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Carrying Water to Newcastle

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"CARRYING WATER TO NEWCASTLE"

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Abstract

Western coals, now being shipped by unit trains to eastern and southern markets, contain from 13% to 32% moisture. Drying of these coals at the mine would reduce the cost of coal to the utilities from 10% to 16% IF the railroads do not materially increase rates on higher BTU coal.

The spontaneous combustion of dry coal can be inhibited, and the savings per unit train should range from $1,375,000 to $4,129,000 per year according to the various minimum tonnage rates. The shipment of dried coal will reduce the tonnages being shipped by 15%, or increase the railroad carrying capacity by approximately 20%, without additional expense to the railroads.

INTRODUCTION

In 1972, Garth A. Duell, Manager, Coal Resources Department, Pacific Power & Light, and I were discussing the moisture content of western coals. I told him of my experience with spontaneous combustion in mills grinding sulphur, and that we had succeeded in eliminating fire completely by introducing the exhaust from our diesel engines into our sulphur ball mills, thereby reducing the volume of oxygen in the mills to less than 8%, which would not support combustion. He then stated that if I could dry coal and thereby substantially increase the number of BTUs per pound—and also prevent the dried coal from spontaneously catching fire—that I should drop everything and devote all my time to it.

At about the same time, I was in Minneapolis in a conference with V. H. Wood, Manager of Fuel Procurement for Northern States Power. As usual the subject of dried coal and the cost of shipping water to Minneapolis came up. His interest was evident in this statement: "When you can safely deliver dried coal, we will get to our drawing boards and design new plants to use it."

* * *

A significant percentage of western coal being shipped by rail to coal-powered electric power plants contains from 20 to 32% of inherent and surface moisture. Drying these coals before carloading, the elimination of spontaneous combustion, and the lower installed KW cost of new power plants may reduce the cost of BTUs delivered to many public utilities. An additional advantage is the reduced weight and the overloading of railroad tracks which will lessen the incidence of track and wheel failure and reduce the amount of energy needed to transport a BTU of coal.

Under the most favorable conditions, a unit train of 100 cars, each carrying 100 tons of Montana coal, would actually be transporting only 8,000 tons of coal and 2,000 tons of water. 75%, or 1,500 tons, of this can be easily and economically removed. The preliminary study shows an average cost of the utilities burning western coal of about $10,500 per unit train trip for transporting water.

This automatically adds up to a higher cost for electricity. Larger freight rates will substantially increase these unnecessary costs.

Studies have been made by Berwin, Dorr-Oliver, Greundler, McNalley-Pittsburgh, and Parry in which up to 32% moisture in coal was reduced to from 5.6% to as little as .98%.

Coal with 5% or less moisture is subject to a combination of spontaneous combustion and large losses due to air turbulence blowing over the tops of moving, open coal cars.

The exhaust gasses from the dryers contain primarily carbon dioxide, nitrogen, and water vapor. This gas should be filtered and compressed to separate the carbon dioxide fraction. The liquid carbon dioxide should then be stored in tanks convenient to the automatic loading chutes used in the continuous loading of unit trains. The carbon dioxide would then be infiltrated into the dry coal as it drops into the coal car, providing an atmosphere which will not support combustion.

The expansion of the carbon dioxide drops the temperature of the gas to 109.3°F. below zero, lowering the temperature of the coal far below a possible combustion temperature. Dry coal is one of the best of all natural insulators and should maintain an incombustible temperature for several weeks in a coal car and even into the stock piles of the utilities.

Should it not be convenient to infiltrate the coal with carbon dioxide during loading, the coal could be maintained continuously in a noncombustible atmosphere high in carbon dioxide and low in temperature by a system in which the exhaust from the diesel engines pulling the unit train is cleaned, compressed, and then distributed into each coal car.*

Flip top gondola cars should be used for dried coal to prevent blowing, coal dust air pollution, spillage, to keep snow and rain off the coal, to prevent freezing, and to decrease losses of entrained inert gasses.

