USE OF COAL DRYING TO REDUCE WATER CONSUMED IN PULVERIZED COAL POWER PLANTS

QUARTERLY REPORT FOR THE PERIOD October 1, 2005 to December 31, 2005

by

Edward Levy
Harun Bilirgen
Ursla Levy
John Sale
Nenad Sarunac

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Energy Research Center
Lehigh University
117 ATLSS Drive
Bethlehem, PA 18015

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ABSTRACT

This is the twelfth Quarterly Report for this project. The background and technical justification for the project are described, including potential benefits of reducing fuel moisture using power plant waste heat, prior to firing the coal in a pulverized coal boiler.

During this last Quarter, the development of analyses to determine the costs and financial benefits of coal drying was continued. The details of the model and key assumptions being used in the economic evaluation are described in this report and results are shown for a drying system utilizing a combination of waste heat from the condenser and thermal energy extracted from boiler flue gas.

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INTRODUCTION

Background

Low rank fuels such as subbituminous coals and lignites contain significant amounts of moisture compared to higher rank coals. Typically, the moisture content of subbituminous coals ranges from 15 to 30 percent, while that for lignites is between 25 and 40 percent, where both are expressed on a wet coal basis.

High fuel moisture has several adverse impacts on the operation of a pulverized coal generating unit. High fuel moisture results in fuel handling problems, and it affects heat rate, mass rate (tonnage) of emissions, and the consumption of water needed for evaporative cooling.

This project deals with lignite and subbituminous coal-fired pulverized coal power plants, which are cooled by evaporative cooling towers. In particular, the project involves use of power plant waste heat to partially dry the coal before it is fed to the pulverizers. Done in a proper way, coal drying will reduce cooling tower makeup water requirements and also provide heat rate and emissions benefits.

The technology addressed in this project makes use of the hot circulating cooling water leaving the condenser to heat the air used for drying the coal (Figure 1). The temperature of the circulating water leaving the condenser is usually about 49°C (120°F), and this can be used to produce an air stream at approximately 43°C (110°F). Figure 2 shows a variation of this approach, in which coal drying would be accomplished by both warm air, passing through the dryer, and a flow of hot circulating cooling water, passing through a heat exchanger located in the dryer. Higher temperature drying can be accomplished if hot flue gas from the boiler or extracted steam from the turbine cycle is used to supplement the thermal energy obtained from the circulating cooling water. Various options such as these are being examined in this investigation.

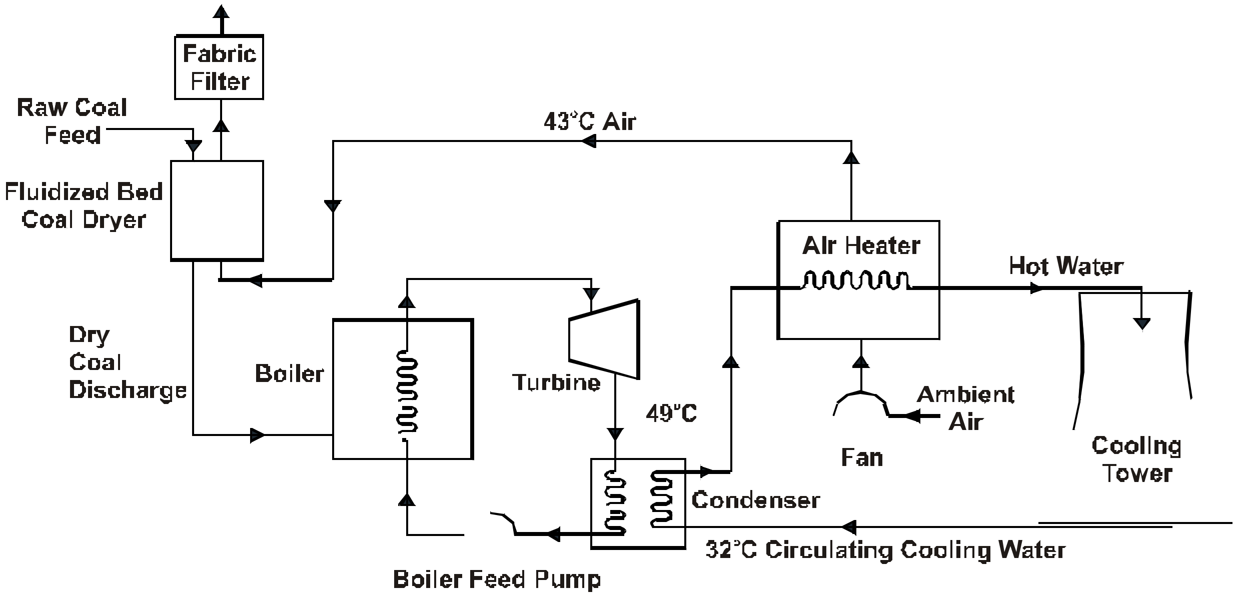

Figure 1: Schematic of Plant Layout, Showing Air Heater and Coal Dryer (Version 1)

