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COAL TECHNOLOGY APPLICATIONS: A LITERATURE REVIEW
OF CONVERTING STEAM BOILERS TO COAL FIRING

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June 30, 1977

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Prepared for U.S. Energy Research & Development Administration under contract No. W-7405-Eng-48.

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COAL TECHNOLOGY APPLICATIONS: A LITERATURE REVIEW OF CONVERTING STEAM BOILERS TO COAL FIRING

INTRODUCTION

It is widely predicted that as the United States rapidly exhausts the less expensive fuel resources upon which much of power generation depends, oil and natural gas prices will rise and abundant coal resources will be exploited as a primary source of energy.⁽¹⁾ Coal will be required not only to satisfy a growing demand for new energy, but to reduce the nation's dependence on oil, to replace facilities which must be reconverted because of uneconomic operation based on alternative fossil fuels, and long planning lead times.⁽²⁾ As a result, the Congress of the United States passed the "Energy Supply and Environmental Coordination Act" in June of 1974.

Section 2 of this Act grants the Federal Energy Administration (FEA) the authority to (a) prohibit certain power plants and major fuel burning installations from burning natural gas or petroleum products as their primary energy source; (b) require that certain power plants in the early planning process be designed and constructed to be capable of using coal as their primary energy source; and (c) allocate coal to power plants and major fuel burning installations that have been prohibited from burning natural gas or petroleum products as their primary energy source.⁽³⁾

In implementing this Act, the FEA will be able to enforce conversion to coal only of those oil- and gas-fired steam electric power plants that have burned coal in the past or those that were built to burn coal but never burned it. Generally boiler units specifically built for gas or oil firing are not fit to burn coal without modifications which would reduce the capacity of the unit by approximately 45 percent;⁽⁴⁾ therefore, such units will probably be exempt.

Table 1 summarizes the utility power plants being considered by FEA for conversion to coal firing. Several electric generating facilities have already been converted to burn coal and more will follow in the near future, thereby providing a total estimated savings of 250,000 barrels of oil per day.⁽⁴⁾ However, conversion to coal firing is a complicated undertaking, the technical factors are not always well known, and the existing data to accomplish this task are widely scattered in the literature or are proprietary information.

This report is a single reference source which summarizes the literature already published on the subject. It is divided into three sections devoted to the three principal engineering aspects: boiler modifications, coal handling and ash removal systems, and environmental control requirements. Only pulverized coal firing is considered because of the preponderance of its use for steam generation in the United States. Much of the material is tentative, rapidly changing, and highly variable in time and place. The information should therefore be considered a guide rather than a set of specifications and will be updated and revised as new data appear in the literature.

Table I

Utility power plants being considered by FEA for conversion to coal firing

1. Plants that reportedly can burn coal with a sulfur content greater than 1% by weight and have adequate precipitators:

Company	Plant	Unit(s)	Capacity, MW
Alabama Electric Cooperative Inc	McWilliams	3	25
Ames (Iowa) Electric Utility	Ames	7	33
Iowa Power & Light Co	Des Moines	10, 11	190
Iowa Public Service Co	Neal	1	139
	Maynard	14	50
Kansas City (Kan) Board of Public Utilities	Kaw River	3	65
	Quindaro	Q-1, Q-2	240
Kansas City Power & Light Co	Hawthorne	3, 4, 5	769
Potomac Electric Power Co	Morgantown	1, 2	1251
Wisconsin Public Service Corp	Weston	2	75

2. Plants that reportedly can burn coal with a sulfur content greater than 1% by weight, but require precipitator upgrading:

Central Hudson Gas & Elec Corp	Danskammer Pt	1, 2	146
Detroit Edison Co	St Clair	5	358
Nebraska Public Power District	Sheldon	1, 2	225
New England Power Co	Brayton Point	1, 2, 3	1162
Virginia Electric & Power Co	Chesterfield	3, 4, 5, 6	1353
	Yorktown	1, 2	375

3. Plants, 100 MW or larger, that reportedly can burn coal with a sulfur content greater than 1% by weight, but require new precipitators:

Arkansas Power & Light Co	Ritchie	1, 2	904
Atlantic City Electric Co	England	1, 2	299
Baltimore Gas & Electric Co	Crane	1, 2	400
	Gould Street	3	104
	Riverside	4, 5	154
	Wagner	1, 2	269
Carolina Power & Light Co	Sutton	1, 2, 3	672
Commonwealth Edison Co	Ridgeland	1-6	690
Delmarva Power Co	Edge Moor	1-4	390
Georgia Power Co	McManus	1, 2	140
Holyoke Water Power Co	Mt Tom	1	136
Iowa Electric Light & Power Co	Sutherland	1, 2, 3	157
Kansas City (Kan) Board of Public Utilities	Kaw River	1, 2	96
Kansas Power & Light Co	Lawrence	3, 4, 5	583
	Tecumseh	9, 10	231
	Somerset	7, 8	194
Montaup Electric Co	South Street	1, 12	104
Narragansett Electric Co	Albany	1-4	400
Niagara Mohawk Power Corp	Schiller	4, 5	100
Public Service Co of NH	Port Wentworth	1, 2, 3	207
Savannah Electric & Power Co	Jefferies	1, 2	100
South Carolina Public Service Auth	James River	3, 4	114
Springfield (Mo) City Utilities	Portsmouth	1-4	650
Virginia Electric & Power Co			

Company	Plant	Unit(s)	Capacity, MW
Western Massachusetts Elec Co	W Springfield	2, 3	164

4. Plants, 100 MW or smaller, that reportedly can burn coal with a sulfur content greater than 1% by weight, but require new precipitators:

Central Maine Power Co	Mason	3, 4	69
Connecticut Light & Power Co	Montville	5	75
Corn Belt Power Cooperative	Wisdom	1	38
Delmarva Power & Light Co (Md)	Vienna	7	38
Fremont (Neb) Dept of Utilities	Wright	7	25
Independence Power & Light Dept	Blue Valley	3	58
Interstate Power Co	Fox Lake	3	62
Kansas City (Kan) Board of Public Utilities	Quindaro	22	35
Oklahoma Gas & Electric Co	Mustang	2	63
Omaha Public Power District	Jones Street	27	40
Potomac Edison Co of Virginia	Riverton	1	40
Public Service Co of Colorado	Zuni	3	75
St Joseph Light & Power Co	Lake Road	5, 6	86
Vineyard Electric Utility	Vineyard	1	25

5. Plants that reportedly can burn coal, but require coal with a sulfur content less than 1% by weight to meet air-pollution regulations:

Atlantic City Electric Co	Deep Water	1, 6	155
Cambridge Electric Light Co	Kendall Square	3	27
Connecticut Light & Power Co	Devon	3, 7, 8	273
	Norwalk Harbor	1, 2	326
Consolidated Edison Co of NY Inc	Arthur Kill	2, 3	826
	Astoria	1-5	1455
	Ravenswood	3	1000
Florida Power Corp	Crystal River	1, 2	847
Hartford Electric Light Co	Middletown	1, 2, 3	422
Jersey Central Power & Light Co	Sayreville	7, 8	248
	Werner	4	60
Long Island Lighting Co	Barrett	1	68
	Far Rockaway	4	114
	Port Jefferson	3, 4	375
New England Power Co	Salem Harbor	1, 2, 3	275
Orange & Rockland Utilities Inc	Lovett	3, 4, 5	449
Philadelphia Electric Co	Cromby	2	200
	Delaware	7, 8	250
Public Service Electric & Gas Co	Bergen	1, 2	650
	Burlington	7	227
	Hudson	1	455
	Kearney	7, 8	294
	Sewaren	4	119
Virginia Electric & Power Co	Possum Point	2, 3, 4	422
West Penn Power Co	Mitchell	3	294
	Springdale	8	142

Source: Power, p. 34, July 1975.