Coal properties in Montana are now the subject of an R&D program to determine the economics and feasibility of drying and shipping coal. Geological studies and comprehensive exploratory drilling shows that in excess of 110 million tons of strippable coal has been proven. The coal's average analysis is:

Raw BTU	9,048/lb.	Moisture	22.37%
Dry BTU	11,653/lb.	Dry ash	8.16%
MAF	12,434/lb.	Dry sulphur	.67%

17.37% of the moisture, or 314 lbs. per ton, can be removed at an estimated cost of $1.5872 per ton of water, $.2355 per ton of input coal, or $.2875 of delivered coal. The coal should be dried with waste coal dust at the mine rather than coal and water on which freight has been paid. Each car of a unit train would either carry only ±83 tons of coal with 5% moisture, or, if the car is designed to carry 100 tons of dried coal, then it would contain approximately 374,000,000 additional BTUs. This is typical of many of the strippable mines in southeast Montana and northeast Wyoming. (See Figure 1.)

COAL DRYERS

The New Dorr-Oliver Fluidized Bed Dryer, 1978

Dorr-Oliver of Stamford, Connecticut is offering a new fluid bed drying system which handles plus 1/4" to minus 2" sized coal feed. The exhaust gas analysis from the dryer runs 3% carbon dioxide (CO_2), 24% moisture, 60% nitrogen, and 13% oxygen. The minus 1/4" coal is used to provide 3 million BTUs to remove each ton of water. Using coal containing 10,000 BTUs to the pound, the system will require 300 lbs. of coal to remove each ton of water.

The estimated cost of a 5,000 ton per day dryer designed for 20% moisture was $1,000,000 and for 30% moisture was $1,400,000. The estimated cost of a 10,000 ton per day dryer designed for 20% was $2,000,000. These dryers use one operator and require 3 million BTUs and 6 KWHs of electricity per ton of water removed. Maintenance and repair is estimated at 3% of the installed cost. These figures are based on coal input into the dryer. Based on the foregoing for comparative purposes the estimated cost of a 5,000 ton per day installation is $1,300,000 for 20% coal and $1,820,000 for 30% coal.

The estimated cost of a 5,000 ton per day coal output containing 5% moisture when using coal containing 30% moisture is as follows:

* Patent #3856087 - Method for Loading and Transporting Coal

Labor, \$7.50 per hour, aggregating	\$ 65,700/yr.
Maintenance and repair	54,600/yr.
Interest at 10% of installed cost	182,000/yr.
Total	\$302,300/yr.

or 16.9¢ per ton of coal output based on an annual production of 1,800,000 tons per year.

Materials and utility cost:

300 lbs. of coal @ \$4.00 per ton = 60¢ per ton
6 KWH of electricity at 3¢ per KWH = 18¢ per ton
Total operating cost - \$0.949 per ton

These figures are based on my estimates on the newly designed dryer following correspondence and extended phone conversations with R. J. Priestly, Dorr-Oliver, Stamford, Connecticut. More detailed and definitive costs will be calculated when written estimates are received from Dorr-Oliver.

The Parry Coal Dryer

This dryer was designed in 1950 and was under continuous development for several years by D. F. Parry, Chief of the Fuels Technology Division, United States Bureau of Mines. My files include records of 21 of these dryers designed for coal, ranging from 6% to 20% moisture, and designed for lignite containing from 36% to 56% moisture.

Moisture in coal was reduced to an average of 1%. 36% moisture lignite was reduced to 4%, and 56% lignite reduced to 11% moisture.

A 5,000 ton per day Parry plant built with 1978 dollars would cost an estimated \$3,543,750. The total estimated operating cost to reduce moisture from 28% to 5% is \$593,750.

A 5,000 ton per day Parry plant is designed to operate 330 days per year and produce 1,650,000 tons of dried coal at a net direct operating cost, including maintenance and repairs, of 36¢ per ton. Interest on plant investments at 10% increased the cost by \$354,375 or \$0.215 per ton of coal output, aggregating a total of \$.575 per ton.

The total cost plus a 15% contingency is calculated to be \$.66 per ton of 5% moisture coal produced. 1,494 tons of water are removed from 6,494 tons of coal. 492,894 tons of water are removed in a year's operation at a cost of \$1.205 per ton.

Freight rates on unit trains from Wyoming and Montana ranged from a low of \$4.85 to Pueblo, Colorado, up to \$15.13 per ton to Hammond, Indiana.

The estimated cost of a 20,000 ton Parry Dryer is \$9,000,000, and the direct operating cost per year is \$2,125,000, a plant cost of 64% per ton of the cost of the 5,000 ton per day facility, or 36% less. The direct operating costs of the 20,000 ton per day plant are estimated to be 11% less.

