COAL FLEXIBILITY TEAM

• Our Charge
  – Improve coal unit turndown, turnaround and ramp rate to integrate with intermittent renewable resources in meeting load demand

• Areas of Focus
  – Turnaround
    • Decrease time from unit minimum regulation load to out of service and back to minimum regulation load as required
  – Turnaround
  – Turndown
    • Reduce unit minimum load (preferably on regulation)
  – Ramp Rates
    • Increase unit load ramp rates (preferably on regulation)

• The Outcomes
  – Lower production cost through fuel savings
  – Lower carbon emissions consistent with Xcel Energy’s goal of an 80% reduction in CO2 emissions from the 2005 level by 2030
XCEL ENERGY SYSTEM

• Three Regions
  – Northern States Power (NSP)
  – Public Service Colorado PSCo)
  – Southwestern Public Service (SPS)

• Two Markets
  – NSP - MISO
  – PSCo – N/A
  – SPS – SPP

• Highest Value
  – NSP - Turndown
  – PSCo - Ramp Rate
  – SPS - Turnaround

<table>
<thead>
<tr>
<th>State</th>
<th>Market</th>
<th>Turnaround</th>
<th>Turndown</th>
<th>Ramp Rate</th>
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<tr>
<td>MN</td>
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<td>✓</td>
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<tr>
<td>CO</td>
<td>N/A</td>
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<tr>
<td>TX</td>
<td>SPP</td>
<td>✓</td>
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</tbody>
</table>
XCEL ENERGY COAL FLEET

- Northern States Power – 2,743 MWN
  - Sherco 1 – 680 MWN
  - Sherco 2 – 682 MWN
  - Sherco 3 – 876 MWN
  - King – 505 MWN

- Public Service Colorado – 2,378 MWN
  - Comanche 1 – 325 MWN
  - Comanche 2 – 335 MWN
  - Comanche 3 – 766 MWN
  - Pawnee – 511 MWN
  - Hayden 1 – 179 MWN
  - Hayden 2 – 262 MWN

- Southwestern Public Service – 2,094 MWN
  - Harrington 1 – 339 MWN
  - Harrington 2 – 339 MWN
  - Harrington 3 – 349 MWN
  - Tolk 1 – 532 MWN
  - Tolk 2 – 535 MWN

- Average age of the units - 41 years
- Drum and Once Through Configurations
  - 1800 – 2400 psig Drum Pressures
  - King – Constant Pressure Supercritical with Cyclone Burners
  - Comanche 3 – Sliding Pressure Supercritical
XCEL’S COAL FLEXIBILITY HISTORY

• 2014
  – SPS begins improving turndown at Harrington to avoid cycling after entering SPP
  – SPS begins improving turnaround at Harrington after cycling proves unavoidable

• 2016
  – SPS begins improving turndown and turnaround at Tolk
  – PSCo begins improving coal unit turndown in anticipation of wind generation
  – NSP begins improving coal unit turndown to avoid cycling after entering MISO

• 2017
  – PSCo begins improving ramp rates to accommodate wind generation

• 2018
  – Xcel Energy forms a collaborative team to improve coal flexibility in all regions
CHALLENGES

• Turnaround
  – Boiler water chemistry; silica and copper holds
  – Unknown shutdown duration prevents positioning equipment effectively
  – Ignitor, flame scanner, supplemental fuel valve/control issues

• Turndown
  – Flame stability at reduce mill loading
  – Minimum flue gas temperature or flow for scrubbing
  – Emission limits (higher limits at reduced load)

• Ramp Rate
  – Boiler temperature control (main, reheat, water wall)
  – Throttle pressure stability
  – Equipment start/stop limitations

• Equipment Stress is a consideration in improving all three attributes
PROJECT TIMELINE

Currently in Progress

- Facilities test to determine new limits and identify projects that will be beneficial to improve flexibility
- Financial and operational analysis on potential projects
- Submit a summary of financially acceptable projects to be approved
- Implement projects and monitor asset health

Currently in Progress
## KEY TAKEAWAYS

<table>
<thead>
<tr>
<th>Location</th>
<th>Descriptions</th>
</tr>
</thead>
<tbody>
<tr>
<td>Comanche</td>
<td>• Unit 1 &amp; 2 Increase in ramp 2.2 MW/min → 6 MW/min, on AGC</td>
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<tr>
<td></td>
<td>• Unit 3 Turndown improved from 500 MW → 480 MW</td>
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<tr>
<td>Harrington</td>
<td>• Unit 1 &amp; 2 decrease turndown 163 MW → 120 MW</td>
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<tr>
<td></td>
<td>• Unit 3 decrease turndown from 163 MW → 130 MW</td>
</tr>
<tr>
<td>Hayden</td>
<td>• Unit 1 turndown testing, targeting 90 MW from 110 MW</td>
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<tr>
<td>King</td>
<td>• King increased ramp rate from 3 MW/min → 5.5 MW/min</td>
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<tr>
<td>Pawnee</td>
<td>• Turndown improved from 300 MW → 200 MW</td>
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<tr>
<td>Sherco</td>
<td>• Unit 1 &amp; 2 turndown improved from 260 MW → 215 MW</td>
</tr>
<tr>
<td>Tolk</td>
<td>• Turndown improved from 185 MW → 125 MW</td>
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