CO$_2$ Emissions Profile of U.S. Cement Industry
Overview

• Purpose of study
• Cement production process
• Energy consumption
• GHG emissions
• State-level analysis
Background and Purpose

• Cement is a key industry from an economic, energy and emissions perspective.

• Have a strong understanding of process-related emissions, combustion-related emissions not as well characterized.

• Useful to have understanding of emission sources at a disaggregated level.
Cement Production Process

- Raw materials, primarily limestone, are extracted from a quarry and crushed.
- Materials finely ground into raw mix and preheated before conveyed to the kiln.

- Clinker is formed in kiln
- Raw mix heated to approximately 1500°C
- Most energy-intensive step in production process

Source: Lafarge
Cement Production Process (2)

• Finish Grinding. Gypsum added; other materials may be added to produce a blended cement.

• Addition of steel balls and a rapidly rotating wheel serve to finely grind and mix the clinker and gypsum.

• Cement stored in silos for shipping

• Shipping typically via road or rail.
Energy Consumption in Cement Production

- Because of the high temperatures achieved in kilns, a variety of fuels can be consumed.

U.S. Historical Cement Production

• Energy consumption is related to whether the wet process or the dry process is used.

• While dry process consumes more electricity, the wet process consumes significantly more fuel and is overall more energy-intensive.

• This transition from the wet to the dry process coincided with increased production in the U.S.
GHG Emissions from Cement Production

• Primarily CO$_2$, but CH$_4$ and N$_2$O may be released through combustion.

• Total emissions a function of whether Portland Cement or Masonry Cement is produced.
  – Portland Cement is made with addition of gypsum: no additional emissions
  – Masonry Cement requires addition of lime.

• In U.S. Inventory, emissions associated with lime manufacture are not accounted for in cement production, rather in the lime manufacture section.
CO$_2$ Emissions from Cement Production

- **Process-related**
  - Created during chemical reaction converting limestone to calcium oxide and CO$_2$
  - Methodology based on Intergovernmental Panel on Climate Change
  - Cement Kiln Dust

- **Combustion-related**
  - Result from the consumption of fuels and electricity.
    - Dry process: 224.2 kgC/st  *(Source: Worrell and Galitsky, 2004)*
    - Wet process: 249 kgC/st
  - U.S. does not calculate combustion-related emissions separately as part of the Inventory of U.S. Greenhouse Gas Emissions and Sinks
Total CO$_2$ Emissions from U.S. Cement Production

Table 1. Historical Trends in Combustion- and Process-related CO$_2$ Emissions from U.S. Cement Manufacturing (MMTCO$_2$)

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<tbody>
<tr>
<td>Combustion-related CO$_2$</td>
<td>30.6</td>
<td>31.3</td>
<td>31.6</td>
<td>32.1</td>
<td>32.9</td>
<td>36.1</td>
<td>36.5</td>
<td>35.5</td>
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<tr>
<td>Process-related CO$_2$ (incl. CKD)</td>
<td>36.1</td>
<td>36.8</td>
<td>37.1</td>
<td>38.3</td>
<td>39.2</td>
<td>40.0</td>
<td>41.2</td>
<td>41.4</td>
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<tr>
<td>Total CO$_2$</td>
<td>66.7</td>
<td>68.1</td>
<td>68.7</td>
<td>70.4</td>
<td>72.1</td>
<td>76.1</td>
<td>77.7</td>
<td>76.9</td>
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ICF communications with Hendrick van Oss, USGS, 15 April 2004.
Developing a Profile of the U.S. Cement Industry

• Methodology
  – Finding facility-level data
    • U.S. Geological Survey and EIA’s Manufacturing Energy Consumption Survey provide aggregated data.
    – Where facility-level data are available, fuel consumption not always provided.
  – Used capacity information
  – Applied known capacity utilization factors
  – Used published average annual carbon emission factor for wet facilities and dry facilities.
State-level Production

Estimated Annual Production by State, 2001

Source: EPA Database 2004

Million Metric Tons

Cement

Clinker
State-level CO₂ Emissions

Cement Industry Carbon Dioxide Emissions, 2001

Source: EPA Database 2004
State-level CO\textsubscript{2} Intensity

Cement Industry Carbon Dioxide Intensity, 2001

Metric tons CO\textsubscript{2} / Metric ton cement

EPA Cement Database 2004
Company Concentration

Company Concentration of CO₂ Emissions

Percent of Total Emissions

Top "X" Companies

Source: EPA Database 2004
Next Steps

• First step

• Try to replace the national average emissions factor with a facility-specific emissions factor for cement production.

• Investigate further mix of “other” fuels consumed in kilns.
Thank you for your time and attention!

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