REFERENCES

1. E. F. Osborn
"Coal and the Present Energy Situation," Science, 183
[4124] 477 (1974).
2. "Project Independence Blueprint,"
Federal Energy Administration (1974).
3. Federal Energy Administration, Energy Supply and Environmental Coordination
Act, 1974, Section 2, Coal Conversion Program, FES 75-1, Final Environmental
Report, April 1976.
4. Geological Society of America, Report of the Committee on Environmental
and Public Planning, "Environmental Impact of Conversion from Gas and
Oil to Coal for Fuel." The Geologist, Newsletter of the Geological
Society of America, July 1974.

BOILER MODIFICATIONS

The literature indicates that a common starting point for all conversions is information about the characteristics of coal since choice of fuel affects everything in the boiler house. For example, coals should be analyzed for their availability; for the composition of volatile matter, carbon, sulfur, and ash; heating value; grindability and availability of sizes; coking tendencies; and ash-softening temperatures. These characteristics determine the need for resizing furnaces, for soot blowers and emission controls, for tube-spacing requirements and the type of combustor needed.

To convert a unit designed for gas requires that the load to the boiler be reduced so that additional time can occur for burnout of coal particles and for heat absorption in the radiant section. High heat absorption is important in reducing the temperature of fly ash below its softening point before the ash enters the convective section.

A boiler's convective section, designed to extract the maximum available heat from the partially cooled flue gas, should be as compact as possible. For natural gas, flue-gas velocity should be about 120 feet per second, and fins on the tubes of heat exchangers should be spaced closely. Fewer fins are used for oil, and flue-gas velocity should be about 60 ft/sec and fins should be much farther apart than for gas or oil. Without such extensive modifications, the load on the converted boiler must be reduced as much as 50%. A soot blower also would be required when converting from gas to coal.

The geometries of oil and gas burners are similar to that used to fire pulverized coal; but, because pretreatment of coal can be expensive, pulverized coal is generally fired only in boilers producing more than 200,000 pounds of steam per hour.

For a smaller industrial boiler, the economics dictate use of a stoker. Stokers are either underfeeding or overfeeding. In the underfeeding design, coal is pushed onto an inclined grate from below. Usually the grate is agitated mechanically to maintain a uniform coal flow. A typical capacity of 25,000 pounds of steam per hour limits this design to small plants.

Of the overfeeding stokers, the spreader is the most versatile, is available in sizes from 5,000 to 400,000 lbs/hr of steam, and is capable of burning virtually any coal. The coal is thrown mechanically into the furnace; large lumps fall onto the grate while fine particles are burned in suspension.

The minimum work required to install a stoker in an oil- or gas-fired furnace includes removal of the existing burners to accommodate a coal-feed system, mounting a mechanical grate and drive system on the boiler floor, and installing an ash pit.

Because gas- and oil-fired units are usually designed to operate under positive pressure and coal units require negative pressure to seal the fuel input section, conversion to coal usually requires addition of a fan and a differential-pressure controller. Air must be preheated for firing pulverized coal; it is also desirable to preheat air for stoker firing, up to 350°F, to improve boiler efficiency by 2% for each 100° F.

REFERENCES

1. S. I. Rottmayer

"Conversion from Oil to Coal-Fired Steam-Generating Units,"
Proc. Midwest Power Conference VI, 56 (1943).

SUMMARY: A careful study is reported of the many influencing conditions that must be made for each proposed conversion. Economics of the project is considered for each proposed type of installation.

2. C. L. Wagoner and A. F. Duzy

"Burning Profiles for Solid Fuels,"
ASME Annual Meeting, November 12-17, 1967.
ASME-Paper - 67 - WA/FU-4 8p.

SUMMARY: A new laboratory procedure is reported for accurately examining the course of oxidation of solid fuel samples.

3. R. C. Attig and A. F. Duzy

"Coal Ash Deposition Studies and Application to Boiler Design,"
Proceedings of the American Power Conference, Vol. 31, 1969, p. 290.

SUMMARY: Results are reported on the underlying causes of ash deposition when firing bituminous coals. Various physical and chemical analyses are discussed which aid in identifying minerals responsible for severe slagging and fouling with bituminous coals.

4. A. F. Duzy and A. H. Rudd

"Steam Generator Design Considerations for Western Fuels,"
Paper presented to the American Power Conference, 1971.

SUMMARY: Progress is reported in helping the boiler designer with bituminous-type Eastern coal ash and in the development of more specific slagging and fouling factors.

5. Editors: The Babcock and Wilcox Company, 161 East 42nd Street,
New York City, N.Y. 10017
"Fuel Ash Effects on Boiler Design and Operation,"
Steam/Its Generation and Use, 38th Edition, pp. 15-1 to 15-17

SUMMARY: An extensive treatise on all phases of steam generation.

6. G. F. Moore and R. F. Ehrler

"Western Coals--Laboratory Characterization and Field Evaluations of
Cleaning Requirements," ASME Misc. Paper No. 73-WA-FU-1, ASME Winter
Annual Meeting, November 11-15, 1973, p. 6.

SUMMARY: A review is presented of the burning characteristics of
eastern and western coals.

7. J. D. Blue, J. L. Clement, and V. L. Smith

"Effect of Coal and Multi-Fuel Firing on Industrial Boiler Design,"
Paper No. 12-3, p. 211-230, TAPPI Engineering Meeting, October 21-24
1974.

SUMMARY: This paper summarizes the effects of fuel characteristics on
boiler design and performance. Coal is a complex fuel and it
is necessary to establish its source and the physical and
chemical characteristics before consideration of boiler size
or equipment selection. Adding wood, oil, or gas burning to
obtain combined fuel firing further affects the design
criteria employed to properly design the boiler.

8. R. J. Gray and G. F. Moore

"Burning the Sub-Bituminous Coals at Montana and Wyoming in Large
Utility Boilers," ASME Winter Annual Meeting, November 17-22, 1974.
ASME Paper No. 74-WA-FU-1.