Torus Disc Dryer

A new dryer has been introduced by the Berwin process equipment group, a division of Strong-Scott Manufacturing Company. This unit, trademarked Torus Disc Dryer, isolates the coal being dried from the combustion gasses and may provide an end product which will be more desirable for some coal users.

The Berwin Corporation also manufactures a Flash Dryer, one of the most sophisticated dryers in use. It is more expensive than any of the other dryers, but it is capable of uniform drying of varying coal sizes, and most efficient in reducing combined moisture. If moisture reduction to 1% is desired, this type of dryer is an effective tool.

Studies of these dryers have been initiated and the results will be available to interested coal users.

McNally Pittsburg Flow Dryer

The Flow Dryer is more automated and uses substantially more electricity for fans than other systems, according to information received from Mr. E. A. Draeger, Project Engineer for McNally Pittsburg.

These dryers were introduced in 1961. Island Creek Coal Company has installed four Flow Dryers successively at their Buchanan County, Virginia, Pocahontas mines.

Mountaineer Coal Company, a division of Consolidation Company, has installed a Flow Dryer at their Robinson Run Mine near Shinnston, West Virginia. The Flow Dryer operates practically unattended and should produce an acceptable dried product on a competitive basis. Comparative studies on this dryer are being made, and the operating data will be made available to interested coal users. (See Figure 2.)

UNIT TRAIN OPERATING COST AND STATISTICS

North Central Wyoming

A unit train carrying 10,000 tons of northern Wyoming coal, which contains 29% moisture, is transporting 2,900 tons of water, of which 2,400 tons can be removed. It will require 360 tons of minus 1/4 inch coal to remove this moisture whether the coal is dried at the mine with low cost coal, or at the utility using delivered-cost coal.

Typical northern Wyoming coal averages 28% moisture. It is being shipped to Pueblo, Colorado, at a cost of $4.85 per ton, to Amarilla, Texas, at a cost of $8.20 per ton, and to San Antonio, Texas, at $12.32 per ton.

The minimum moisture being shipped (384,100 tons) to Pueblo, Colorado, costs $1,862,885 per year. The minimum moisture being shipped (460,000 tons) to Jeffrey, Kansas, costs $2,750,800 per year. The minimum moisture being shipped (345,000 tons) to Amarilla, Texas, costs $2,829,000 per year. The minimum moisture being shipped (621,000 tons) to San Antonio, Texas, costs $7,712,820 per year. The minimum moisture being shipped (805,000 tons) to Metropolis, Illinois, costs $8,259,300.

Hanna Coal Field, Wyoming

Hanna, Wyoming, coal runs from 11.6% to 14.5% moisture, and averages 13.44% moisture. A 10,000 ton unit train will be carrying 844 tons of removable moisture. A unit train from Hanna to Lawrence, Kansas, must be composed of 95 cars or more and carry 9,000 tons or more. The most favorable rate is $10.04 per ton, which is based on a minimum annual haulage of 1,800,000 tons, or 5,000 tons a day, 360 days a year. The minimum amount of removable water hauled to Lawrence per year is 151,920 tons at a cost of $1,525,276.

The minimum rate on Hanna coal to Plains or Waukegan, Illinois, is $10.79, which is based on a minimum of 2,100,000 tons per year. The least amount of removal of water is 177,240 tons, transported at a cost of $1,912,419.

Hanna coals contain less moisture than most western coals being shipped by unit train. The net savings from Hanna coal are less favorable and substantially less than the savings on northeast Wyoming coal, southeast Montana coal, and lignite.

Southeastern Montana

Typical southeastern Montana coals contain approximately 1,500 tons of removable moisture per unit train.

The minimum rate to Redfield, Arkansas, is $13.29 per ton, and is based on a minimum of 1,900,000 tons per year, or 5,278 tons per day. The least amount of removable moisture is 285,000 tons per year, at a cost to the utility of $3,787,650.

The minimum rate to Hammond, Indiana, is $15.13 per ton, and the minimum annual tonnage is 2,000,000 tons, or 5,556 tons per day. The least amount of removable moisture being carried amounts to 300,000 tons, at a cost of $4,539,000 per year.

The minimum rate to Havanna, Indiana, a distance of 1,168 miles by rail is $13.53, and the minimum tonnage per year is 3,500,000 tons, or 9,722 tons per day. The least amount of removable moisture is 525,000 tons per year, at an annual cost of $7,102,250.

