FGD Gypsum Use
Progress & Opportunities

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Presentation for
McIlvaine Hot Topic Hour
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Innogyps Inc.

- Innogyps Inc. 1997- present
  - Promoting innovation and growth in the global gypsum industry
    - Internally develop new products/processes
    - Provide information relating to gypsum business development and technology trends
    - Provide consulting services
  - 150 clients over 15 years, many patents granted
  - International reputation in gypsum industry
  - Increasing involvement in gypsum from FGD in USA

Presentation today is primarily related to FGD Gypsum use
What is the problem?

• FGD scrubbers at coal fired power plants produce large quantities of coal combustion products (CCP), including FGD gypsum.

• Although utilization rates have grown, in most regions CCP supply exceeds demand creating financial and environmental burdens for the power plants.
What is gypsum?

**Calcium sulfate dihydrate -**

\[ \text{CaSO}_4 \cdot 2\text{H}_2\text{O} \]

- **Natural gypsum**
  - selenite, alabaster, massive, gypsite
- **Byproduct or Synthetic gypsum**
  - Flue gas desulfurization (SO2 + air + Lime )
  - Phosphogypsum, Titanogypsum, Fluorogypsum,
  - any neutralized sulfuric acid
Gypsum – Why is it used?

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3. $\text{Ca}^{2+}, \text{S}, \text{SO}_4^= \text{ content} – \text{Cement, agriculture}$
4. Non-toxic fine particles
5. Low cost

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Beer, bread
Pharmaceuticals
Chemical carriers (pesticides, etc.)
Adsorbents, Cat litter
Medical, dental (plaster casts)
Toothpaste, Classroom chalk
Landfill cover
What is the market for gypsum?

North America

- Total used
  - 2007 - 33 million tons
  - 2011 – 23 million tons

  Gypsum board > 90%
  Cement and agricultural ~ 5%
  Special uses - remainder

Global

- Total produced
  - 2007 - 127 million tons
  - 2011 - 148 million tons

  - China, Iran, Spain, USA, Thailand, most countries
  - Large volumes used for plasters and cement in some regions
  - Gypsum board use growing in developing countries

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What is the competition to FGD Gypsum?

<table>
<thead>
<tr>
<th>Source</th>
<th>Availability</th>
<th>Advantages</th>
<th>Disadvantages</th>
</tr>
</thead>
<tbody>
<tr>
<td>FGD Gypsum</td>
<td>Regional, Growing</td>
<td>Price, purity, consistent</td>
<td>Wet, transport</td>
</tr>
<tr>
<td>Mined Rock</td>
<td>Widespread</td>
<td>Price, dry</td>
<td>Naturally variable</td>
</tr>
<tr>
<td>Recycled board</td>
<td>Growing</td>
<td>“Green”</td>
<td>Logistics cost</td>
</tr>
<tr>
<td>Phosphogypsum</td>
<td>Regional</td>
<td>Price</td>
<td>Impurities</td>
</tr>
<tr>
<td>Titanogypsum</td>
<td>Few locations</td>
<td>Color?</td>
<td>Handling</td>
</tr>
<tr>
<td>Any neutralized sulfuric acid</td>
<td></td>
<td></td>
<td>Impurities, small volumes</td>
</tr>
</tbody>
</table>
Gypsum Supply Options - Global

Map shows overall gypsum growth potential – Mature, Growing, Future
Major gypsum mines with export potential –
Significant FGD gypsum production –
Phosphogypsum use -

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How much of this is FGD Gypsum?

Approximate % of gypsum used that is from FGD sources  XX%
Where is FGD Gypsum made in USA?

USA FGD Scrubbers – SO2 Emissions

Each ton of SO2 scrubbed will make 2.7 tons of FGD gypsum

Source: U.S. Energy Information Administration, 2011 Forecast

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USA Board Plants Using FGD Gypsum

General FGD Gypsum Supply/Demand

USA FGD Scrubbers – SO2 Emissions

Each ton of SO2 scrubbed will make 2.7 tons of FGD gypsum

Source: U.S. Energy Information Administration, 2011 Forecast

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Source: U.S. Energy Information Administration, based on Form EIA-860
How does FGD Gypsum quality compare?

<table>
<thead>
<tr>
<th></th>
<th>Gypsum Rock</th>
<th>FGD Gypsum</th>
</tr>
</thead>
<tbody>
<tr>
<td>Purity</td>
<td>80-95%</td>
<td>Consistently 95%</td>
</tr>
<tr>
<td>Salt</td>
<td>Low, some surprises</td>
<td>Controlled by washing</td>
</tr>
<tr>
<td>Handling</td>
<td>Conventional</td>
<td>Control particle shape and moisture content</td>
</tr>
<tr>
<td>Moisture content</td>
<td>Low but variable</td>
<td>Controlled by process</td>
</tr>
<tr>
<td>Consistency</td>
<td>Naturally variable</td>
<td>Process consistent</td>
</tr>
</tbody>
</table>

Quality requirements depend on end use application.

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Economics of FGD Gypsum Use

SO$_2$  Sulfite  Gypsum  Plaster  Special Plaster

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Economics of FGD Gypsum Use

<table>
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<tr>
<th>Processing Cost</th>
<th>Selling Price</th>
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<tbody>
<tr>
<td>Scrub $$$$/t</td>
<td>Not Salable</td>
</tr>
<tr>
<td>Landfill cost $20/t</td>
<td>Not Salable</td>
</tr>
<tr>
<td>Oxidize $5/t</td>
<td>$0-5/t</td>
</tr>
<tr>
<td>Calcine 10/t</td>
<td>$20-150/t</td>
</tr>
<tr>
<td>Process $1-100 /t</td>
<td>$100-1000/t</td>
</tr>
</tbody>
</table>

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What are the barriers to using more?

• Some existing markets are saturated (board)
• Competition from existing mines and manufacturing plants – likely needed in future
• New uses require process/market knowledge which is generally only available to gypsum companies
• Regulatory restrictions on use – US EPA
What are the opportunities for the future?

• Remove regulatory uncertainty (EPA)
  – Make FGD Gypsum Fully Exempt under RCRA 40 C.F.R. § 261.4(a)

• FGD Gypsum
  – Global growth in gypsum board – export?
  – USA housing recovery will help
  – Learn to process gypsum to plasters that are useful

• FGD Materials Wet Scrubbers
  – Oxidize and process as above

• FGD Materials Dry Scrubbers
  – Grow stabilization, fill and mining applications

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