Columbia Generating Station
Air Quality Control System Retrofit Project

2016 Minnesota Power Systems Conference
St. Paul, MN
November 9, 2016

Presented by:
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Columbia Energy Center - Background

- Unit 1, 512 MW Nameplate, In-service in 1975
- Unit 2, 511 MW Nameplate, In-service in 1978
- Jointly owned by;
  - Wisconsin Power and Light 46.2%
  - Wisconsin Public Service 31.8%
  - Madison Gas and Electric 22.0%
- 150 employees
- Original cost - $305 M
### AQCS Background

To comply with environmental regulations:

1. **Wisconsin’s mercury rule** – required 90% mercury removal on both units starting in 2015
2. **Federal and state regulations (in flux)** – required 90% SO2 removal by about mid-2014
   - 1. Clean Air Visibility Rule (CAVR)
   - 2. Clean Air Interstate Rule (CAIR)
   - 3. Cross State Air Pollution Rule (CSAPR)
3. **Compliance with an EPA Consent Decree**
   - 1. $SO_2 < 0.075$ lb/MMBTU
AQCS System - Overall Process
AQCS System – Major Components Supplied by Babcock and Wilcox

Lime and recycle ash preparation
• Produces hydrated lime slurry
• Reuses fly ash and scrubber by-product to reduce reagent costs

Spray Dryer Atomizer (SDA)
• Sprays hydrated lime and recycled material
• Mixes the reagent and the flue gas

Pulse Jet Fabric Filter (PJFF)
• Captures scrubber by-product, fly ash, and mercury

EPC Contractor: Black and Veatch, Kansas City
AQCS System – Physics and Chemistry

SO₂ + CaOH $\rightarrow$ CaSO₃ + H₂O

Spinning at 9000 rpm
Construction

Before, February 2012

After, October 2014
Construction and Laydown Areas
Completed Project – Results

- Safety – No lost time accidents
  - Over 1.9 million hours worked
  - About 800 craft at peak

- Schedule
  - Ahead of schedule about two months
  - Over two years of construction
  - Over five years project duration (licensing, engineering, etc.)

- Equipment Performance
  - Met all environmental and contract guarantees
    - SO$_2$, PM, Aux Power, Reagent Consumption

- Cost
  - $38 million under budget
  - < 0.3% change orders
## Final Cost and Emission Rates

<table>
<thead>
<tr>
<th>Timeframe</th>
<th>Sulfur Dioxide (#/MMBTU)</th>
<th>Mercury (#/TBU)</th>
<th>Particulate (#/MMBTU)</th>
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<tbody>
<tr>
<td>U1 Pre-AQCS</td>
<td>0.59</td>
<td>7.23</td>
<td>0.0889</td>
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<tr>
<td>U2 Pre-AQCS</td>
<td>0.60</td>
<td>3.99</td>
<td>0.0200</td>
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<td>Requirement</td>
<td>0.075</td>
<td>1.20</td>
<td>0.0150</td>
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<tr>
<td>U1 2016</td>
<td>0.045</td>
<td>0.49</td>
<td>0.0017</td>
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<tr>
<td>U2 2016</td>
<td>0.046</td>
<td>0.46</td>
<td>0.0019</td>
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</tbody>
</table>

**Final Cost**

$627.0 M approved

$588.6 M final
Ductwork Tie-Ins

Very tight work space

Extreme cold working conditions

24 X 7 work
Access for Atomizer Maintenance

Atomizer pit stairs vs. ladders

Unit walkway connection
Pebble lime reacts with water causing an exothermic reaction.
Atomizer Oil Cooler Fouling

Biological growth – high lube oil temperatures
Lime Unloading

Too many bends in the unloading piping

- Excessive erosion
- Excessive fines – line pluggage
Waste Silo Unloading

Heavy dusting when unloading the waste product silo
Stack Icing

- Ice forms at lower loads – Melts at higher loads
- Safety concern, damage to ductwork lagging
- Added heat tracing
Atomizer Vibration

- Over 50 trips per month
- Motor rotor through-bolt differential expansion
- Spray nozzle wear
- Slurry flow control
- Vibration monitoring equipment
Recycle Slurry Tank Agitators
Agitator Changes

Original w/ 5 Hp Motors

New w/ 10 Hp Motors
Chemical Usage 2015

Columbia 1 (C1) and Columbia 2 (C2) Original, 2015 Forecast and Current Chemical Usage Rates

- Total
- Flue Gas Treatment
- Activated Carbon
- CaBr2
- Lime

$ per MWh

- C2 Current
- C2 2015 Forecast
- C2 Original Design
- C1 Current
- C1 2015 Forecast
- C1 Original Design
Chemical Usage 2016

Columbia 1 (C1) and Columbia 2 (C2) Original, 2016 Forecast and Current Chemical Usage Rates

- **Chemical Component**
  - Total
  - Flue Gas Treatment
  - Activated Carbon
  - CaBr2
  - Lime

- **Chemical Component Costs**
  - C2 Current
  - C2 2016 Forecast
  - C2 Original Design
  - C1 Current
  - C1 2016 Forecast
  - C1 Original Design

- **Cost per MWh**
  - Range: $0.00 to $1.40

- **Types of Chemicals**
  - Lime
  - CaBr2
  - Activated Carbon
  - Flue Gas Treatment

- **Comparison**
  - Original Design vs. Current Usage
  - Forecast vs. Actual Usage

- **Source**
  - Alliant Energy
Conclusion

- Project completed with;
  - No lost time incidents
  - Ahead of schedule
  - Under budget
  - All contract guarantees were met
  - Major operating issues have been resolved

- Project received national recognition from;
  - Power Magazine
  - Power Engineering Magazine
  - ENR

- Systems perform at a high degree of operability/reliability
  - Equipment redundancy and unit cross-ties