SUMMARY: A numerical indices are presented to provide the designer
with a basic tool for classifying coal ash characteristics.

9. Editors of Power Magazine

"Power From Coal--Part I: A Special Report on Coal Selection and Handling," Power, p. s.1, February 1974.

SUMMARY: This report outlines the basics of coal selection, key facts about coal, and equipment and methodology of coal handling. This first report should serve as a most useful tool for those who select the main equipment and for those who manage that equipment once it is installed.

10. Editors of Power Magazine

"Power From Coal--Part II: A Special Report on Coal Combustion," Power, p. s.25, March 1974.

SUMMARY: Part 2 of "Power from Coal" covers the important aspects of coal burning and ash handling, how coal burns, present-day stokers, and equipment and technology of firing pulverized coal.

11. A. Bogot and R. C. Sherrill

"Oil-to-Coal Reconversion Isn't Easy--Or Cheap," Electric Light and Power, p. 40, October 20, 1975.

SUMMARY: Conversion to coal on existing oil and gas units requires a complete engineering study of each individual unit, a thorough analysis of available coals and plant space. Meeting environmental standards for both sulfur and particulate emissions may be possible, but not always practical with the coals available.

12. A. Bogot and R. C. Sherrill

"Principal Aspects of Converting Steam Generators Back to Coal Firing," Paper presented at NCA/BCR Coal Conference and Expo II, October 21-23, 1975.

SUMMARY: Reconversion to coal firing is not always easy nor can it be considered to be low cost. Cost for a particular unit varies depending on what specific problems are encountered. However, it is not uncommon for a unit to cost \$10,000,000 to convert from oil firing to coal firing.

In operation, difficulties can be encountered if the original coal or one with constituents and characteristics similar to the original coal cannot be obtained. With the "new" coal, the performance of the coal firing system and steam generator may be reduced. If a unit cannot be operated at its design rating, the net cost of operation increases.

13. A. W. Bell and B. P. Breen

"Converting Gas Boilers to Oil and Coal,"
Chemical Engineering, p. 93, April 26, 1976.

SUMMARY: Extensive engineering is involved in changing from gas or oil to coal burning. Prior to a final decision on conversion, similar, already-converted boilers should be examined, and operating problems discussed with plant personnel. Technical factors are discussed in detail which must be considered in conversion and the equipment needed for the changeover is presented.

14. A. Bogot and R. C. Sherrill

"Reconverting Steam Generator Firing to Coal or Coal Blends,"
Paper presented at the Coal Blending and Utilization Conference,
June 16-17, 1976, Des Moines, Iowa.

SUMMARY: Returning to coal firing requires that considerable attention be given to aspects other than strictly mechanical ones. If coal cannot be obtained that is the same, or similar to the design fuel, it is probable that blending of various coals will be required. Merely blending to obtain an acceptable sulfur level will not necessarily satisfy all or most of the operational criteria. Investigation must be made of ash amounts, ash constituents, ash fusion temperatures, pulverizer capabilities, precipitator effectiveness, steam generator performance, and coal handling/blending techniques. Much of the information desired will have to be obtained through experimentation on an operating unit particularly since each blend used will have different characteristics.

15. Bernard P. Breen and Arlen W. Bell

"Converting to Coal: How the Savings Stack up Against Cost and Aggravation," Energy Research Reports, p. 6, July 1976.

SUMMARY: Conversion to coal is a complicated business and not for the neophyte. Savings can be large--fuel costs can be cut \$140 to \$230 per hour. A brief review is presented of the required boiler modifications.

16. Staff Report of Power Magazine

"Should You Convert to Coal?"
Power, p. 3, July 1976.

SUMMARY: This paper reports on a study that reveals it is impractical to convert to coal industrial boilers that were designed to burn oil or gas, unless those premium fuels are not available and a substantial downrating in steam capacity can be absorbed.

17. V. L. Smith

"Coal Firing and Industrial Boiler Design--the Modern Approach,"
J. of Eng. for Power, Trans. ASME, July 1976, p. 297 (1976).

SUMMARY: Coal is becoming increasingly more favorable as a fuel because of rising petroleum prices. The technology of firing coal has advanced tremendously as a result of new coal source discoveries and higher pressure and temperature steam generation. This paper defines the modern classification of the different coals found in the United States and presents the respective design parameters for each classification. The varying design parameters in conjunction with the coal classifications are then related to modern industrial boiler design.

COAL HANDLING AND ASH REMOVAL SYSTEMS

The second technical aspect to consider is the installation of the equipment required for physically receiving, storing, transporting, pulverizing, burning the coal and removing the ashes. Attention must be given to:

- (a) Physical location of new coal storage facilities, if required, relative to the steam generator and existing docks or railroad tracks.
- (b) The purchase of coal unloading equipment.
- (c) Modernization and/or automation of any existing equipment.
- (d) Physical limitations in locating or moving in new equipment, such as pulverizers, ductwork, pulverized coal piping, and fuel burning equipment.
- (e) The ability to procure long lead time items from desired vendors; the heating value, grindability, and moisture content of the coal; and the fineness of product must all be considered when sizing pulverizers.
- (f) Provision for the collection and disposal of both furnace ash and fly ash collected by a precipitator or scrubber system. Here again, coal selection is most important, for the mineral matter content of the coal will determine the duty imposed on particulate collection equipment and the sizing of the disposal system.

REFERENCES

1. Editors: The Babcock and Wilcox Company, 161 East 42nd Street,
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4. Editorial Staff of Power Magazine

"Power from Coal - A Special Report on Coal Ash-Handling Systems,"
Power, March 1974, p. S.44.

SUMMARY: A detailed summary is presented of the basic steps and equipment involved in ash-handling systems. System selection is closely related to ash content, how coal is burned, and amount and type of ash collected.

5. Editorial Staff of Power Magazine

"Power from Coal - A Special Report on Coal Handling Systems,"
Power, February 1974, p. S.11.

SUMMARY: A detailed summary is presented of the basic steps and equipment involved in handling coal; i.e., unloading, stocking, reclaiming, crushing, and storage facilities.

ENVIRONMENTAL CONTROL REQUIREMENTS

Tables 1-3 summarize the relative potential impacts on land, water and air resources of converting gas and oil burning plants to coal. Although the impacts will increase as a result of the conversion from oil and gas to coal burning, these impacts can be significantly reduced by the utilization of available, effective control measures.