Lignite

Lignite coals from Montana and the Dakotas will average well over 30% moisture, probably 36%, and will contain at least 3,100 tons of removable moisture per unit train. Due to the low BTU content and high moisture, lignite coals could best be used in place for production of artificial gas or electricity. (See Figure #3).

PROBLEMS AND PROJECTIONS

Railroads will probably wish to increase the freight rates on dried coal, although they would benefit materially from the reduced weight of the unit train.

Steps may be needed to inhibit spontaneous combustion of coal once it is delivered and stored at power plants.

Coal fired boilers may have to be redesigned to use dried coal; however, it has been suggested that new coal-fired plants designed for dried coal will have lower operating costs and a lesser investment cost per KW of power produced.

Apparent average savings over costs from Montana to Central States power plants would be approximately $.99 per ton, or $100 per car, $10,000 per unit train, and about $400,000 per unit train per year.

Figure 1

WESTERN COAL ANALYSIS

	Moisture	BTUs per lb.	Ash	Sulphur
Hanna Wyoming Field	14.50%	10,523	6.94%	0.78%
	13.46	10,699	6.94	0.78
	11.	11,020	7.1	0.70
	13.66	10,806	6.50	0.45
	13.96	10,000	6.68	0.37
Wyodac Gillette Wyoming	29%	8,000	6.5%	0.50%
Southeast Montana - (Busby-Decker)	25.01%	9,280	5.70%	0.68%
	24.48	9,364	4.66	0.37
	25.59	9,060	6.15	0.73
	23.87	8,660	10.71	0.64
Montana Dakota Lignites	36.0%	6,640	12.14%	0.78%
Antelope Creek Wyoming	21.91%	9,312	4.54%	0.34%
	22.20	9,402	6.47	0.66
	21.77	9,456	6.26	0.45
	22.62	9,326	5.21	0.46

Figure 3

SHIPPING COSTS OF WATER

Northern Wyoming Coal Mines

Destination	Rate per Ton	Minimum Annual Tonnage	Moisture	Minimum Water (Tons)	Cost
Pueblo, Colo.	4.85	1,670,000	28%	384,100	1,862,885
Jeffery, Kansas	5.98	2,000,000	"	460,000	2,750,800
Amarilla, Texas	8.20	1,500,000	"	345,000	2,829,000
San Antonio, Texas	12.42	2,700,000	"	621,000	7,712,820
Metropolis, Ill.	10.26	3,500,000	"	805,000	8,259,300

S.E. Montana Coal Mines

Destination	Rate per Ton	Minimum Annual Tonnage	Moisture	Minimum Water (Tons)	Cost
Redfield, Ark.	13.29	1,900,000	20%	285,000	3,787,650
Hammond, Indiana	15.13	2,000,000	20%	300,000	4,539,000
Havana, Indiana	13.53	3,500,000	20%	525,000	7,103,250

Hanna Wyoming Coal Field

Destination	Rate per Ton	Minimum Annual Tonnage	Moisture	Minimum Water (Tons)	Cost
Plains, Illinois	10.79	2,100,000	13.44%	177,240	1,912,419
Laurence, Montana	10.04	1,800,000	13.44%	151,000	1,525,276