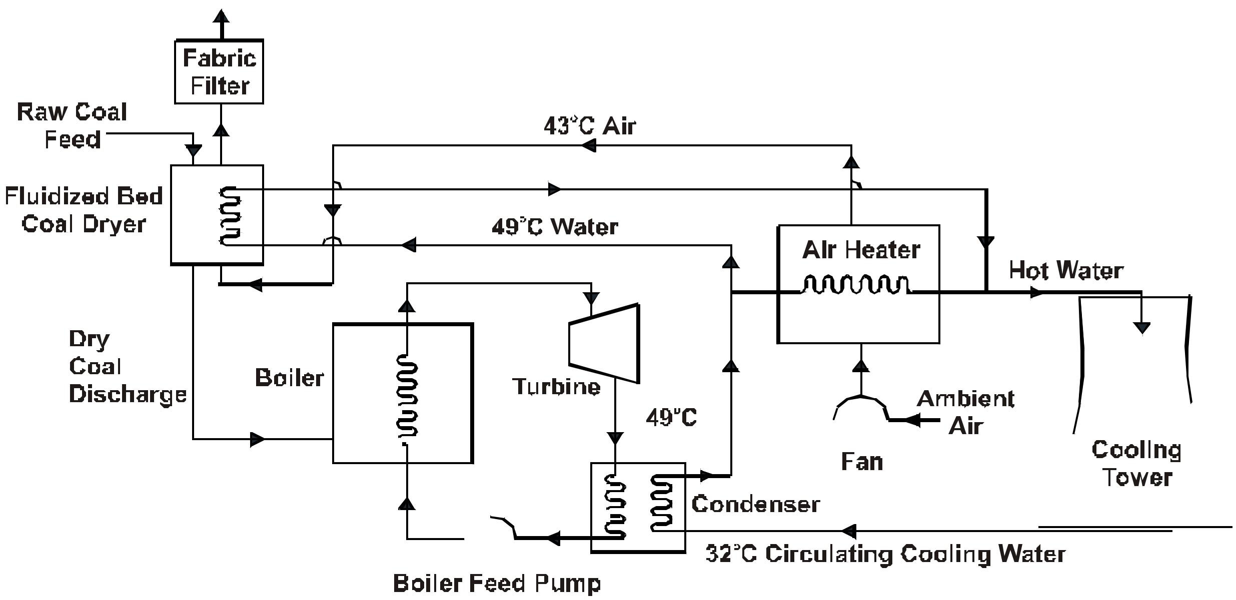

Figure 2: Schematic of Plant Layout, Showing Air Heater and Coal Dryer (Version 2)

Previous Work

Two of the investigators (Levy and Sarunac) have been involved in work with the Great River Energy Corporation on a study of low temperature drying at the Coal Creek Generating Station in Underwood, North Dakota. Coal Creek has two units with total gross generation exceeding 1,100 MW. The units fire a lignite fuel containing approximately 40 percent moisture and 12 percent ash. Both units at Coal Creek are equipped with low NO_x firing systems and have wet scrubbers and evaporative cooling towers.

A coal test burn was conducted at Coal Creek Unit 2 in October 2001 to determine the effect on unit operations. The lignite was dried for this test by an outdoor stockpile coal drying system. On average, the coal moisture was reduced by 6.1 percent, from 37.5 to 31.4 percent. Analysis of boiler efficiency and net unit heat rate showed that with coal drying, the improvement in boiler efficiency was approximately 2.6 percent, and the improvement in net unit heat rate was 2.7 to 2.8 percent. These results are in close agreement with theoretical predictions (Figure 3). The test data also show the fuel flow rate was reduced by 10.8 percent and the flue gas flow rate was reduced by 4 percent. The combination of lower coal flow rate and better grindability combined to reduce mill power consumption by approximately 17 percent. Fan power was reduced by 3.8 percent due to lower air and flue gas flow rates. The average reduction in total auxiliary power was approximately 3.8 percent (Ref. 1).

This Investigation

Theoretical analyses and coal test burns performed at a lignite fired power plant show that by reducing the fuel moisture, it is indeed possible to improve boiler performance and unit heat rate, reduce emissions and reduce water consumption by the evaporative cooling tower. The economic viability of the approach and the actual impact of the drying system on water consumption, unit heat rate and stack emissions will depend critically on the design and operating conditions of the drying system.