TABLE 1

RELATIVE POTENTIAL IMPACTS ON LAND RESOURCES FROM COAL, OIL AND GAS FIRED POWER PLANTS AND RELATED ACTIVITIES AND THE INCREMENTAL IMPACTS OF CONVERTING GAS AND OIL BURNING PLANTS TO COAL

	Coal					
	Strip Mining	Deep Mining	Oil*	Gas*	Δ (Coal-Oil)**	Δ (Coal-Gas)**
<u>Fuel Production</u>						
Land-use	high	moderate	low	low	+	+
Terrestrial ecology	high	moderate	moderate	moderate	$\sim 0^{\dagger}$	$\sim 0^{\dagger}$
Aesthetics	high	low	low	low	+	+
Noise	moderate	low	low	low	$\sim 0^{\dagger}$	$\sim 0^{\dagger}$
<u>Fuel Transportation</u>						
Land-use	high		high	high	0	0
Terrestrial ecology	moderate		low	low	+	+
Aesthetics	moderate		low	low	+	+
Noise	high		none	none	++	++
<u>Power Production</u>						
Land-use	high		low	low	+	+
Terrestrial ecology	high		low	low	+	+
Aesthetics	high		low	low	+	+
Noise	high		low	low	+	+

* Assuming Domestic Production

** Δ (Coal-Oil) = Incremental impacts resulting from converting oil burning power plants to burn coal, 0 = impacts are equal, ~ 0 = impacts are nearly equal, + = impacts are higher, ++ = impacts are substantially higher, - = impacts are lower

Δ (Coal-Gas) = Incremental impacts resulting from converting gas burning power plants to burn coal, 0 = impacts are equal, ~ 0 = impacts are nearly equal, + = impacts are higher, ++ = impacts are substantially higher, - = impacts are lower

$\dagger$ Assuming a significant quantity will be obtained by underground mining

Source: H. Roffman and A. Roffman, Proceedings--Institute of Environmental Sciences, 152 (1976).

TABLE 2

RELATIVE POTENTIAL IMPACTS ON WATER RESOURCES FROM COAL, OIL AND GAS
FIRED POWER PLANTS AND RELATED ACTIVITIES AND THE INCREMENTAL
IMPACTS OF CONVERTING GAS AND OIL BURNING PLANTS TO COAL

	Coal		Oil*	Gas*	Δ (Coal-Oil)**	Δ (Coal-Gas)**
	Strip Mining	Underground Mining				
<u>Fuel Production</u>						
Water use	moderate	moderate	low	low	+	+
Surface water contamination	high	high	low	low	+	+
Groundwater contamination	high	high	low	low	+	+
<u>Fuel Transportation</u>						
Water use	low		none	none	+	+
Surface water contamination	low		moderate	low	-	0
Groundwater contamination	low		moderate	low	-	0
<u>Power Reduction</u>						
Water use	high		high	high	0	0
Thermal contamination	high		higher	higher	-	-
Surface water contamination	moderate		moderate	moderate	0	0
Groundwater contamination	high		low	negligible	+	++

* Assuming domestic production

** Δ (Coal-Oil) = Incremental impacts resulting from converting oil burning power plants to burn coal, 0 = impacts are equal, + = impacts are higher, ++ = impacts are substantially higher, - = impacts are lower.

Δ (Coal-Gas) = Incremental impacts resulting from converting gas burning power plants to burn coal, 0 = impacts are equal, + = impacts are higher, ++ = impacts are substantially higher, - = impacts are lower.

Source: H. Roffman and A. Roffman, Proceedings--Institute of Environmental Sciences, 152 (1976).

TABLE 3

RELATIVE POTENTIAL IMPACTS ON LAND RESOURCES FROM COAL, OIL AND GAS
FIRED POWER PLANTS AND RELATED ACTIVITIES AND THE INCREMENTAL
IMPACTS OF CONVERTING GAS AND OIL BURNING PLANTS TO COAL

	Coal		Oil*	Gas*	Δ (Coal-Oil)**	Δ (Coal-Gas)**
	Strip Mining	Deep Mining				
<u>Fuel Production</u>						
Primary:						
SO ₂	none	none	moderate to high	none	-	0
NO _x	none	none	moderate to high	none	-	0
Particulate Matter	moderate	low to moderate	moderate	none	~0	+
H ₂ S	none	none	moderate to high	moderate to high	-	-
CO	low	low	none	none	+	+
CO ₂	low	low	moderate to high	moderate to high	-	-
Hydrocarbons	low	low	moderate to high	moderate to high	-	-
Trace Elements	none	none	low	none	-	0
Secondary:						
Sulfates	none	none	moderate to high	none	-	0
Nitrates	none	none	moderate to high	none	-	0
Photochemical Oxidants	none	none	moderate to high	none	-	0
<u>Fuel Handling</u>						
Primary:						
SO ₂	none		none	none	0	0
NO _x	low		low	none	~0	+
Particulate Matter	moderate		low	none	+	+
H ₂ S	none		none	none	0	0
CO	low to moderate		low to moderate	none	~0	+
CO ₂	low to moderate		low to moderate	none	~0	+
Hydrocarbons	low to moderate		low to moderate	none	~0	+
Trace Elements	none		none	none		0

Source: H. Roffman and A. Roffman, Proceedings--Institute of Environmental Sciences, 152 (1976).

TABLE 3 (Continued)

	Coal		Oil**	Gas*	Δ (Coal-Oil)**	Δ (Coal-Gas)**
	Strip Mining	Deep Mining				
Secondary:						
Sulfates	none		none	none	0	0
Nitrates	none		none	none	0	0
Photochemical Oxidants	low		low	none	~0	+
<u>Power Production</u>						
Primary:						
SO ₂	moderate to high		moderate	negligible	+	+
NO _x	moderate to high		moderate	moderate	+	+
Particulate Matter	moderate to high		low	negligible	+	+
H ₂ S	none		none	none	0	0
CO	none		none	none	0	0
CO ₂	moderate		moderate to high	moderate	-	~0
Hydrocarbons	none		moderate to high	none	-	0
Trace Elements	low to moderate		low	none	+	+
Secondary:						
Sulfates	moderate		low to moderate	low	+	+
Nitrates	moderate		low to moderate	low to moderate	+	+
Photochemical Oxidants	low to moderate		low to moderate	low	~0	+

* Assuming domestic production

** Δ (Coal-Oil) = incremental impacts resulting from converting oil burning power plants to burn coal, 0 = impacts are equal, ~0 = impacts are nearly equal, + = impacts are higher, - = impacts are lower
 Δ (Coal-Gas) = incremental impacts resulting from converting gas burning power plants to burn coal, 0 = impacts are equal, ~0 = impacts are nearly equal, + = impacts are higher, - = impacts are lower

Source: H. Roffman and A. Roffman, Proceedings--Institute of Environmental Sciences, 152 (1976).

The pollutants most directly associated with coal-fired boilers involve cooling-water discharge temperatures, unburned carbons and particulates, sulfur dioxide (SO_2) and nitrogen oxide (NO_x) emissions in the stack gases.

Proper selection of type and capacity of emission control equipment is governed by the following factors which should be considered before purchase: the properties of the delivered coal, the size of the boiler plant, the type of firing, and federal, state and local emission control regulations for the particular site.