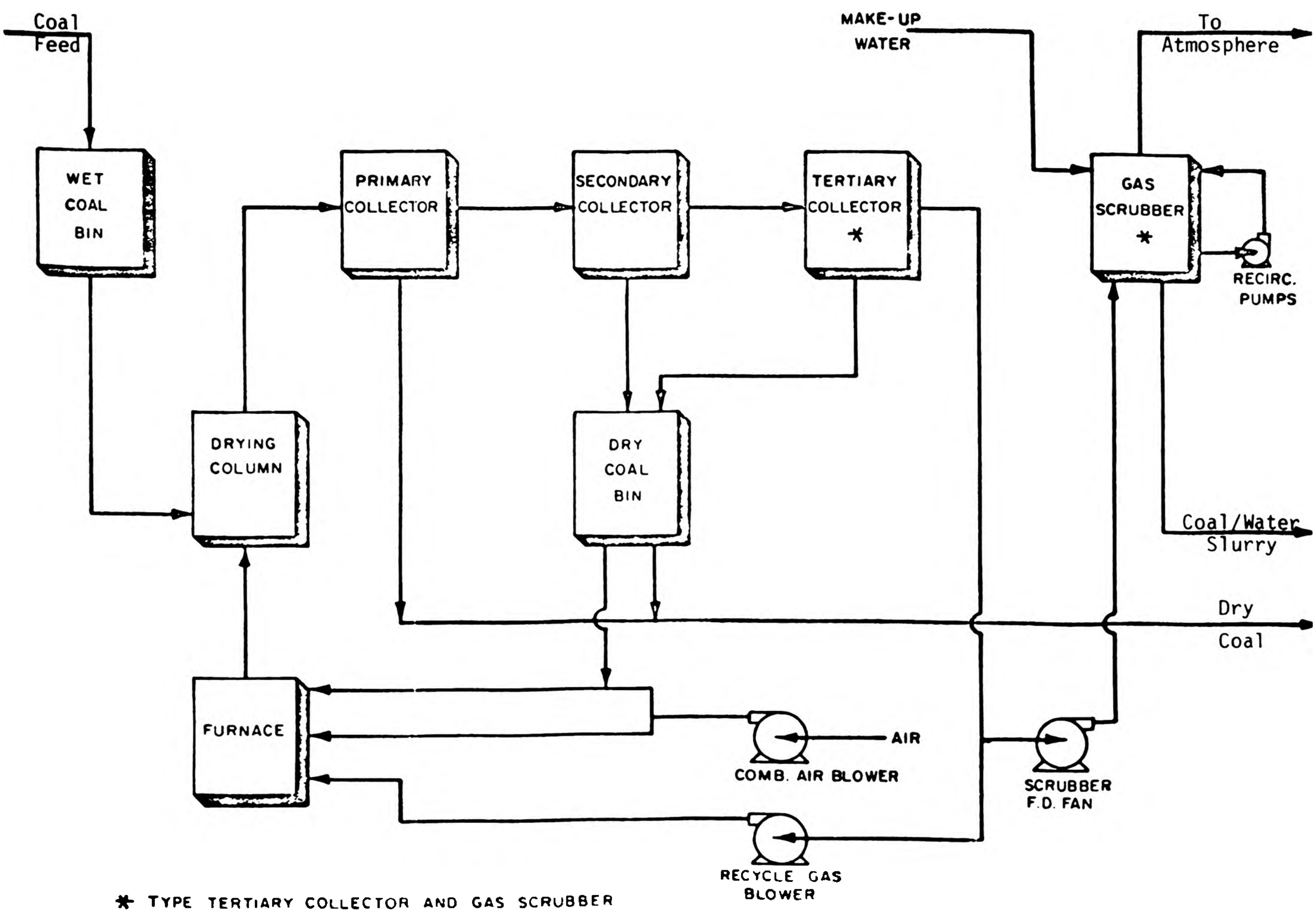
Figure 2

EXHAUST GASES FROM COAL DRYERS

		Initial Water Content of Coal	H_2O	CO_2	O_2	N	Water Content Dried Coal
Parry Turbulent Entrainment Dryer	#1	30%	48.4	6.5	1.4	43.7	1.09
	#2	30%	52.0	6.7	0.4	40.9	.98
	#3	32%	51.4	5.7	0.9	41.0	4.8
	#4	32%	50.9	5.8	—	41.4	5.6
Dorr-Oliver		20%	24	3	13	60	5
Fluid Bed		30%	25	3	13	60	5

CHART 1

BLOCK FLOW DIAGRAM
PARRY COAL DRYING PLANT



* TYPE TERTIARY COLLECTOR AND GAS SCRUBBER UNITS DEPENDENT ON AIR POLLUTION CODE REQUIREMENTS

BIOGRAPHY

Lloyd Lore Wartes, Consulting Professional Engineer, is Executive Vice President of Ecothermia, Inc., President of Colorado Geoengineering Trust, and President and Chairman of the Board of Argentorado Mines Corporation. Directed heat transfer and storage in cooperation with utilities in Wyoming, Oregon, and Washington. Holds patents for solar concentrators, electric furnaces, heat storage, drying processes, and fire suppression, and has a number of patents pending in related areas. He acted as consultant to the City of Grand Coulee during construction of Grand Coulee Dam and has directed or acted as consultant to over twenty corporations and agencies on exploration, research, and development.