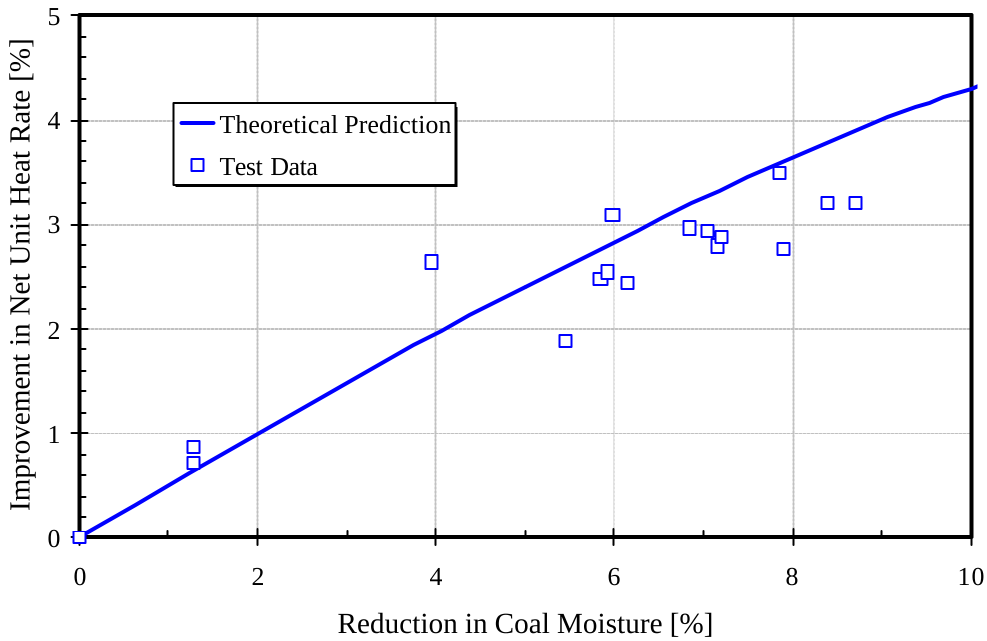

Figure 3: Improvement in Net Unit Heat Rate Versus Reduction in Coal Moisture Content

The present project is evaluating low temperature drying of lignite and Powder River Basin (PRB) coal. Drying studies are being performed to gather data and develop models on drying kinetics. In addition, analyses are being carried out to determine the relative costs and performance impacts (in terms of heat rate, cooling tower water consumption and emissions) of the various drying options, along with the development of an optimized system design and recommended operating conditions.

The project is being carried out in five tasks. The original Task Statements included experiments and analyses for both fluidized bed and fixed bed dryers (see previous Quarterly Reports). After the project was started, it became clear there is no advantage to using fixed bed dryers for this application. For this reason, the technical scope was changed in June 2004 to emphasize fluidized bed drying. The Task Statements in this report reflect this change in emphasis.

Task 1: Fabricate and Instrument Equipment

A laboratory scale batch fluidized bed drying system will be designed, fabricated and instrumented in this task. **(Task Complete)**

Task 2: Perform Drying Experiments

The experiments will be carried out while varying superficial air velocity, inlet air temperature and specific humidity, particle size distribution, bed depth, and in-bed heater heat flux. Experiments will be performed with both lignite and PRB coals. **(Task Complete)**

Task 3: Develop Drying Models and Compare to Experimental Data

In this task, the laboratory drying data will be compared to equilibrium and kinetic models to develop models suitable for evaluating tradeoffs between dryer designs. **(Task Complete)**

Task 4: Drying System Design

Using the kinetic data and models from Tasks 2 and 3, dryers will be designed for lignite and PRB coal-fired power plants. Designs will be developed to dry the coal by various amounts. Auxiliary equipment such as fans, water to air heat exchangers, dust collection system and coal crushers will be sized, and installed capital costs and operating costs will be estimated**. (Task Complete)**

Task 5: Analysis of Impacts on Unit Performance and Cost of Energy

Analyses will be performed to estimate the effects of dryer operation on cooling tower makeup water, unit heat rate, auxiliary power, and stack emissions. The cost of energy will be estimated as a function of the reduction in coal moisture content. Cost comparisons will be made between dryer operating conditions (for example, drying temperature and superficial air velocity). **(Task in Progress)**

EXECUTIVE SUMMARY

Background

Low rank fuels such as subbituminous coals and lignites contain relatively large amounts of moisture compared to higher rank coals. High fuel moisture results in fuel handling problems, and it affects station service power, heat rate, and stack gas emissions.

This project deals with lignite and subbituminous coal-fired pulverized coal power plants, which are cooled by evaporative cooling towers. The project involves use of the hot circulating cooling water leaving the condenser to provide heat needed to partially dry the coal before it is fed to the pulverizers.

Recently completed theoretical analyses and coal test burns performed at a lignite-fired power plant showed that by reducing the fuel moisture, it is possible to reduce water consumption by evaporative cooling towers, improve boiler performance and unit heat rate, and reduce emissions. The economic viability of the approach and the actual impact of the drying system on water consumption, unit heat rate and stack emissions will depend critically on the design and operating conditions of the drying system.

This project is evaluating alternatives for the low temperature drying of lignite and Power River Basin (PRB) coal. Laboratory drying studies are being performed to gather data and develop models on drying kinetics. In addition, analyses are being carried out to determine the relative costs and performance impacts (in terms of heat rate, cooling tower water consumption and emissions) of drying, along with the development of an optimized system design and recommended operating conditions.

Results

A cost study has been performed for a 537 MW lignite fired unit equipped with a coal drying system which utilizes a combination of waste heat from the condenser and thermal energy extracted from boiler flue gas. Ranges of values are given for costs and benefits, reflecting the range of interest rates and unit costs for which the analyses were performed.