Federal performance standards for the direct firing of boilers are as follows:

SO_2 - $1.20 \text{ lb}/10^6 \text{ Btu}$ or 520 ppm

NO_x - $0.70 \text{ lb}/10^6 \text{ Btu}$ or 525 ppm

Particulate - $0.10 \text{ lb}/10^6 \text{ Btu}$ or 0.06 grams

By the year 2000, a reasonable expectation is that sulfur levels will have to be controlled, on the average, to $0.2\text{-}0.4 \text{ lb}/10^6 \text{ Btu}$.

Three major methods are presently employed by large coal-fired utility plants for reducing particulate and gaseous emissions. They are: stacks, electrostatic precipitators, and wet scrubbing systems.

Stacks are utilized at electric generating facilities primarily as an aid in dispersing those emissions which are finally released after the discharge treatment. Stacks as high as 1,200 feet are currently in use. While not functioning as a removal device, they are capable of reducing aerial concentrations below those which would be achievable with use of alternate discharge methods.

Electrostatic precipitators dominate the market today and are firmly established as a particulate removal device for utility boilers. In the future they may well prove to be the most economical choice for power boilers over the range of available coals. See Fig. 1.

Wet scrubbers employing proper scrubbing liquids are capable of combining particulate removal with an additional capacity for withdrawal of gaseous pollutants through absorption and chemical reaction. As an example, mixing soda ash, magnesium oxide, or ammonia reagent with the scrubbing water allows removal of up to 90 percent of the SO_2 from the exhaust stream. Lime may also be employed with somewhat lower removal efficiencies. See Table 4.

NO_x control is ordinarily performed by optimizing burner design and minimizing excess O_2 operation. See Table 5.

Control of cooling-water discharge temperatures is usually accomplished by various impoundments and cooling towers. Other measures that could be used include: increasing power plant efficiency, finding productive uses for waste heat, and integrating with total energy systems.

FIG. 1 Extrapolated fractional efficiency of control devices. Efficiency has been determined on a mass basis. [Shannon, L. J., Particulate Pollutant System Study, II, Fine Particle Emissions, NTIS, Springfield, VA, Publ. PB203521 (1971).]

TABLE 4

SUMMARY OF SULFUR DIOXIDE CONTROL PROCESS SYSTEMS*

Processor method	Reactant input requirements	Throw-away or recovery	Investment costs (dollars/kW for coal boilers)	Operating costs (mills/kWh)		Sulfur dioxide removal efficiency	Comments
				No credit for sulfur recovery	Credit for sulfur recovery		
Low-sulfur fuel	NA	NA	0	2.0-5.0	NA	NA	Costs dependent on location and fuel type
Dry limestone injection	Limestone, 200°, Stoich	Throw away	12-14 (200 MW new)	0.6-0.8	NA	22-45°	Costs dependent on solids removal, variables removal dependent on limestone type, and boiler load limited in applicability
Wet line limestone scrubbing	Lime, 100-1200°, stock limestone 120-150°, Stoich	Throw away	27-46 (200-1000 MW new or retro)	1.1-2.2	NA	80-90°	Costs dependent on solids removal considerations, new or retrofit scrubber type, lime or limestone, size of unit, etc. Considered most advanced technology. Several commercial units in operation testing on EPA prototype initiated
Magnesium oxide scrubbing	MgO alkali water fuel for regeneration and drying	Recovery of conc. H_2SO_4	33-58 (200-1000 MW new or retro)	1.5-3.0	0.9-2.6	80-90°	Costs dependent on same factors for wet limestone. Boston electric unit to start up in March 1972. H_2SO_4 assumed marketed at \$18/ton on-site acid production
Monsanto catalytic oxidation (add-on)	Vanadium pentoxide catalyst (periodic replacement)	Recovery of dilute H_2SO_4	45-50 (1000 MW new)	2.1-2.5	1.8-2.2	80-90°	Costs dependent on same factors as for wet limestone. Boston electric unit to start up in March 1972. H_2SO_4 assumed marketed at \$9/ton (conc. basis)

*[Princiotta, F. T., Environmental Protection Agency, Research Triangle Park, NC, Publ. PB-228706 (1972).]

TABLE 5

COMPARISON OF LEADING NO₂ CONTROL TECHNIQUES

Technique	Comments
Off-stoichiometric (biased firing, overfire airports, low excess air)	Method relies on creation of fuel-rich, reducing atmosphere. Biased firing allows air to go only through selected burners; overfire adds NO ₂ ports above burners to stage combustion; low excess air requires special burners. Method is inexpensive, effective but fireside deposits, corrosion, slagging a problem.
Low combustion air temperature	Valid method but will lead to decrease in boiler efficiency unless economizer is enlarged, feedwater temperature lowered.
Flue-gas recirculation through burners	Method cools combustion air and is effective, especially with pulverized coal. Expensive to apply and operate, requiring added controls. Best choice is on large, new units.
Improved burner/furnace combinations	Aim is to design furnace enclosure and burner locations so sufficient time is allocated in furnace for complete combustion of coal when fired with slower and more controlled rates of heat releases. Method is inexpensive, effective.
Increase furnace cooling surface	An effective method but very costly, requiring more radiant superheater surface for more diffuse burning, less turbulence.

Source: Power, p. 63, April 1974.

REFERENCES

1. Editors of Power Magazine

"Power from Coal - Part III: A Special Report on Combustion Pollution Control," Power, p. S.57, April 1974.

SUMMARY: A technical review is presented of the four key equipment designs for curbing stack dust emissions knowing the properties of the coal to be used and the characteristics of the power plant.

2. Federal Energy Administration, Office of Energy Resource Development, Office of Fuel Utilization, Washington, D.C. 20461.

"Coal Conversion Program - Final Environmental Statements," April 1975.

SUMMARY: This report describes the specific authorities delegated to FEA by the Energy Supply and Environmental Coordination Act of 1974 in relation to converting certain power plants and major fuel burning installations from petroleum to coal as a source of energy. The study describes the current national environment in which coal conversion will take place; assessment and availability of pollution control equipment; critical air pollutants most directly affected by the Act, including the effects of coal supply, coal quality and the availability of pollution control equipment; adverse effects of coal utilization; alternative policy actions to coal utilization; energy implications and environmental impacts of conversion; economic impact of programs to convert existing power plants; and the potential of coal supplies available for conversion.

3. M. Sittig

Environmental Sources and Emissions Handbook,
Noyes Data Corporation, Park Ridge, New Jersey (1975).

SUMMARY: A practical handbook surveying the origins of both air and water pollution.

4. D. M. Ottmers, Jr.

"Factors Affecting the Application of Flue-Gas Desulfurization Systems to Gas-and-Oil-Fired Power Plants Being Converted to Coal-Fired Units," Coal Util. Symp., 2nd, Nat'l Coal Assn/Bitum Coal Res Coal Conf. & Expo 2, Louisville, Ky, p. 229 (1975).

