



## Lignite Fuel Enhancement System

### WHY DRY COAL?

Coal burns. Water doesn't. Softer coals, such as lignite, naturally have a higher water content than other types of coal. Reducing the amount of water in the fuel through a drying process has several advantages:

- Increase the energy density and value of coal.
- Reduce the total volume of flue gases that must be handled throughout the system.
- Improve the overall power plant efficiency.

### DRYING + REFINING = "DRYFINING™"

The idea may be simple, but developing the best process for drying coal has been complex. We started researching the coal enhancement process in 1997. Today, as a result of our research and partnerships, we're using a process to "DryFine™" the coal at Coal Creek Station to make it cleaner and more efficient. We're enhancing the power of lignite by using a product that would otherwise be wasted: the waste heat generated by the Coal Creek Station.

### EARLY RESEARCH

In 2000-2001, The Falkirk Mining Company, Great River Energy and The Coteau Properties Company participated in the Lignite Fuel Enhancement Incremental Moisture Reduction Project. Small-scale tests showed it was possible to dry lignite incrementally, with relatively low-temperature air. We succeeded in reducing the moisture content of lignite by six percent, and noted efficiency gains and reduced emissions in the plant. The results prompted further studies.

Next, we built a pilot plant fluidized bed dryer with a capacity to dry 2 1/2 tons per hour. The unit processed 350 tons of coal and refined lignite as predicted, using low temperature heat. Again the refined lignite improved plant efficiencies and reduced emissions. With the results, we finalized a design for the U.S. Department of Energy.

### PARTNERSHIP WITH DOE

The Lignite Fuel Enhancement System was one of eight projects selected in 2003 in the initial phase of the U.S. Department of Energy's Clean Coal Power Initiative, a 10-year, \$2 billion commitment to clean coal technology. The program competitively sought commercial-scale technology

demonstrations to continue and expand the use of coal as a fuel source. This \$31.5 million project at Coal Creek Station was administered by the DOE's Office of Fossil Energy, and managed by the National Energy Technology Laboratory.

### PHASE I—OPERATION OF PROTOTYPE

The Clean Coal Power Initiative project included the testing of a 115-ton per hour prototype dryer that supplied up to one-sixth of the coal for Coal Creek Station's Unit 2, a 546-megawatt unit. Round-the-clock testing of the prototype began on March 20, 2006.



*Coal Creek Station near Underwood, ND.*

The prototype unit dried and refined the lignite before it entered one of eight pulverizers that feed lignite to the boiler. The project was successful in increasing boiler efficiency, decreasing stack flow, and reducing emissions.

### PHASE II—COMMERCIAL DEMONSTRATION

Based on the results of Phase I, DOE and Great River Energy announced a full scale commercial demonstration of the coal drying and refining project in late fall 2006. The project included final design and construction of a full set of four modules for Unit 2, with each capable of processing 135 tons of coal per hour.



Due to the success of the initial prototype results, Great River Energy expanded beyond the scope of the DOE project by building four coal DryFiners for Unit 1. Construction was finalized in 2009, and the lignite used at the power plant is now "Dryfined," yielding more energy and fewer emissions.

A significant finding of our research is that our coal DryFining process separates particles by density. That means that a significant amount of higher density compounds containing sulfur and mercury can be sorted out and returned to the mine rather than oxidized in the boiler. The low temperature of the drying process prevents volatile gases from escaping into the air. All dust is collected as well. The DryFining process results in emissions reductions from the physical removal of impurities in the coal, the overall increase in plant efficiencies and the system benefits derived from lower volumes of drier stack gases.

### EXPECTED RESULTS

Great River Energy's coal DryFining process at Coal Creek Station:

- Reduces the moisture of lignite from 38.5 percent down to 29.5 percent.
- Increases the BTU content of lignite from 6,250 to 7,100 BTU/lb.
- Reduces fuel input 14 percent by weight.
- Increases overall power plant efficiency by 2 to 4 percent.
- Reduces stack emissions:
  - Sulfur dioxide by more than 40 percent.
  - Mercury by more than 40 percent.
  - Nitrogen oxide by more than 20 percent.
  - Carbon dioxide by 4 percent.