The results show the reduction in fuel costs and avoided costs of emissions due to heat rate improvements from coal drying are the dominant benefits from a cost perspective. Of less importance, but still significant, are a decrease in lost generation due to unscheduled mill outages and savings from reduced costs of mill maintenance, reduced coal ash disposal, and reduced use of makeup water for power plant cooling. Finally, for most cases considered, the drying system caused an increase in station service power due to the power requirements of the fluidization air fans and coal crushers. For an annual interest rate of 7.5% and the mean cost savings scenario, the break even point is at 16 percent moisture reduction, with the return on investment increasing linearly to 20.9 percent at 19 percent moisture reduction.

ECONOMIC EVALUATION OF COAL DRYING

Previous reports from this project contain descriptions of analyses carried out to compute the effects of coal drying on unit heat rate, station service power, stack emissions, and water consumption for evaporative cooling. The last part of the project has consisted of analyses to determine the cost effectiveness of coal drying and the effects of drying system design and process conditions on drying costs. This report describes the methodology and key assumptions used to estimate the costs and benefits of coal drying and presents results of analyses. The results presented here are for a drying system which utilizes a combination of waste heat from the condenser and thermal energy extracted from boiler flue gas. The cost analyses are for a 537 MW lignite power plant.

Capital and Operating Costs

Previous analyses carried out in this investigation used mass and energy balances to determine the effects of coal product moisture on unit performance and emissions. Those analyses also generated information on flow rates of coal and flow rates and temperatures of air, flue gas and cooling water at various state points in the system. This information was then used to determine the required sizes and operating conditions of key components of the drying system such as fluidized bed dryers, fans, heat exchangers and baghouses. Estimates of installed capital costs were obtained from vendors and from the open literature. Where possible, cost estimates were obtained from independent sources as a cross check on the numbers being used. The annual fxed charge, which includes interest, depreciation, taxes and insurance, was calculated assuming a 20 year life and interest rates ranging from 6.5 to 8.5%.

The total installed costs and annual fixed costs are given in Table 1 as a function of extent of drying and interest rate. It was assumed the lignite being used by the plant has an as-received moisture content of 38.5 percent (kg $H_2O \times 100$/kg moist coal), and analyses were carried out for coal product moistures ranging from 28.9 to 19.5 percent (that is, for percentage reduction in moisture from 9.6 to 19 percent). Table 1 shows total installed costs ranging from $23.4 to $24.4 million, with annual fixed costs from $3.6 to $4.1 million.

It was assumed the drying system operates 24 hours a day and seven days a week. Costs for operating and maintenance manpower were estimated by assuming one operator for all the dryers during each operating shift and two maintenance personnel for all the dryers during one shift each day. The operating costs include salaries and wages, employee benefits, supervision, and supplies for operation and maintenance. The operating costs also include electrical power to drive the fluidization air fans and coal crushers and these are included as components in the total station service power, as described later in this report.

Excluding contributions due to Station Service Power, the annual O&M costs were estimated to be $507,321 for all four moisture levels, and the total annual fixed and O&M costs range from $4.1 to $4.6 million (Table 1).

Table 1

Capital and Operating and Maintenance Costs

% CHANGE IN MOISTURE	TOTAL INSTALLED COST	ANNUAL INTEREST %	ANNUAL FIXED COST	ANNUAL O&M COST	TOTAL FIXED AND O&M COSTS
9.60	$23,446,409	6.5	$3,622,470	$507,321	$4,129,791
10.80	$23,550,919	6.5	$3,638,617	$507,321	$4,145,938
16.00	$24,034,968	6.5	$3,713,403	$507,321	$4,220,724
19.00	$24,387,259	6.5	$3,767,832	$507,321	$4,275,153
9.60	$23,446,409	7.5	$3,856,456	$507,321	$4,363,786
10.80	$23,550,919	7.5	$3,873,655	$507,321	$4,380,976
16.00	$24,034,968	7.5	$3,953,272	$507,321	$4,460,593
19.00	$24,387,259	7.5	$4,011,216	$507,321	$4,518,537
9.60	$23,446,409	8.5	$3,967,132	$507,321	$4,474,453
10.80	$23,550,919	8.5	$3,984,815	$507,321	$4,492,136
16.00	$24,034,968	8.5	$4,066,717	$507,321	$4,574,038
19.00	$24,387,259	8.5	$4,126,324	$507,321	$4,633,645

Financial Benefits

The potential financial benefits fall into six categories:

- Reduced Fuel Costs
- Reduced Ash Disposal Costs
- Avoided Costs of Emissions Control
- Reduced Station Service Power (or, in some cases, the cost of increased station service power)
- Water Savings
- Reduced Mill Maintenance Costs
- Reduced Lost Generation Due to Mill Outages

The factors considered in quantification of these benefits are described in the following sections of this report. Three estimates are listed for some of the unit cost parameters to reflect the ranges of possible values. For this reason, a range of values (minimum to maximum) will be given for the total benefits.

Reduced Fuel Costs

The results presented in previous reports show that use of power plant waste heat to dry the coal before pulverizing it results in a reduction in unit heat rate. Thus, for a fixed gross power output, the percentage improvement in heat rate results in a proportional percentage reduction in coal use. A delivered coal cost of $17.36/ton was assumed for the analysis.

Reduced Ash Disposal Costs

A reduction in coal use results in a reduction in ash disposal costs. Ash disposal costs of $8 to $16/ton were assumed. Table 2 summarizes the calculated savings due to reduced fuel and ash disposal costs.

