Compliance Strategy Options and Costs for PM2.5 Control

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McIlvaine Company Hot Topic Hour
May 12, 2011
Options

Baghouse (BH)
- Pulse Jet (PJ)*
- Reverse Air (RA)*

Electrostatic Precipitator (ESP)
- Wet ESP
- Dry ESP*
- Conversion to BH

*Cost Comparison
Assumptions

- Inlet Volume to Baghouse/ESP = 3,000,000 ACFM
- Normal Operating Temperature = 280 °F
- Coal Sulfur Content = 3.0%
- Outlet Particulate from Baghouse/ESP = 0.0005 grains/ACFM
## Technical Comparison

<table>
<thead>
<tr>
<th>Cleaning Method</th>
<th>Reverse Air</th>
<th>Pulse Jet</th>
<th>ESP</th>
</tr>
</thead>
<tbody>
<tr>
<td>Air Pressure</td>
<td>Low</td>
<td>Compressed</td>
<td>NA</td>
</tr>
<tr>
<td>Filter Media</td>
<td>Woven*</td>
<td>Felt*</td>
<td>NA</td>
</tr>
<tr>
<td>Bag Diameter/Plate ga.</td>
<td>12 inch</td>
<td>6 inch</td>
<td>18 ga.</td>
</tr>
<tr>
<td>Bag Length/Plate Ht.</td>
<td>35 feet</td>
<td>28 feet</td>
<td>48 feet</td>
</tr>
<tr>
<td>Plate Spacing</td>
<td>NA</td>
<td>NA</td>
<td>16 in.</td>
</tr>
<tr>
<td>Collect dust</td>
<td>Inside tube</td>
<td>Outside Tube</td>
<td>NA</td>
</tr>
<tr>
<td>Filtration Mechanism:</td>
<td>Dust Cake</td>
<td>Felt + Dust</td>
<td>NA</td>
</tr>
<tr>
<td>With Membrane</td>
<td>Surface</td>
<td>Surface</td>
<td>NA</td>
</tr>
<tr>
<td>No. of Casings</td>
<td>2</td>
<td>2</td>
<td>2</td>
</tr>
<tr>
<td>No. of Fields</td>
<td>NA</td>
<td>NA</td>
<td>4</td>
</tr>
<tr>
<td>No. of Chambers</td>
<td>NA</td>
<td>NA</td>
<td>3</td>
</tr>
<tr>
<td>Experience:</td>
<td>30 years</td>
<td>15 years</td>
<td>&gt;50 years</td>
</tr>
<tr>
<td>With ePTFE Membrane</td>
<td>10 years</td>
<td>7 years</td>
<td>NA</td>
</tr>
</tbody>
</table>

* With and without ePTFE Membrane
Limitations

• All numbers valid for comparison
• Not to be used for budgetary purposes
• Individual vendors quotes higher and lower
• Relative size of RA & PJ valid
• ESP and Baghouse arrangements vary
• Selection & refined design needed
# Parts Comparison

