Converting a Coal-fired Plant: Benefits and Challenges

Source: U.S. Energy Information Administration / Monthly Energy Review April 2021

March 25 – May 3: 40 Straight Days
LOAD FOLLOWING – THE NEW NORMAL FOR U.S. COAL PLANTS?
POWERGEN+ April 28, 2021
Phillip Graeter
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Introduction

• Energy Ventures Analysis is a consulting firm located in the Washington DC area, specializing in energy commodity market analysis since 1981
• In 2019/20, the National Association of Regulated Utility Commissioners (NARUC) hired EVA to develop a white paper on coal flexibility and reliability for state utility regulators
• EVA analyzed hourly operating data of U.S. coal plants for the years 2008, 2018, 2019, and 2020 to highlight trends in coal plant operations and recommend possible technologies and practices plant owners can adopt to increase a coal plant’s flexibility, reliability, and profitability
U.S. coal plants operate more and more at less optimal utilization rates

Average distribution of utilization rates for coal-fired EGUs

<table>
<thead>
<tr>
<th>% of hours</th>
<th>2008</th>
<th>2018</th>
<th>2019</th>
<th>2020</th>
</tr>
</thead>
<tbody>
<tr>
<td>Offline</td>
<td>17%</td>
<td>32%</td>
<td>34%</td>
<td>42%</td>
</tr>
<tr>
<td>&lt; 40%</td>
<td></td>
<td></td>
<td>6%</td>
<td>7%</td>
</tr>
<tr>
<td>40 - 60%</td>
<td></td>
<td></td>
<td>12%</td>
<td>14%</td>
</tr>
<tr>
<td>60 - 80%</td>
<td></td>
<td></td>
<td>15%</td>
<td>14%</td>
</tr>
<tr>
<td>&gt; 80%</td>
<td>55%</td>
<td>37%</td>
<td>30%</td>
<td>25%</td>
</tr>
</tbody>
</table>

Source: EVA analysis of EPA CEMS data

U.S. coal plants experience more starts at colder equipment temperatures & are offline much longer

Average number of starts by category & average outage length

<table>
<thead>
<tr>
<th>Avg. no. of starts per unit</th>
<th>2008</th>
<th>2018</th>
<th>2019</th>
<th>2020</th>
</tr>
</thead>
<tbody>
<tr>
<td>Hot Start (&lt; 12h)</td>
<td>3.72</td>
<td>1.96</td>
<td>2.05</td>
<td>1.77</td>
</tr>
<tr>
<td>Warm Start (12 - 48h)</td>
<td>3.09</td>
<td>1.75</td>
<td>1.83</td>
<td>1.64</td>
</tr>
<tr>
<td>Cold Start (48 - 120h)</td>
<td>3.37</td>
<td>2.79</td>
<td>2.42</td>
<td>2.38</td>
</tr>
<tr>
<td>LT Outage (&gt; 120h)</td>
<td>4.12</td>
<td>4.45</td>
<td>4.48</td>
<td>4.18</td>
</tr>
<tr>
<td>Avg. Outage Length</td>
<td>16.2</td>
<td>14.2</td>
<td>14.8</td>
<td>25.4</td>
</tr>
</tbody>
</table>

Source: EVA analysis of EPA CEMS data
Load changes at coal plants are much more frequent – but also depends on location

Possible improvements to prepare coal plants for the new load-following reality

- **Cycling efficiency improvements**
  - Examples include sliding pressure operation, variable speed-drives, and boiler draft control schemes

- **Establishing and following cycle chemistry guidelines for flexible operations**
  - Correct layup procedures, combined with appropriate chemical treatment during shutdown and startup, will significantly reduce corrosion and deposits in the steam cycle equipment, including the boiler, steam-touched tubing, and the turbine

- **Accurate cycling cost estimation**
  - Helps inform plant’s true dispatch position based on operating costs
  - Cost estimates are based on increased routine maintenance costs, damage to major components, and estimated cost of consumables per start

- **Flexible operation studies**
  - These studies reduce component damage through procedure optimization and design modification

- **Data collection and operator coaching**
  - Plant data for critical components should be collected and screened to identify and understand the most damaging operational conditions
  - Simplified damage algorithms for creep and fatigue should be developed for operator coaching using collected data
Coal Plant Conversions

Garry King
SVP, Global Services Leader, Power, Black & Veatch

Spectrum of Coal Plant Conversions

- **Fuel Switch to Natural Gas**
  - Boiler and burner Modifications

- **Fuel Switch to Biomass**
  - Replace or modify boiler system

- **Partial Repower**
  - Add simple cycle gas turbine

- **Repower to Combined Cycle**
  - Reuse steam turbine and...

- **Reuse Existing Site for new CC**
  - Minimal reuse of support systems

Benefits vary depending on the situation:

- Life extension
- Higher plant output
- Increased efficiency
- Enhanced environmental performance
- Improved operability/maintainability
Conversion Considerations

Technical and Financial:
- Fuel costs and price volatility
- Anticipated dispatch profiles
- Age and condition of plant equipment
- Capital costs, including gas pipeline
- Plant modification costs
- O&M costs, post-conversion

Non-Technical:
- Environmental
- Local acceptance
- Political
- Future regulations

A financially viable project can be derailed by non-technical issues.