SUMMARY: This paper addresses the technical and economic factors associated with application of flue gas desulfurization (FGD) systems to the power plant population which presently burn gas or oil but which formerly have burned coal. The discussion considers lime/limestone, magnesium oxide, and sodium based scrubbing processes. While catalytic oxidation is also considered a commercially available SO₂ control process, it is generally more applicable to new boilers than existing boilers. Particular attention is given to lime/limestone scrubbing systems since these are presently regarded as most technically advanced and widely applicable.

5. A Bogot and R. C. Sherrill

"Oil-to-Coal Reconversion Isn't Easy--Or Cheap,"
Electric Light and Power, p. 40, October 20, 1975.

SUMMARY: Conversion to coal on existing oil and gas units requires a complete engineering study of each individual unit, a thorough analysis of available coals and plant space. Meeting environmental standards for both sulfur and particulate emissions may be possible, but not always practical with the coals available.

6. A. Bogot and R. C. Sherrill

"Principal Aspects of Converting Steam Generators Back to Coal Firing,"
Paper presented at NCA/BCR Coal Conference and Expo II, October 21-23,
1975.

SUMMARY: Reconversion to coal firing is not always easy nor can it be considered to be low cost. Cost for a particular unit varies depending on what specific problems, as indicated in this paper, are encountered. However, it is not uncommon for a unit to cost \$10,000,000 to convert from oil firing to coal firing.

In operation, difficulties can be encountered if the original coal or one with constituents and characteristics similar to the original coal cannot be obtained. With the "new" coal, the performance of the coal firing system and steam generator may be reduced. If a unit cannot be operated at its design rating, the net cost of operation increases.

7. A. W. Bell and B. P. Breen

"Converting Gas Boilers to Oil and Coal,"
Chemical Engineering, p. 93, April 26, 1976.

SUMMARY: Extensive engineering is involved in changing from gas to oil to coal burning. Prior to a final decision on conversion, similar, already-converted boilers should be examined, and operating problems discussed with plant personnel. Technical factors which need to be considered in conversion are discussed in detail and the equipment needed for the changeover are presented.

8. A. Bogot and R. C. Sherrill

"Reconverting Steam Generator Firing to Coal or Coal Blends,"
Paper presented at the Coal Blending and Utilization Conference,
June 16-17, 1976, Des Moines, Iowa.

SUMMARY: Reconverting to coal firing may not be simple--nor is it an inexpensive venture. Considerable attention must be given to aspects other than strictly mechanical ones. If coal cannot be obtained that is the same as, or similar to, the design fuel, it is probable that blending of various coals will be required. Investigation of ash amounts, ash constituents, ash fusion temperatures, pulverizer capabilities, precipitator effectiveness, steam generator performance, and coal handling/blending techniques must be made. Much of the information desired will have to be obtained through experimentation on an operating unit particularly since each blend used will have different characteristics.

9. Staff Report

"Controls Meet Strict EPA Rules,"
Power, Plant Design Today, p. 46, November 1976.

SUMMARY: This article reviews the environmental program at Green River and identifies the leading reasons why the plant has earned Power's Environmental Protection Award.

10. Staff Report

"Switch Back to Coal Puts Renewed Emphasis on Particulate Removal,"
Power, Efficiency and Reliability, p. 41, November 1975.

SUMMARY: A detailed review is presented of the technical aspects involved in selecting equipment for controlling stack emissions--fabric filters, electrostatic precipitators, scrubbers and mechanical collectors.

11. J. Graham

"Coal and NEPA Shape Unit Design,"
14th Steam Station Design Survey, Electrical World, p. 43,
November 15, 1975.

SUMMARY: Four closely interrelated factors are discussed which have dominant influences on fossil steam-station design over the past few years: the switch to coal, environmental-control regulations, system optimization, and regional influences.

12. D. M. Ottmers, Jr., J. L. Phillips and T. G. Sipes

"Factors Affecting the Application of Flue Gas Desulfurization Systems to Gas-and Oil-Fired Power Plants Being Converted to Coal-Fired Units"
Coal Utility Symposium, 2nd, at National Coal Association Coal Res Coal Conference & Expo 2, Louisville, Kentucky, 1975.

SUMMARY: This paper addresses the technical and economic factors associated with application of flue gas desulfurization (FGD) systems to the power plant population which presently burn gas or oil but which formerly have burned coal. Particular attention is given to lime/limestone scrubbing systems since these are presently regarded as most technically advanced and widely applicable. Major technical and economic trends illustrated here are expected to apply to each of these flue gas cleaning methods.

13. J. T. Yeh, C. R. McCann, J. J. Demeter and D. Bienstock

"Removal of Toxic Trace Elements from Coal Combustion Effluent Gas"
Pittsburgh Energy Research Center, Pittsburgh, Pennsylvania,
September 1976.

SUMMARY: Trace element emissions are reported from the combustion of pulverized coal. Baghouse temperature, baghouse pulse cycle, and combustion excess-air level were varied to determine their effect on the ability of the fly ash to retain these trace elements. Experimental data show that near complete retention of Hg and Se in combustion gas by fly ash is possible with significant retention of the other trace elements studied. Whereas data on coal-fired power plants equipped with conventional electrostatic precipitators indicate that over 80% of the mercury in the coal feed escaped to the atmosphere while the other trace elements were lost at varying degrees.

14. H. Roffman and A. Roffman

"Environmental Considerations of Converting Fossil-Fueled Power Plants from Oil or Natural Gas to Coal",
Proceedings--Institute of Environmental Sciences, 152 (1976).

SUMMARY: Impacts to the air and discharges to water bodies are expected to increase as a result of the conversion from oil and gas to coal burning. Available, effective control measures should significantly reduce these impacts. An objective cost/benefit analysis will indicate that the conversion to coal is a positive action.

EQUIPMENT LISTING

This section includes a listing of the many companies in the United States and abroad specializing in coal conversion engineering and equipment. The literature indicates that this is a sophisticated multi-million dollar business for many firms. In most cases engineering analysis has been reduced to computer modeling techniques for speed, information storage and retrieval. Companies offering services in this area of engineering are as follows:

EQUIPMENT LIST

Coal unloading system

Unloading station, 1 ..... American Bechtel Inc
500-ton pit capacity, four 3200-cu ft discharge hoppers
 Hopper-car shaker, 1 ..... Robins Engineers & Constructors
 Unloading-station discharge-hopper feeders, 4 .....
     FMC Corp, Material Handling Equipment Div
Each vibrating type, 700 tons/hr, 54 in. wide x 78 in. long
 Intermediate belt conveyors, 2 ..... FMC Corp
Each 700 tons/hr, 36 in. wide, 430 ft/min; one 28 ft long, one 38 ft
 Storage-feed belt conveyor, 1 ..... FMC Corp
2800 tons/hr, 60 in. wide x 775 ft long, 646 ft/min, two 350-hp motor drives with speed reducers, 10-hp creep drive
 Storage-feed belt-conveyor scale, 1 .....
     Merrick Scale Manufacturing Co
 Dust collector, 1 ..... US Filter Corp, Mikropul Div
Baghouse type, 10,000 cfm, 10 ft OD x 25 ft high, electric trace heating, located on storage-feed belt conveyor
 Trackmobile, 1 ..... Whiting Corp