### POTENTIAL IMPACT OF TECHNOLOGY

This technology has great potential for other power plants throughout the world. Successful commercial application of the technology could result in striking benefits nationwide. In the United States today:

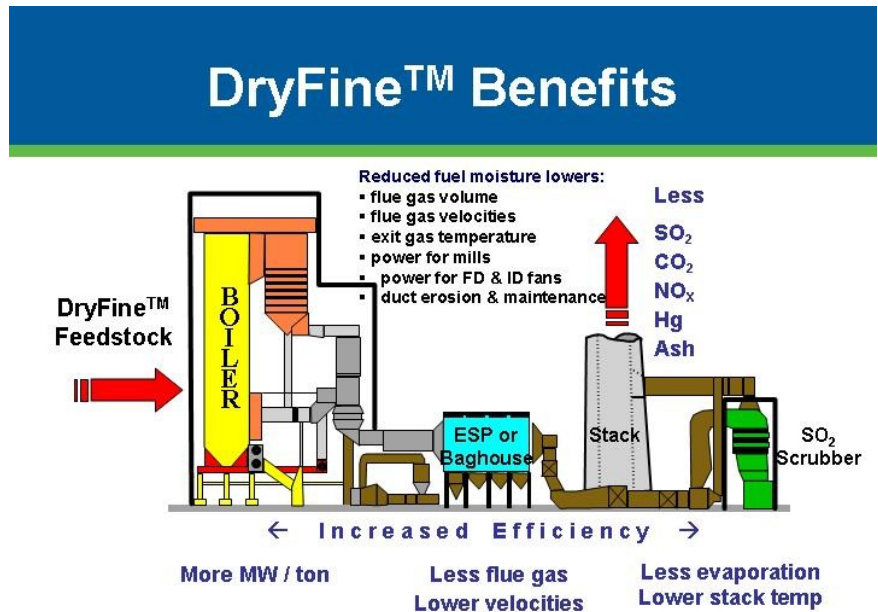
- 35 power generation units, with an installed capacity of 15 gigawatts, burn lignite.
- 250 units, with an installed capacity of about 100 gigawatts, burn Powder River Basin coal, a subbituminous coal with a high moisture content.

If used by new and existing power plants, the technology would significantly reduce air emissions in the United States.

### LICENSING OF TECHNOLOGY

The agreement with the U.S. Department of Energy includes a provision for commercializing the technology. Great River Energy is pleased to announce the selection of WorleyParsons Group as our preferred engineer and commercialization partner. WorleyParsons is a world class engineering firm with offices in 37 countries. We are receiving interest from all over the world, and having a local presence nearby will be a strategic asset in moving commercialization efforts forward. Worley Parsons is trained in the art and is well equipped to identify, evaluate, define and execute the

customization of our process design package to power plants that stand to benefit from the dramatic efficiency improvements and emissions reductions associated with Great River Energy's coal DryFining process. This innovative technology, developed in North Dakota, will be contributing to cleaner and more efficient power plants across the country and all around the world.



### ABOUT GREAT RIVER ENERGY

Great River Energy is a not-for profit wholesale electric cooperative, serving 28 distribution cooperatives in Minnesota and covering 60 percent of the state, geographically. It is the second largest power supplier in Minnesota. For more information, visit:

[www.GreatRiverEnergy.com](http://www.GreatRiverEnergy.com)



GREAT RIVER ENERGY®

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WorleyParsons is a leading provider of professional services to the energy, resource and complex process industries. The company's services cover the full asset spectrum both in size and lifecycle from the creation of new assets to services that sustain and enhance the value of operating assets. Worley Parsons' global

strategy, supported by more than 30,000 personnel across 37 countries, is one of



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developing fully functional operations at a local level wherever our customers need us. It provides our company with insight into their requirements and the local knowledge to deliver tailored, high-quality solutions. Major hub operations in the Americas, Asia, Europe and Australia are used for added technical expertise and for larger delivery capability.

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