Table 2

Annual Ash Disposal and Fuel Savings

% Moisture Reduction	Fuel Savings	Ash Disposal Savings		
		Minimum	Mean	Maximum
9.61	$991,085	$67,869	$101,803	$135,738
10.76	$1,059,840	$75,201	$112,801	$150,402
16.05	$1,577,144	$169,202	$253,803	$338,404
19.07	$1,768,355	$217,331	$325,996	$434,661

Avoided Costs of Emissions Control

The reduction in coal use also leads to reductions in emissions of SO_2, NO_x, CO_2 and Hg. Assuming a fixed moisture-free composition of coal fed to the plant, the rates of emissions of SO_2 and CO_2 are directly proportional to the rate at which coal, on a moisture free basis, is burned, and thus the percentage reductions in emissions of SO_2 and CO_2 are equal to the percentage reductions in heat rate. Just with the SO_2 and CO_2, the rate of emissions of Hg will be reduced due to a reduction in the rate at which moisture-free coal is burned. But in addition, there is evidence from laboratory experiments and theoretical analyses that a reduction in flue gas moisture results in enhanced Hg oxidation and thus enhanced Hg capture by particulates. If this happens, the percentage reduction in Hg emissions will be larger than the percentage reduction in heat rate. The magnitude of this effect will be site specific and field tests would be needed to quantify the magnitude of the reductions in Hg emissions. Similarly, the impact of coal drying on NO_x emissions is site specific. For purposes of the analyses carried out in this investigation, percentage reductions of the emissions of NO_x, H_g, SO_2 and CO_2 are all assumed to equal the percentage change in heat rate.

The full-load baseline emissions assumed for the analysis are shown in Table 3 and the costs of emissions used to estimate the avoided costs for each of the four gaseous pollutants are shown in Table 4. Table 5 summarizes the avoided costs due to reductions in NO_x, SO_2, Hg and CO_2.

Table 3

Annual Full-Load Baseline Emissions

NO_x (lb/MMBtu)	NO_x (tons/yr)	SO_2 (lb/MMBtu)	SO_2 (tons/yr)	Hg (lb/yr)	CO_2 (tons/yr)
0.22	4,486	0.864	17,625	226	4,416,093

Table 4

Unit Costs of Emissions

NO_x	$2,400/ton
SO_2	$750 to $1,500/ton
Hg	$20,000/lbm
CO_2	$9.10 to $18.20/ton

Table 5

Avoided Costs of Emissions Control

% Moisture Reduction	NO_x	Hg	SO_2			CO_2		
			Minimum	Mean	Maximum	Minimum	Mean	Maximum
9.61	$85,240	$85,757	$251,159	$334,879	$502,318	$761,188	$1,141,782	$1,522,376
10.76	$89,726	$90,270	$264,378	$352,504	$528,756	$801,251	$1,201,876	$1,602,501
16.05	$134,590	$135,405	$396,567	$528,756	$793,134	$1,201,876	$1,802,814	$2,403,752
19.07	$152,535	$153,459	$449,443	$599,257	$898,885	$1,362,126	$2,043,189	$2,724,252

Water Savings

Reductions in makeup water requirements for evaporative cooling towers due to coal drying will result in avoided costs for water. The cooling tower analyses indicate water reductions of up to 140,000 gallons per day are possible for a 537 MW lignite fired power plant which uses the drying scheme analyzed in this report. The cost of water for large industrial users varies from location to location in the United States, with water costs from $0.50 to $3.00 per 10^3 gallons being typical. Table 6 lists the water savings as a function of degree of drying and the unit cost of water. (Note: For the specific drying system evaluated here, the analysis indicates the cooling tower water savings are relatively constant over the range of moisture levels shown in Table 6.)

Table 6

Annual Water Savings

% Moisture Reduction	Water Savings (Gallons/Year)	Water Savings ($/year)		
		Minimum[(a)]	Mean[(b)]	Maximum[(c)]
9.61	62.5×10^6	$31,273	$93,819	$187,638
10.76	62.5×10^6	$31,273	$93,819	$187,638
16.05	62.5×10^6	$31,273	$93,819	$187,638
19.07	62.5×10^6	$31,273	$93,819	$187,638

(a) $\$0.50/10^3$ gallon, (b) $\$1.50/10^3$ gallon, (c) $\$3.00/10^3$ gallon

In some circumstances, there will be additional financial benefits if the reduction in makeup water requirements results in a decreased need to derate the unit due to a scarcity of water for cooling.

<u>Reduced (or Increased) Station Service Power</u>

The components of station service power affected by coal drying include the induced draft and forced draft fan power, mill and crusher power and power for the fluidization air fans.

Coal drying results in a decreased flow rate of combustion air and a decreased flow rate of flue gas, thus reducing the power requirements for the forced draft and induced draft fans. Fan power is assumed to be proportional to the air or flue gas flow rate.

Pulverizer power requirements depend on the flow rate of coal through the pulverizers and the energy requirement for grinding per ton of coal. Coal drying results in a reduction in the energy requirements for grinding per ton of coal.