Coal handling system

Live-storage-pile reclaim hoppers, 4 ..... FMC Corp
Each holds 450 tons of coal
 Live-storage-pile reclaim-hopper feeders, 4 ..... FMC Corp
Each vibrating type, 35-75 tons/hr, 36 in. wide x 96 in. long
 Emergency-reclaim-hopper feeder, 1 ..... FMC Corp
Vibrating type, 150-250 tons/hr, 36 in. wide x 72 in. long
 Reclaim conveyor, 1 ..... FMC Corp
125 tons/hr (250 tons/hr future), 30 in. wide x 440 ft long
 Magnetic separators, 2 ..... Dings Co
 Dust collectors, 2 ..... US Filter Corp, Mikropul Div
Each baghouse type, 10,000 cfm, 10 ft OD x 25 ft high, located at conveyor transfer points before and after crusher house
 Sampling conveyor, 1 ..... FMC Corp
125 tons/hr (250 tons/hr future), 30 in. wide x 23 ft long, 350 ft/min. It directs coal to two separate streams—one to the sampling system and one to the silo-feed conveyor
 Crusher, 1 ..... Pennsylvania Crusher Corp
Hammermill type, 150 tons/hr, 60-hp motor drive
 Coal sampling system, 1 ..... Sturtevant Mill Co, FMC Corp
Includes a primary cutter, vibrating feeder, crusher, tertiary sampler, and sample collector
 Silo-feed belt conveyor, 1 ..... FMC Corp
125 tons/hr (250 tons/hr future), 30 in. wide x 520 ft long
 Tripper conveyor, 1 ..... FMC Corp
125 tons/hr, 30 in. wide x 330 ft long, 300 ft/min.
 Dust collectors, 2 ..... Flex-Kleen Corp
Each baghouse type, serves a group of four silos
 Safety equipment ..... Various manufacturers
Conveyors are equipped with a fire sprinkler system. Tunnel under the live pile, and the silos, are equipped with a methane analyzer, which alarms in the boiler control room and shuts down all electrical equipment in the event of high concentrations of gas

Steam generating equipment and auxiliaries

Coal silos, 8 ..... Pittsburgh-Des Moines Steel Co
Each 150-ton capacity (6800 cu ft), 14 ft diam x 55 ft high
 Coal feeder, 1 per silo ..... Stock Equipment Co
Gravimetric type, feed rate extends from 6579 to 48,976 lb/hr
 Pulverizers, 4 per boiler ..... Babcock & Wilcox Co
Each serves two burners, ball-and-ring type, 36,600-lb/hr capacity based on 1 1/4 x 0 coal with 40.3 grindability and 23.9% moisture; 200-hp, 4.16-kV motor drive by Allis-Chalmers Corp
 Pulverizer/feeder seal-air fans, 2 per boiler ..... Diebold Inc
 Burners, 8 per boiler ..... Babcock & Wilcox Co
Each circular-register type with coal nozzle, jet-type oil atomizer, and gas atomizer
 Boilers, 2 ..... Babcock & Wilcox Co
Each 650,000 lb/hr at 625 psig/750F
 Forced-draft fan, 1 per boiler ..... American Standard Inc
Horizontal backward-curved airfoil type, 256,788 acfm at 80F, 12.4-in.-H₂O pressure rise, double inlet, hand and automatic inlet-vane control, air-cooled lube-oil system which also serves the drive system; 1000-hp, 4.16-kV motor drive by Allis-Chalmers Corp
 Induced-draft fan, 1 per boiler ..... American Standard Inc
Horizontal radial-tip type, 414,806 acfm at 311F, 13.2-in.-H₂O pressure rise, double inlet, hand and automatic inlet- and outlet-damper control, air-cooled lube-oil system which also serves the drive system; 2000-hp, 4.16-kV motor drive by Allis-Chalmers Corp
 Air preheater, 1 per boiler ..... Air Preheater Co
Ljungstrom regenerative type; air entering/leaving, 80F/654F; gas entering/leaving (corrected), 788F/306F
 Glycol air heater, 1 per boiler ..... American Standard Inc
Glycol/water solution preheats combustion air from -40F to 80F for the regenerative air preheater
 Glycol heater, 1 per boiler ..... American Standard Inc
16.12-million Btu/hr transferred from 200-psig/400F process steam to the glycol/water solution
 Glycol circulating pumps, 2 per boiler ..... FMC Corp, Pump Div
One required for normal operation, one on standby; each 800 gpm at 55 psig, 50-hp motor drive
 Sootblowing system ..... Copes-Vulcan Inc
Fully automatic system uses 600-psig superheated steam as the blowing medium. System consists of six long retractable blowers for the superheater and boiler banks, 30 short retractable wall blowers, and air-preheater cleaning devices

EQUIPMENT LIST

Turbine/generators and auxiliaries

Turbine/generators, 2 .....Turbodyne Corp
Each 11.5 MW; automatic-extraction, backpressure type
 Turning gear, 1 per unit.....Westinghouse Electric Corp
 Turning-gear lube-oil pump, 1 per unit.....Worthington Corp
 Lube-oil reservoir, 1 per unit.....Worthington Corp
 Lube-oil heater, 1 per unit.....
     Emerson Electric Co, Edwin L Wiegand Div
 Main lube-oil pump, 1 per unit.....Worthington Corp
     Shaft-driven type, 128 gpm at 80 psig
 Auxiliary lube-oil pump, 1 per unit.....Worthington Corp
     Single-stage centrifugal pump driven by a single-stage steam turbine, 128 gpm at 80 psig
 Lube-oil coolers, 2 per unit.....American Standard Inc
     One required for normal operation, one on standby
 Vapor exhauster, 1 per unit.....Dresser Industries Inc
 Lube-oil filters, 3.....Carborundum Co
     One duplex filter located in the bearing-lubrication and turning-gear lines, two single-element filters in the control-oil system
 Lube-oil purifier, 1.....Keene Corp
     Three-stage gravity/pressure-type filter and oil conditioner
 Lube-oil-purifier vent fan, 1.....Dresser Industries Inc
 Lube-oil purification system circulation pump, 1.....
     Worthington Corp
     10 gpm at 40 psig, 0.75-hp motor drive
 Gland-seal condenser, 1 per unit.....American Standard Inc
 Turbine/generator fire-prevention system, 1 per unit.....
     Chemetron Corp