<table>
<thead>
<tr>
<th>REVERSE AIR</th>
<th>REVERSE AIR</th>
<th>PULSE JET</th>
<th>PULSE JET</th>
<th>ESP</th>
</tr>
</thead>
<tbody>
<tr>
<td>10 oz. FG</td>
<td>10 oz. FG + ePTFE membrane</td>
<td>16 oz. PPS</td>
<td>16 oz. PPS + ePTFE membrane</td>
<td>$368/insulator</td>
</tr>
<tr>
<td>35 ft L x 12 in D</td>
<td>35 ft L x 12 in D</td>
<td>28 ft L x 6 in D</td>
<td>28 ft L x 6 in D</td>
<td>192 insulators</td>
</tr>
<tr>
<td>$95/bag (± 7%)</td>
<td>$142/bag (± 7%)</td>
<td>$70/bag (± 15%)</td>
<td>$123/bag (± 15%)</td>
<td>$70,656/192</td>
</tr>
<tr>
<td>16,128 bags</td>
<td>16,128 bags</td>
<td>23,296 bags</td>
<td>23,296 bags</td>
<td>$40,250/other</td>
</tr>
<tr>
<td>$1,525,095 / bag set</td>
<td>$2,287,642 / bag set</td>
<td>$1,629,132 / bag set</td>
<td>$2,868,912 / bag set</td>
<td>$4,600 / TR set</td>
</tr>
<tr>
<td>$259,661 labor</td>
<td>$259,661 labor</td>
<td>$187,533 labor</td>
<td>$187,553 labor</td>
<td>24 TR sets</td>
</tr>
<tr>
<td>$1,784,756 / bag set + labor</td>
<td>$2,547,303 / bag set + labor</td>
<td>$1,816,665 / bag set + labor</td>
<td>$3,056,445 / bag set + labor</td>
<td>$110,400 / 24 sets</td>
</tr>
<tr>
<td>9 yr. life</td>
<td>9 yr. life</td>
<td>6 yr. life</td>
<td>6 yr. life</td>
<td>5 yr. life</td>
</tr>
<tr>
<td>$198,306 / yr bags + labor</td>
<td>$283,034 / yr bags + labor</td>
<td>$201,852 / yr bags + labor</td>
<td>$339,605 / yr bags + labor</td>
<td>$88,522 / yr parts + labor</td>
</tr>
</tbody>
</table>
Bag & ESP Parts Replacement Expenditure Timeline

- Reverse Air (9 yr) $1,784,756
- Pulse Jet (6 yr) $1,816,665
- ESP - Insulators and TR Sets (5 yr) $442,612
- Reverse Air w/Membrane (9 yr) $2,547,303
- Pulse Jet w/Membrane (6 yr) $3,056,445
### Annual Costs-ESP & Baghouse

**Fifteen Year Straight Line**

Baglife: RA= 9 yr, PJ = 6 yr, ESP Insulators/TR = 5 yr

*For comparison only & not for budgetary purposes*

Interest charges not included

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<tr>
<th>REVERSE AIR</th>
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<th>ESP</th>
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<tr>
<td></td>
<td></td>
<td>16 oz. PPS</td>
<td>16 oz. PPS + ePTFE membrane</td>
<td>Insulators / TR</td>
</tr>
<tr>
<td>10 oz. FG</td>
<td>10 oz. FG + ePTFE membrane</td>
<td>$26,450,000 (house)</td>
<td>$26,450,000 (house)</td>
<td>$28,750,000 (stacked)</td>
</tr>
<tr>
<td>$44,850,000 / yr (house)</td>
<td>$44,850,000 / yr (house)</td>
<td>$26,450,000 (house)</td>
<td>$26,450,000 (house)</td>
<td>$28,750,000 (stacked)</td>
</tr>
<tr>
<td>$2,990,000 / yr (house)</td>
<td>$2,990,000 / yr (house)</td>
<td>$1,763,333 / yr (house)</td>
<td>$1,763,333 / yr (house)</td>
<td>$1,916,667 / yr (stacked)</td>
</tr>
<tr>
<td>$198,306 / yr (bags)</td>
<td>$283,034 / yr (bags)</td>
<td>$201,852 / yr (bags)</td>
<td>$339,605 / yr (bags)</td>
<td>$88,522 / yr (insul./TR)</td>
</tr>
<tr>
<td>$3,188,306 / yr</td>
<td>$3,273,034 / yr</td>
<td>$1,965,185 / yr</td>
<td>$2,102,938 / yr</td>
<td>$2,005,189 / yr</td>
</tr>
</tbody>
</table>
Reliability
Keys to trouble-free operation

1) Conservative G/C and/or SCA Equiv.
2) Vendor with direct experience
3) Detailed specification
4) QA/QC & Installation
5) Training, Start-up
6) O&M plan & implementation
7) Operate above the acid dew point
8) True for both Baghouse and ESP
ESP Pros & Cons

