Optimization of Air Pollution Control Equipment

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Optimization Opportunities

1. Emissions reduction (NOx, SOx, Hg, Opacity)
   - CSAPR raises need for NOx and Sox reduction
   - Low NOx burners and overfire air systems optimization
2. Heat Rate Reduction
3. Faster and More Efficient Ramping
4. Reduced EFOR
5. Improved Coal Mill Operations
6. Improved Post-Combustion Operations
Optimization Opportunities and Benefits

Pre-Combustion
• Coal/Fuel Blending Optimization – 1-2% production increase
• Mill Optimization – lower LOI, heat rate improvement, pluggage detection

Combustion
• NOx Reduction – 10-30%
• Heat Rate Improvement – 0.25-1.5%
• Dynamic Steam Temperature Control – +/- 1%, reduce steam turbine cyclic life expenditure
• Ramp Rate Improvement – up to 100%
• Intelligent Soot-blowing – up to 0.25% heat rate improvement, lower EFOR
• LOI Reduction – 10-30%

Post-Combustion
• SCR’s – Reduce NH₃ slip; Lower capital equipment costs;
  • 2% additional reduction in NOx
• FGD’s – Increase SO₂ removal efficiency with less limestone consumption
## Typical Results

<table>
<thead>
<tr>
<th>Site</th>
<th>NOx Reduction</th>
<th>Heat Rate Improvement</th>
<th>Annual Benefit</th>
</tr>
</thead>
<tbody>
<tr>
<td>A (340 MW CE Gas)</td>
<td>12.3%</td>
<td>0.65%</td>
<td>$950,000</td>
</tr>
<tr>
<td>B (195 MW CE Twin Furnace)</td>
<td>&gt;10%</td>
<td>&gt;0.5%</td>
<td>$325,000</td>
</tr>
<tr>
<td>C (600 MW B&amp;W Supercritical)</td>
<td>15-20%</td>
<td>0.5%</td>
<td>$1,200,000</td>
</tr>
<tr>
<td>D (850 MW CE Split Furnace)</td>
<td>24%</td>
<td>0.68%</td>
<td>$1,418,000</td>
</tr>
<tr>
<td>E (850 MW CE Split Furnace)</td>
<td>18%</td>
<td>0.98%</td>
<td>$2,043,000</td>
</tr>
</tbody>
</table>
Ramp Rate Enhancements

- Steam Temperature Control Impact
- Sliding Throttle Pressure Optimization

Relative Ramp Rate Improvement – 2% - 4%

Coal Price - $2.00 per MMBTU
Fuel Displaced Price - $5.00 per MMBTU
Ramp up and down to 50% load once per day

$250,000 per year for 250 MW plant
Soot Blowing Optimization Benefits

- Improve Heat Rate by up to 0.25% by improving heat transfer ($185,000 per year for 250 MW plant)
- Reduce NOx 5-10%
- Reduce or eliminate the need for units to drop load for a deslag
- Significantly reduce tube erosion
- Automatically operate the current systems, in closed loop mode, on all units with very little operator intervention.
- Ties together or coordinates the various Water Cannons and Steam Soot Blowers
New Approach to Nonlinear Control

Model Predictive Control Algorithms
- In Use since the 1970s
- Superior Dynamic Response
- Ideal for Constraint Control
- Inherently Linear

Radial Basis Function Neural Nets
- Developed For Identifying Dynamic Data
- Allows Nonlinear Modelling
Combustion Optimization

Initial distribution of boiler combustion—poor performance on both tails

Optimize – tighten and shift distribution
Combustion Optimization Case Study

Heat Rate Improvement: **0.68%**

NOx Reduction: **24% Average**
- 30% Maximum reduction; 22% Minimum reduction

On-line time **97.6%**
- High Operator Acceptance

Improved Steam Temperature Control:
- Superheater Steam T exceeded 1010°F < 1%

More effective Soot Blowing Strategy
- Reduced Maintenance on the ash hopper
- Less tube erosion ($100K per year)

More effective control strategies/limits defined...

Estimated Fuel Cost Savings - **$709,000/yr /unit**
(cap. factor 0.7 at fuel cost of $2/MMBTU)
Summary

- Model Predictive, Multivariable Control complemented by Neural Networks is effective for reducing emissions and optimizing air pollution control systems while achieving fast and accurate dynamic response.

- Improved load response, better steam temperature control and more effective soot blowing can be achieved while reducing emissions.

- Proven results.