steel</td>
<td>2,200</td>
</tr>
<tr>
<td>China</td>
<td>6,000</td>
<td>Cement</td>
<td>1,600</td>
</tr>
<tr>
<td>UK</td>
<td>500</td>
<td>Paper</td>
<td>500</td>
</tr>
<tr>
<td>New Zealand</td>
<td>40</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Nepal</td>
<td>3</td>
<td></td>
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</table>

*source: International Energy Agency*

source: US Energy Information Administration (fossil fuels)
CO₂ emissions by country
World cement production in 2009

China: 49%
Others Asia: 13.5%
India: 6.5%
Japan: 2.2%
Oceania: 0.4%
Others Europe*: 0.5%
CEMBUREAU: 10.8%
CIS: 3.2%
Other America: 6%
USA: 3.1%
Africa: 4.7%
Imperatives to Reduce CO₂

- Climate Change
- Cost Reduction/Avoidance
- Future Scarcity of Fossil Fuels
- Taxes & Legislation
- Expectations of customers, investors and employees
But this is the real imperative!
WBCSD:CSI- 24 member companies, 100 countries
WBCSD: Communication Partners
Direct CO$_2$ emissions - clinker

Carbon Dioxide Emission from Clinker Production

<table>
<thead>
<tr>
<th></th>
<th>Percentage</th>
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<tbody>
<tr>
<td>Calcination (Process)</td>
<td>61%</td>
</tr>
<tr>
<td>Combustion (Fuel)</td>
<td>39%</td>
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mpa cement
Levers to reduce CO$_2$ emissions in cement clinker production

- Clinker substitution
- Energy efficiency
- Alternative fuels / biomass
- Carbon capture and storage
IEA Roadmap - Portfolio of CO2 Abatement Measures

Cement roadmap targets

<table>
<thead>
<tr>
<th>Year</th>
<th>Direct emissions (Gt CO₂)</th>
</tr>
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<tbody>
<tr>
<td>2010</td>
<td>2.33</td>
</tr>
<tr>
<td>2030</td>
<td>2.22</td>
</tr>
<tr>
<td>2050</td>
<td>1.86</td>
</tr>
</tbody>
</table>

Cement sector CO₂ emissions reductions below the baseline, low demand scenario, 2006-2050

- Baseline emissions: 2.34 Gt
- Opportunities for CO₂ emissions reductions:
  - Energy efficiency: 10%
  - Alternative fuel use and other fuel switching: 24%
  - Clinker substitution: 10%
  - Carbon capture and storage (CCS): 56%

CCS is a core element for long-term CO₂ reduction

Source: WBCSD/IEA
# Good progress to date

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</thead>
<tbody>
<tr>
<td>Net CO2 / tonne clinker, kg/tonne</td>
<td>907</td>
<td>863</td>
<td>847</td>
<td>843</td>
<td>842</td>
<td>838</td>
</tr>
<tr>
<td>Net CO2 / tonne cementitious, kg/tonne</td>
<td>754</td>
<td>712</td>
<td>672</td>
<td>662</td>
<td>656</td>
<td>646</td>
</tr>
<tr>
<td>Heat Consumption, MJ/tonne clinker</td>
<td>4266</td>
<td>3763</td>
<td>3686</td>
<td>3666</td>
<td>3676</td>
<td>3657</td>
</tr>
<tr>
<td>% Alternative fuel</td>
<td>2.7</td>
<td>6.2</td>
<td>9.4</td>
<td>9.7</td>
<td>10.3</td>
<td>11.0</td>
</tr>
<tr>
<td>Clinker/cement ratio, %</td>
<td>83</td>
<td>82</td>
<td>79</td>
<td>78</td>
<td>77</td>
<td>76</td>
</tr>
<tr>
<td>Electricity Consumption kWhr/tonne cement</td>
<td>114.7</td>
<td>112.9</td>
<td>111.1</td>
<td>110.1</td>
<td>109.7</td>
<td>109.9</td>
</tr>
</tbody>
</table>
Tilbury

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Use of waste-derived fuels

- Waste-derived materials: tyres, waste solvents, MBM biomass, paper/plastic mix, packaging, RDF, sludge
- In EU, 18% replacement of fossil fuels on average (up to 70% in some EU regions)
- In UK, 26% replacement of fossil fuels
- Equivalent to over 330,000 tonnes of coal in 2007
Fuel and energy mix UK Cement