This is illustrated in Figure 4 which summarizes laboratory data from Reference 2 on the effect of feed moisture content on pulverizer specific power requirements for seven different lignites. These data show the power/ton of lignite feed varied linearly with coal moisture level, with the specific power at 20 percent moisture being 2/3 of the specific power at 40 percent moisture. Both the reduced coal flow rate and the reduction in grinding energy per ton of coal were taken into account in this analysis.

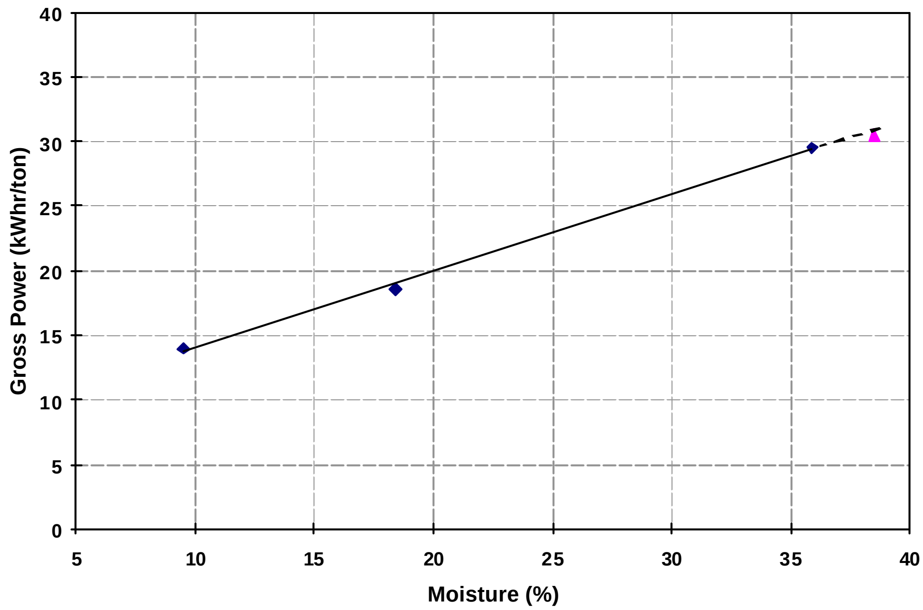

Figure 4a: Effect of Lignite Feed Moisture on Gross Pulverizer Power (kWhr/ton). Adapted from Data by Ellman et al. (Reference 2).

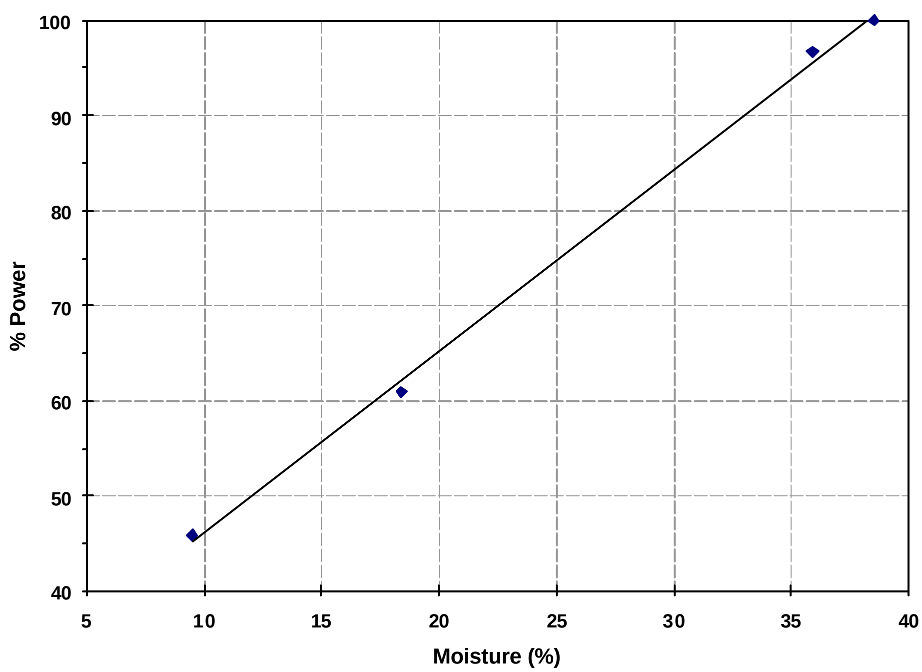

Figure 4b: Effect of Lignite Feed Moisture on Relative Pulverizer Power (kWhr/ton).

As noted above, coal drying results in a reduction of the power requirements for the coal pulverizers and for the induced draft and forced draft fans. But it also leads to the addition of two new power components … the power required to drive the fans for the fluidization air and the power for the coal crushers. The flow rate of fluidization air depends on dryer size, which, in turn, depends on the temperature(s) of the heat source(s) used for drying and the difference between the inlet and exit coal moisture levels. The effects of the crusher power and the fluidization air fans on station service power are included in the analysis.

The impacts of drying on station service power are summarized in Table 7. The station service power requirements increase to values above the baseline for low levels of drying and then decrease to values below the baseline as the coal product moisture is reduced to lower levels. Electrical power is assumed to cost $0.05/kWh in this analysis.

