DRY SORBENT INJECTION

ENABLING NEW OPERATIONAL EFFICIENCIES BY CONTROLLING EMISSIONS FROM COAL PLANTS EFFECTIVELY AND INEXPENSIVELY

Shuman Moore -- CEO, ClearChem Development, LLC
ClearChem is New Furnace Sorbent Injection Technology

✓ Decades-old attempts at furnace sorbent injection (FSI) showed poor results
✓ ClearChem is different – it solves past problems to release the full promise of FSI
   o Sub-micron sized reagent particles are highly reactive and minimize deposits
   o Computational Fluid Dynamic (CFD) modeling enhances sorbent furnace coverage
   o Burner zone/fuel reagent application for longer reaction time & no sintering or pore pluggage
   o High efficiency reagent utilization minimizes ESP/FF concerns
ClearChem and Dürr are working together to offer technology combinations, allowing maximum flexibility in a “One Stop Shop” for profitably meeting new plant APC requirements as well as for existing facilities.

Water recovery: ClearChem’s acid gas removal allows addition of lower cost condensing heat exchangers that improves plant heat rate while offsetting a power plant’s consumptive water use or selling water to third parties.

Allows increased plant efficiency (every ~40°F lower flue gas temp. equals ~1% efficiency gain), plus gain 2% to 4% more by recovering the heat of vaporization of water (ie, a possible total heat rate, fuel use & CO2 reductions totaling 6% – 8%).
CLEARCHEMFSI ATTRIBUTES:

- Effective scavenging of SO$_3$, SO$_2$, HCl & HF
- Minimizes tube deposits & ESP/FF impact
- Dry, fully reacted reagent provides minimal Ca increase and no sodium leaching in fly ash
- High surface area for some capture of oxidized mercury, but when combined with CCF and/or CHX more capture expected
- Allows lower exit gas temps with associated benefits
- Only acid gas control technology that allows effective emissions control during plant startup and shut down
PROBLEM / OPPORTUNITY

- Coal-fired generation is a critical component of global energy supply and will be for a long time, but …

- Regulation threaten plant viability: NOx, SOx, Heavy Metals, Water, Particulates, CARBON

- Existing solutions (FGD, etc.) are piecemeal, disruptive, and prohibitively expensive

- Market participants are being forced toward 3 bad extremes:
  1. Early retirement of profitable generating capacity;
  2. Greatly reduced generation with minimal check on pollution;
  3. Expensive FGD upgrades/additions.
ClearChem recently formed to develop, patent, and market an improved FSI process

ClearChemFSI™ is FSI that works. ClearChem:

- is an innovative, patented emission control process that involves injection of sub-micron sized particles of widely available, off the shelf reagents such as limestone (calcium carbonate) directly into a boiler/furnace
- has wide operational range, can be effectively used as a “polishing” acid gas removal system combined with an FGD system, or as a stand alone system
- is simplest and most capital-efficient mitigation of sulfur and other acid gas pollutants (up to 85%) from the combustion of carbon based fuels like coal, MSW (municipal solid waste), petroleum cokes, tires & residual oils, etc.
- has a very small footprint, fast order, delivery & tie in (ie, in service in 3 to 6 months ARO)
- ClearChem is ~10% of the combined CAPEX & OPEX cost of existing FGD systems
MARKETS

**Domestic US:**
- In excess of 1,400 coal-fired utility power plants (~38% of total US electricity production)
- Hundreds of smaller domestic industrial boilers, combustors and incinerators
- Utility & Industrial combined U.S. coal production in 2013 was just below **1 billion** short tons (984.8 Million short tons in 2013) – annual production trending down
- ClearChem is targeting ~4% (~10,500 Mega Watts (MW)) of the ~270,000 MW US coal power plant market remaining after currently planned coal plant retirements

**International:**
- **7.687 Billion** short tons in 2012 supplying ~40% of international electricity generation – annual production trending up, with China and India using the most coal with an extremely urgent need for air pollution control, representing **~7X the US market**
# COMPETITIVE COMPARISON – SO2 REMOVAL

## Comparison of ClearChem Economics on SO2 Capture

<table>
<thead>
<tr>
<th>Scenario</th>
<th>No existing SO2 control</th>
<th>With existing SO2 scrubbers</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Key assumptions:</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Utility cost of capital</td>
<td>6%</td>
<td>6%</td>
</tr>
<tr>
<td>Unit size</td>
<td>300 MW</td>
<td>300 MW</td>
</tr>
<tr>
<td>Useful life/finance life</td>
<td>15 years</td>
<td>15 years</td>
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<tr>
<td>Capacity factor</td>
<td>40%</td>
<td>80%</td>
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<tr>
<td>SO2 output</td>
<td>35 lbs/MWh</td>
<td>35 lbs/MWh</td>
</tr>
<tr>
<td>CCFSI license fees</td>
<td>Max target</td>
<td>Max target</td>
</tr>
<tr>
<td><strong>Added cost per kWh:</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Traditional Scrubber</td>
<td>$0.0216</td>
<td>$0.0035</td>
</tr>
<tr>
<td>Traditional DSI (Trona)</td>
<td>$0.0166</td>
<td>$0.0045</td>
</tr>
<tr>
<td><strong>ClearChemFSI</strong></td>
<td><strong>$0.0085</strong></td>
<td><strong>$0.0030</strong></td>
</tr>
</tbody>
</table>
 Licensees:

 Reagent Suppliers:

 Strategic:
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