**Advantages:**
1) Low pressure drop
2) High experience
3) High temperature capability

**Disadvantages:**
1) Very sensitive to fluctuations in gas stream conditions: flow, temperature, particulate & gas composition, dust loading
2) Not effective in capturing some contaminants: heavy metals, dioxins
Baghouse Pros & Cons

Advantages:
1) Extremely high efficiency on both course & fine particulate
2) Relatively insensitive to gas stream fluctuations including flow, dust loading and particulate and gas composition
3) Relatively simple operation
4) In the case of pulse jet relatively small “footprint”

Disadvantages:
1) Temperature limited by bag selection (500°F max)
2) Relatively high flange to flange pressure drop
3) Bag change might require respiratory protection
Figure 2. Mercury Removal Trends with Activated Carbon from NETL Phase I Test Program
## Summary Comparison

<table>
<thead>
<tr>
<th></th>
<th>Reverse Air</th>
<th>Reverse Air w/Membrane</th>
<th>Pulse Jet</th>
<th>Pulse Jet w/Membrane</th>
<th>ESP</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Initial House Cost</strong></td>
<td>$45 mil</td>
<td>$45 mil</td>
<td>$26.5 mil</td>
<td>$26.5 mil</td>
<td>$28.8 mil</td>
</tr>
<tr>
<td><strong>Annual O&amp;M Expense</strong></td>
<td>$198,306/yr</td>
<td>$283,034/yr</td>
<td>$201,852/yr</td>
<td>$339,605/yr</td>
<td>$88,522/yr</td>
</tr>
<tr>
<td><strong>Total Annual Cost</strong></td>
<td>$3.2 mil/yr</td>
<td>$3.3 mil/yr</td>
<td>$2.0 mil/yr</td>
<td>$2.1 mil/yr</td>
<td>$2.0 mil/yr</td>
</tr>
</tbody>
</table>

**Size (ft):**
- Height: 84 ft, 84 ft, 81 ft, 81 ft, 85 ft
- Width: 151 ft, 151 ft, 111 ft, 111 ft, 326 ft
- Length: 255 ft, 255 ft, 177 ft, 177 ft, 101 ft

**Reliability:**
- Years experience:
  - Reverse Air: 30+
  - Reverse Air w/Membrane: 10+
  - Pulse Jet: 15+
  - Pulse Jet w/Membrane: 7+
  - ESP: 50+
- Reported:
  - Reverse Air: Very Good/Excellent
  - Reverse Air w/Membrane: Very Good/Excellent
  - Pulse Jet: Very Good
  - Pulse Jet w/Membrane: Very Good
  - ESP: Excellent

**Flexibility:**
- Gas Volume:
  - Reverse Air: Very Good
  - Reverse Air w/Membrane: Very Good
  - Pulse Jet: Very Good
  - Pulse Jet w/Membrane: Very Good
  - ESP: Fair
- Coal Characteristics:
  - Reverse Air: Excellent
  - Reverse Air w/Membrane: Excellent
  - Pulse Jet: Excellent
  - Pulse Jet w/Membrane: Excellent
  - ESP: Fair/Poor

**Future:**
- Fine Particle:
  - Reverse Air: 99.99% +
  - Reverse Air w/Membrane: 99.99%
  - Pulse Jet: 99.99%
  - Pulse Jet w/Membrane: 99.99%
  - ESP: 99%
- Mercury:
  - Reverse Air: 90%*
  - Reverse Air w/Membrane: 90%*
  - Pulse Jet: 90%*
  - Pulse Jet w/Membrane: 90%*
  - ESP: 60%*
  - Comparative cost for mercury capture:
    - Reverse Air: $1.5 mil/yr**
    - Reverse Air w/Membrane: $1.5 mil/yr**
    - Pulse Jet: $1.5 mil/yr**
    - Pulse Jet w/Membrane: $1.5 mil/yr**
    - ESP: >$10 mil/yr**

* Sorbent efficiency  **Carbon Injection comparative cost for mercury capture
Size Comparison