DryFining™ to Improve Efficiency and Lower Emissions
5+ Years of Commercial Operations

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Great River Energy

- Generation & Transmission cooperative
- 28 member cooperatives in MN
- Serving 655,000 homes & businesses
- 880 employees
- $1 Billion revenue
- $4 Billion total assets
- Investment grade debt
- 2,800+ MW of generation
- 4,500+ miles of transmission lines
Heat Rate Improvement Technology Comparison

- Advanced Ultra-Supercritical at 1350F/1400F (732C/760C)
- Ultra-SuperCritical at 1250F/1292F (680C/700C)
- Low-T Fuel Drying
- Ultra-SuperCritical at 1120F/1120F (604C/604C)
- Dual Reheat
- Natural Draft Cooling Tower
- Reduce cooling tower approach temperature
- Low-T Air Pre-heating
- Low-T Feedwater Pre-heating
- Reduce Air Heater Leakage (6% to 1%)

Source: EPRI
Before considering carbon capture, leverage efficiency with investments that lower cost and improve carbon intensity

- Turbine upgrades
- Combined heat and power
- Low temperature drying
What is DryFining™ fuel enhancement?

- DryFining is a technology utilizing waste heat and mechanical separation for drying and refining low-rank coal.
- DryFining can benefit a large portion of US and world coal-fired plants.
- DryFining benefits:
  - Cost effective
  - Significant reductions in pollutants
  - Improved plant efficiency
  - Lower CO₂ intensity for power
Coal Dryers

Feed Stream (Crushed Wet Coal)

Dilution Air

1st Stage

Dust Collector

Dust Collector Fan

2nd Stage

Auger

Segregation Stream

3rd Stage

Fluidizing Air (Cold PA)

1st and 2nd Stage Fluidizing Air

Screw Feeder

Moist Fluidizing Air & Elutriated Fines

Rejected for Further Cleaning

Product Stream
Coal Creek Station DryFining Retrofit

- DOE Clean Coal Power Initiative
- Engineering and construction from 2006-2009
- Construction performed without additional outage time
- Both units retrofitted simultaneously
DryFining for 600 MW (500 TPH)
Dust Collectors for 600 MW
## Moisture Reduction

### Prototype Coal Dryer Performance: March to April, 2006

<table>
<thead>
<tr>
<th>Test Date</th>
<th>Total Coal Moisture Content [%]</th>
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<tbody>
<tr>
<td></td>
<td><strong>Wet Feed</strong></td>
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<td>3/19</td>
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- **As Mined**
- **DryFine**

![Diagram showing moisture content changes](image)

The diagram illustrates the changes in moisture content from as-mined coal to a dried product.

**H₂O**

**Wet Feed**

**Dried Product**

**GREAT RIVER ENERGY**
Reduction in Fuel per MW Produced

DryFining Commercial Date
DryFining Performance & Emissions

13% Lower moisture lignite feedstock

\( \Delta M_{\text{coal}} = -9.5\% \)

6-mill operation

\( \Delta \text{HR}_{\text{net}} = -3.5\% \)

\( \Delta \eta_B = 3.4\%-\text{points} \)

Less moisture in flue gas:
- \(36^\circ\text{F} \) lower exit gas temperature
- 5.8% lower exit gas volume
- 5.8% lower exit gas velocity
- 9.9% less power for mills
- 17.3% less power for ID fans
- Less erosion & maintenance

Higher efficiency throughout

\( \Delta V_{\text{stack, STP}} = -5.8\% \)

Lower WFGD bypass

\( \Delta \text{SO}_2 = 18\% \)

43% less SO\(_2\)
30% less NO\(_x\)
2.2% less CO\(_2\)
35-40% less Hg
2.5% less ash

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DryFining Net $/Ton Savings

Net operational savings per ton of coal

- Net Savings: $2.76
- Fuel Savings: $1.57
- Reduced Station Service: $0.91
- Mill Maint: $0.08
- NH3 savings - NOX: $0.66
- Lime savings - SO2: $0.32
- ACI savings - Hg: $0.12
- $(0.12) - DryFining Parts & Labor
- $(0.23) - Operators
- $(0.56) - DryFining power requirements
### Reference Design (U.S. Equipment Cost)

**2x660 MW (900 TPH with 15 pts H₂O removal)**

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<tr>
<th>Qty</th>
<th>Component</th>
<th>USD</th>
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<tr>
<td>10</td>
<td>DryFining™ fuel enhancement modules</td>
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<td>10</td>
<td>Fluidizing Air Fans</td>
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<td>Instrumentation &amp; Controls</td>
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*Great River Energy*
TSM is our partner/licensee in China
Thank you

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