Table 7

Incremental Cost of Station Service Power

% Moisture Reduction	Δ Station Service Power (MW)	$/year
0.00	0	0
9.61	1.583	+589,350
10.76	1.400	+521,220
16.05	0.732	+272,524
19.07	-0.188	-69,992

Mill Maintenance and Availability

Pulverizer maintenance requirements depend on coal feed rate, coal mineral content and the grinding characteristics of the coal. All three parameters affect wear rates of mill grinding surfaces and rates of wear and tear on components such as shafts, gear boxes and classifier blades.

This study focuses on retrofit applications, where as a result of coal drying, the existing pulverizers collectively handle lower coal feed rates than is the case without drying. Laboratory grinding studies with lignites (Reference 3) also show that the grinding capacity of a mill depends strongly on moisture content, with significant increases of grinding capacity as moisture content decreases. These two factors (reduced coal feed rate to the boiler and increased mill grinding capacity) can often make it possible to take one or more mills out of service while still operating the boiler at full load conditions.

Estimates were made of the impacts of operating with fewer mills on maintenance costs and on the cost of lost generation due to unscheduled mill outages. These estimates are based on data obtained from surveying a group of coal-fired electric utility companies. The estimates assume the power plant has six pulverizers and requires all six to be in operation when firing wet coal, but with coal drying, it can operate at full load using only five pulverizers.

It is assumed each operating pulverizer is normally inspected twice a year, with each inspection costing $25,000 for parts and labor. It is also assumed each operating pulverizer normally undergoes a major overhaul every two years, with an average cost per overhaul for parts and labor of $235,000 per mill. Assuming the inspections and major overhauls are performed during low load periods or during outage periods for other maintenance work, the reduction in maintenance costs from operating five instead of six mills is $167,500 per year.

Being able to operate at full load conditions with five instead of six mills in operation (that is, with one excess mill available for emergency situations) also leads to cost savings in the event there is an unscheduled mill outage at a time of peak power production. Table 8 summarizes the avoided costs of lost power generation due to unscheduled mill outages, where it was assumed unit derates of 1/6 x 537 MW ranging from 0.5 to 1.5 days per year with replacement power costing $0.05/ kWhr, are avoided due to coal drying.

Table 8

Mill Maintenance Savings – Lost Power Generation

Days of Lost Generation/Year	Avoided Costs/Year
0.5	$44,312
1.0	$88,623
1.5	$132,935

Annual Cost Savings Due to Coal Drying

The individual cost savings shown in Tables 2, 5, 6, 7 and 8 can be added to obtain the total annual cost savings due to coal drying (see Table 9). The annual savings depend strongly on the coal product moisture level and the assumptions used for the individual cost parameters. At the largest percentage moisture reduction considered in this study, the estimated annual savings ranged from $4.4 to $6.7 million. Comparison of the individual parameters affected by drying shows, for the drying system configuration analyzed here, the most important savings are the fuel savings and the avoided costs due to reduction of SO_2 and CO_2 emissions. Less important, but still significant, are savings due to avoided costs of Hg and NO_x emissions, reduced costs of mill maintenance, a decrease in lost generation due to unscheduled mill outages, reduced costs of ash disposal, and reduced use of makeup water for power plant cooling. For most of the cases considered, the drying system caused an increase in station service power due to power requirements for the fluidization air fans and coal crushers.

Table 9

Summary of Annual Savings

% Moisture Reduction	Minimum Savings	Mean Savings	Maximum Savings
9.6	$1,896,033	$2,501,138	$3,221,237
10.8	$2,102,531	$2,735,740	$3,488,348
16.0	$3,585,344	$4,509,929	$5,597,977
19.0	$4,416,325	$5,462,724	$6,690,212

Comparison of Costs and Benefits

The comparison of costs and benefits is summarized in Figure 5 as annual dollars versus percentage moisture reduction. The benefits (that is, the savings) at each moisture level cover a range from the minimum to maximum savings, reflecting the range of unit costs assumed for each parameter. The costs of drying also cover a range of values, reflecting the range of interest rates used in the analysis.

These results show that for this particular drying system and the hypothetical coal-fired generation unit which has been analyzed, the cost effectiveness of the technology increases as the coal product moisture decreases. For an annual interest rate of 7.5% and the mean cost savings scenario, the break even point is at 16 percent moisture reduction, with the return on investment increasing linearly to 20.9 percent at 19 percent moisture reduction (Figure 6).