2008 Total Works Energy Use % by Source (inc delivered electricity)

- Coal, 58.55%
- Delivered electricity, 11.81%
- Coke, 0.00%
- Gas Oil, 0.60%
- Pet coke, 5.61%
- Natural Gas, 0.48%
- Heavy Fuel Oil, 0.00%
- Kerosene, 0.38%
- LPG, 0.00%
- Paper/Plastic mix, 0.00%
- Packaging & RDF, 5.43%
- Sludges (paper and sewage), 0.51%
- MBM - Meat & Bone Meal, 3.43%
- Waste Solvents, 4.63%
- Waste oils, 0.05%
- Tyres, 8.53%
- Other, 22.58%
What is Carbon Capture and Storage?

The removal of CO2 from exhaust gases.

Two possible methods applicable to cement:
- Post-combustion - Scrubbing kiln gas to separate CO2 exhaust gases
- Oxy-Combustion - Combustion in O2 instead of air

The possible storage options/recovery:
Carbon Capture and Storage
A long term possibility?

- IEA GHG - UK Cement industry Study
- CCS Cement plant will cost double a non-CCS cement plant
- Operational costs also double
- Need for transport infrastructure
- Technical barriers for Oxyfuel and post combustion
Barriers

Scale of operations
First mover risk
Pipeline network
Storage sites
Long term liabilities
Carbon price
Level global playing field

Source: IEA GHG programme
Low Carbon Cements
Low Carbon Cements

The Key Challenges:

Develop Economic Manufacturing Process

Demonstrate Performance

Market entry

Funding
Manufacturing process challenges

Availability of raw materials

Scaling up and CO2 balance

Energy requirements

Economics

Regulatory Permits (IPPC, EA etc)
Novacem

- Based on magnesium oxide and hydrated magnesium carbonates
- Accelerated carbonation of magnesium silicates under elevated levels of temperature and pressure (180 °C / 150 bar)
- Carbonates produced are heated at low temperatures (700 °C) to produce MgO
- Use of magnesium silicates eliminates CO2 emissions from raw materials processing
## Environmental and Economic Performance

<table>
<thead>
<tr>
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<th>Cement (Current EU Average)</th>
<th>Cement (EU BAT in 10 yrs)</th>
<th>Novacem</th>
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<tbody>
<tr>
<td>Capacity (Mt clinker pa)</td>
<td>2.0</td>
<td>2.0</td>
<td>0.5-1.0 (?)</td>
</tr>
<tr>
<td>Fuel consumption</td>
<td>100% (3.7 GJ/tonne)</td>
<td>80%</td>
<td>50% (?)</td>
</tr>
<tr>
<td>Electricity consumption</td>
<td>100% (110 kWhe/tonne)</td>
<td>80%</td>
<td>100-120% (?)</td>
</tr>
<tr>
<td>CO2 emission (tonne/tonne clinker)</td>
<td>0.88</td>
<td>0.79</td>
<td>-0.05 (?)</td>
</tr>
<tr>
<td>CAPEX (M€)</td>
<td>230</td>
<td>260</td>
<td>260 (?)</td>
</tr>
<tr>
<td>OPEX</td>
<td>100%</td>
<td>95%</td>
<td>100% (?)</td>
</tr>
<tr>
<td>Cost of production (€ per tonne clinker)</td>
<td>37</td>
<td>36</td>
<td>?</td>
</tr>
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Performance challenges

Testing/validation

Long term performance

Codes and standards
Some of the barriers

- Very conservative industry
- Service life requirements
- ‘Time bombs’
- Prescriptive standards
- Decades of research on Portland Cement performance

"Your proposal is innovative. Unfortunately, we won’t be able to use it because we’ve never tried something like this before."
Hierarchy of Approvals

- ISO
- European Standard
- National Standard
- Publicly Available Specification
- Certification/Tech Approval
- Company data/technical reports

CONSENSUS

CUSTOMIZATION
‘Novel’ cements?
Concrete thermal mass - exemplar buildings

Millennium Green - Nottinghamshire (Gusto Homes)

BedZed - South London (Zed Factory)

St Matthews - Lambeth (PRP Architects)

Jubilee Library - Brighton (Lomax, Cassidy & Edwards / Bennetts associates)
Summary

Global cement industry is taking a long term view on sustainability

Cement industry has developed a good track record on sustainability issues through programs like the CSI

Novel cement formulations are promising but face significant hurdles to become a practical alternative