Keys to a Successful Repower

- Address social and regulatory matters early
- Strong collaboration between project participants
- Aim at future operating requirements and needs
- Realistic evaluation of current assets for reuse
- Thorough study before choosing a path
- Open model on economic trade-offs
MHI KM CDR Process™
Post Combustion Carbon Capture Technology
Jerrad Thomas – Business Development Manager

Mitsubishi Heavy Industries Group at a Glance

As a global leader in engineering and manufacturing, Mitsubishi Heavy Industries (MHI) Group delivers innovative and integrated solutions across a wide range of industries from commercial aviation and transportation to power plants and gas turbines, and from machinery and infrastructure to integrated defense and space systems.

<table>
<thead>
<tr>
<th>COMPANY HIGHLIGHTS</th>
</tr>
</thead>
<tbody>
<tr>
<td>$36.7BN Annual revenue</td>
</tr>
<tr>
<td>More than 24,600 Patents</td>
</tr>
<tr>
<td>54% Sales outside Japan</td>
</tr>
<tr>
<td>130 Years of Innovation</td>
</tr>
<tr>
<td>83,000 Employees worldwide</td>
</tr>
<tr>
<td>400+ Domestic &amp; overseas companies</td>
</tr>
</tbody>
</table>

(FY2019 Results @110JPY/$)
**KM CDR Process™ Overview**

- **Amine washing system reduces VOC emissions and amine loss**
- **KS-1™ solvent with high CO₂ capacity, low degradation, and low regeneration energy**
- **Heat integration system to reduce steam consumption**

**KM CDR Process™** = Kansai Mitsubishi Carbon Dioxide Recovery Process

- Amine-based technology
- Capable of capturing ~95% CO₂ from combustion gas sources
- Proprietary features developed over 30 years of experience
- CO₂ purity >99.9% (dry basis)

**MHI's KM CDR Process™ Flue Gas Applications**

- **Tested gases include:**
  - Natural gas-fired boiler exhaust
  - Oil-fired boiler exhaust
  - Coal-fired boiler exhaust
  - Gas turbine exhaust (simulated)

- **Industrial applications:**
  - Power plants (NGCC, coal-fired, or biomass)
  - Steam methane reformer furnace exhaust
  - Cement plants
  - Steel plants
  - Catalytic crackers
  - Natural gas processing

**Typical Flue Gas Conditions**

<table>
<thead>
<tr>
<th>Component</th>
<th>Unit</th>
<th>Coal Fired Boiler</th>
<th>NG Fired GT</th>
<th>NG Fired Boiler</th>
</tr>
</thead>
<tbody>
<tr>
<td>CO₂</td>
<td>Vol.%</td>
<td>10 - 14</td>
<td>3 - 4</td>
<td>8 - 9</td>
</tr>
<tr>
<td>O₂</td>
<td>Vol.%</td>
<td>4 - 6</td>
<td>10 - 15</td>
<td>1 - 2</td>
</tr>
<tr>
<td>SOx</td>
<td>ppm (dry)</td>
<td>1 - 50</td>
<td>&lt;0.3</td>
<td>&lt;1</td>
</tr>
<tr>
<td>PM (Dust)</td>
<td>mg/Nm³</td>
<td>3 - 10</td>
<td>NA</td>
<td>NA</td>
</tr>
</tbody>
</table>

**Other possible constituents in the flue gas depending on the industrial application:**

- NOx
- CO
- H₂S
- Hydrocarbons
- Heavy metals
- Halides (HCl, HBr, HF)
Chemical production has been the main driver for the deployment of the KM CDR Process™.

- 1999 Malaysia: 210 Mt/d for Urea, NG Furnace
- 2000 Bahrain: 450 Mt/d for Urea, NG Furnace
- 2005 Japan: 330 Mt/d for General Use, Oil / NG Boiler
- 2009 Bahrain: 450 Mt/d for Urea, NG Furnace
- 2010 UAE: 400 Mt/d for Urea, NG Furnace
- 2011 Pakistan: 340 Mt/d for Urea, NG Furnace
- 2012 India (Vijapur): 450 Mt/d for Urea, NG Furnace
- 2014 Qatar: 580 Mt/d for Methanol, NG Furnace
- 2016 U.S.A (WA Parish): 4,776 Mt/d for EOR, Coal Boiler
- 2016 U.S.A (NM Plant): 4,776 Mt/d for EOR, Coal Boiler
- 2017 Japan: 230 Mt/d for Chem Process Gas
- 2018 Vietnam: 340 Mt/d for Urea, NG Furnace
- 2019 Vietnam: 450 Mt/d for Urea, NG Furnace
- 2020 Qatar: 500 Mt/d for Methanol, NG Furnace
- 2021 Russia: 1,500 Mt/d for Urea and Melamine, NG Furnace
- 2022 Bangladesh (scheduled): 240 Mt/d for Urea, NG Furnace
- 2023 India (Aromatics): 460 Mt/d for Urea, NG Furnace
- 2024 India (Vijapur): 450 Mt/d for Urea, NG Furnace
- 2025 India (Phulpur): 450 Mt/d for Urea, NG Furnace
- 2026 Japan: 330 Mt/d for General Use, Oil / NG Boiler
- 2027 Ukraine: 1,200 Mt/d for Urea and Melamine, NG Furnace
- 2028 India (Phulpur): 450 Mt/d for Urea, NG Furnace
- 2029 India (Aonla): 450 Mt/d for Urea, NG Furnace
- 2030 India (Kakinada): 450 Mt/d for Urea, NG Furnace
- 2031 India (Vijapur): 450 Mt/d for Urea, NG Furnace
- 2032 Bangladesh (scheduled): 240 Mt/d for Urea, NG Furnace

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