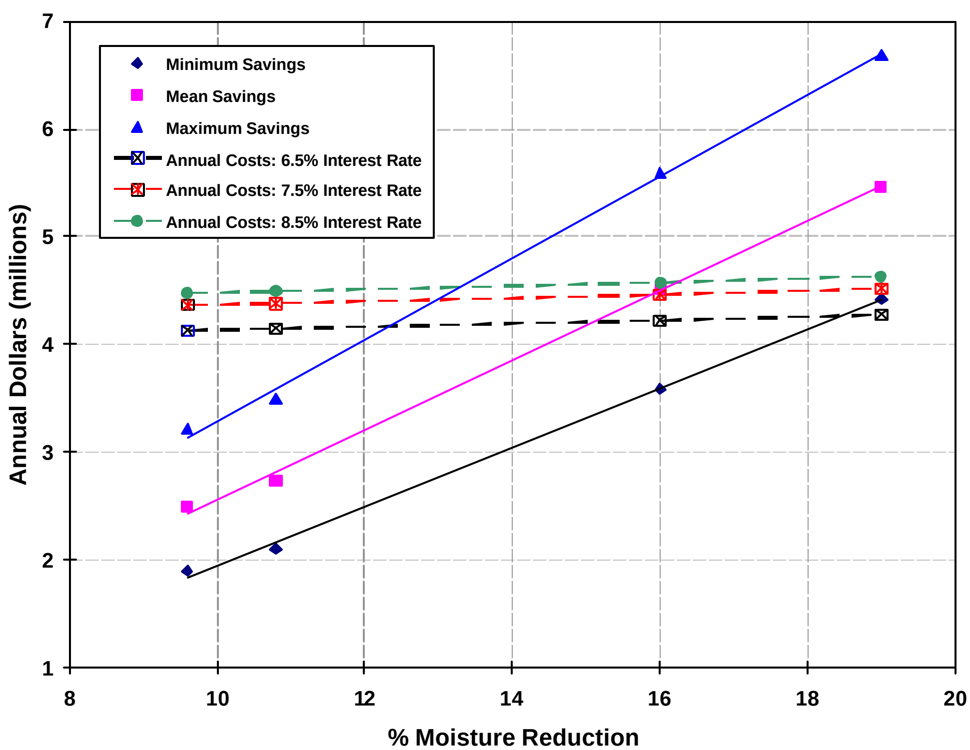

Figure 5: Comparison of Annual Costs and Benefits

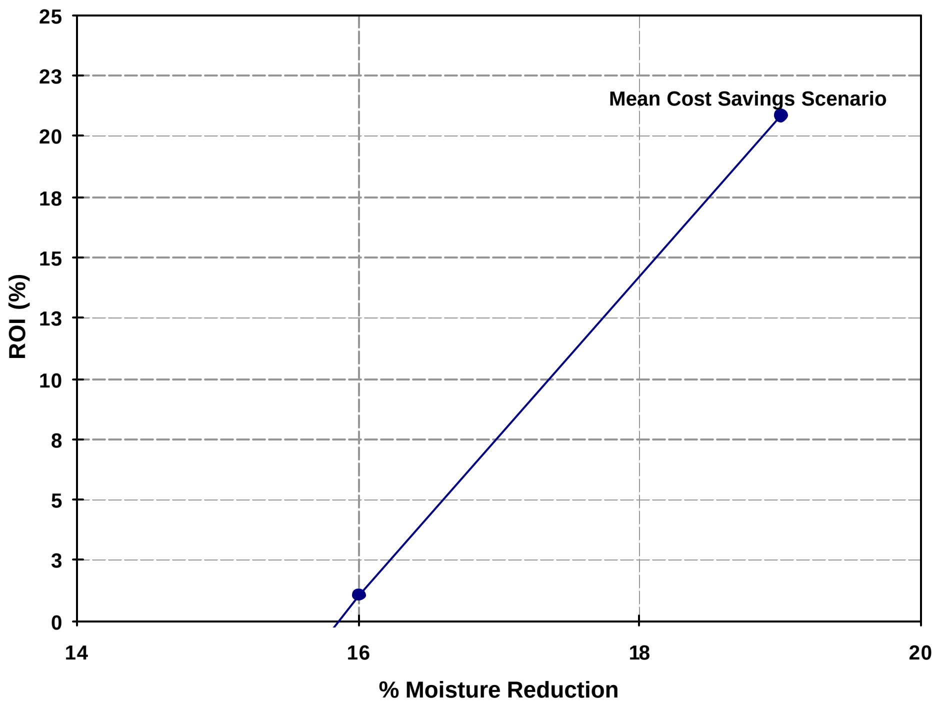

Figure 6: Return on Investment for 7.5% Annual Interest and Mean Cost Savings Scenario

CONCLUSIONS

A cost study has been performed for a 537 MW lignite fired unit equipped with a coal drying system which utilizes a combination of waste heat from the condenser and thermal energy extracted from boiler flue gas. Ranges of values are given for costs and benefits, reflecting the range of interest rates and unit costs for which the analyses were performed.

The results show the reduction in fuel costs and avoided costs of emissions due to heat rate improvements from coal drying are the dominant benefits from a cost perspective. Of less importance, but still significant, are a decrease in lost generation due to unscheduled mill outages and savings from reduced costs of mill maintenance, reduced coal ash disposal, and reduced use of makeup water for power plant cooling. Finally, for most cases considered, the drying system caused an increase in station service power due to the power requirements of the fluidization air fans and coal crushers. For an annual interest rate of 7.5% and the mean cost savings scenario, the breakeven point is at 16 percent moisture reduction, with the return on investment increasing linearly to 20.9 percent at 19 percent moisture reduction.

PLANS FOR NEXT QUARTER

The project ends on March 31, 2006. During this next quarter, a cost study will be performed on a second type of drying system and work will begin on writing the Final Report.

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