Boiler and turbine/generator controls

Combustion-control system, 1 per boiler.....Bailey Meter Co
 Burner-management system, 1 per boiler.....
     Electronics Corp of America
 Feedwater-control system, 1 per boiler.....Bailey Meter Co
 Steam-temperature spray-water control system.....Bailey Meter Co
 Pulverizer-air-temperature control system.....Bailey Meter Co
 Energy-management system.....Westinghouse Electric Corp

Environmental-control system

Electrostatic precipitator, 1 per boiler.....Research-Cottrell Inc
     Efficiency, 99.1%; normal power consumption, 1155 kW; maximum power consumption, 1424 kW; flue-gas velocity, 4.9 ft/sec; flue-gas retention time, 6.14 sec; flue-gas flow/volume, 973,000 lb/hr/655,000 acfm; flue-gas inlet temperature, 825F; 16 ash hoppers complete with vibrators and level indicators
 Sulfur-dioxide scrubber, 1 per boiler.....
     FMC Corp, Environmental Equipment Div
 Scrubber recirculating pumps, 2 per scrubber.....Gallagher Co
     Each 6800 gpm at 91.6-ft head; 300-hp, 4.16-kV motor drive
 Flue-gas reheater, 1 per scrubber.....Peabody Engineering Corp
     Gas-fired furnace raises 126F scrubber outlet gases to 200F.
 Scrubber-water makeup pump, 1.....FMC Corp, Pump Div
     200 gpm at 59-ft head
 Nitrogen-oxides booster fan, 1 per boiler.....American Standard Inc
     Single-inlet type, 44,600 acfm at 554F, 9.8-in.-H₂O pressure rise
 Stack, 1.....Hermit Corp
     300 ft, 26-ft-diam carbon-steel shell, two 11-ft-diam liners covered with corrosion-resistant flake coating

Ash-handling system

Bottom-ash conveying system.....
     Ecoleire Inc, Allen-Sherman-Hoff Div
 Flyash conveying system.....Ecoleire Inc, Allen-Sherman-Hoff Div
 Ash-sludge-water pumps, 6.....Barrett, Haentjens & Co
     Each 2000 gpm at 324 psig; three pumps in series supply water to the ash ductors, remaining three pumps on standby
 Seal-water pumps, 2.....Sundstrand Corp, Machine Tool Div
     One pump required for normal operation to protect ash-sludge-pump packing from ash-contaminated water, one on standby; each 20 gpm at 300 psig
 Sludge water overflow pumps, 2.....Gallagher Co
     One pump required for normal operation, one on standby; each 600 gpm at 56 psig
 Sludge-water-system acid-feed pumps, 2.....Milton Roy Co
     Each 11.5 gal/hr at 325 psig

Condensate and feedwater system

Boiler-feedwater pumps, 3.....Bingham-Williamette Co
     Two required for normal operation, one on standby; each five-stage double-volute suction, horizontally split centrifugal type rated 1860 gpm at 989 psig; 1500-hp, 4.16-kV motor drive by Allis-Chalmers Corp
 Boiler-feedwater-pump recirculation-flow control valve, 1 per pump.....Yarway Corp
 Boiler-feedwater sample coolers, 2.....Calgon Corp
 High-pressure desuperheater water pumps, 2.....
     Bingham-Williamette Co
     One required for normal operation, one on standby; each 400 gpm at 745 psig, supplies clean condensate to attenuator in boiler superheater outlet, automatic recirculation valve by Yarway Corp; 300-hp, 4.16-kV motor drive
 Medium-pressure desuperheater water pumps, 2.....
     FMC Corp, Pump Div
     One required for normal operation, one on standby; each 283 gpm at 308 psig, supplies clean condensate to the 200- and 25-psig steam desuperheaters in the turbine extraction and backpressure lines, respectively; 125-hp motor drive
 200-psig steam desuperheater, 1.....
     Ametek Inc, Schutte & Koerting Div
     Desuperheats 290,000 lb/hr of 200-psig steam from 625F to 402F±5 deg F with 72 gpm of 200-psig/200F condensate and 4500 lb/hr of 600-psig/750F atomizing steam; desuperheater control valve regulated by a Foxboro Co control station
 25-psig steam desuperheater, 1.....
     Ametek Inc, Schutte & Koerting Div
     Desuperheats 340,000 lb/hr of 25-psig steam from 485F to 277F ±5 deg F with 73 gpm of 25-psig/220 F condensate and 4500 lb/hr of 600-psig/750F atomizing steam
 Condensate return pumps, 2.....FMC Corp, Pump Div
     One required for normal operation, one on standby; each 30 gpm at 51-ft differential head; 1.5-hp motor drive

Water-treatment system

Hot process reactor, 1.....Graver Water Conditioning Co
     1500 gpm, upflow sludge-contact sedimentation tank containing one clean- and one dirty-backwash water storage compartment, 60-min detention of water in reaction and settling zones
 Anthracite filters, 5.....Youngstown Steel Tank Co
     Each designed to remove last traces of turbidity from the clarified makeup, 11.5 ft diam x 4 ft high, 300 gpm, 36-in.-high bed of anthracite coal, 1560-gpm backwash flow rate, 10-min backwash cycle

EQUIPMENT LIST

Zeolite softeners, 5 ..... Youngstown Steel Tank Co
Each designed to remove virtually all hardness from filtered makeup, 6.5 ft diam x 5 ft high, 235 gpm, 30-in.-high resin bed (83 cu ft), regeneration with 10% brine solution required after throughput of 710,000 gal of softened water with 40 ppm of total hardness, 398-gpm backwash flow rate

Filter and softener backwash pumps, 2 ..... Goulds Pumps Inc
One required for normal operation, one on standby; each 1560 gpm at 95-ft differential head; 50-hp, 480-V motor drive

Booster pumps, 2 ..... Goulds Pumps Inc
One required for pumping reactor effluent through pressure filters (for post filtration) and through zeolite softeners (for hardness polishing), one on standby; each 1700 gpm at 140-ft differential head

Treated-water cooler, 1 ..... APV Co
315 sq ft of heating surface, 16.8-million Btu/hr transferred to 750,000 lb/hr of 85F water to cool 562,000 lb/hr of treated water from 225F to 195F and thereby prevent flashing in the storage tank

Treated-water tank, 1 ..... Pittsburgh-Des Moines Steel Co
840,000 gal, maintains treated water at 50F when outdoor temperature is 0F

Treated-water pumps, 2 ..... FMC Corp, Pump Div
One required for normal operation, one on standby; each 3240 gpm at 95-psi differential head; 300-hp, 4.16-kV motor drive

Sulfite injection system ..... Milton Roy Co
 Chelant/amine injection system ..... Milton Roy Co

30-ton lime storage bin, 1 ..... Graver Water Conditioning Co
 Lime dust collector, 1 ..... Flex-Kleen Corp

Lime feeder, 1 ..... Pennwalt Corp, Wallace & Tiernan Div
 Lime feed tank, 1 ..... Pennwalt Corp, Wallace & Tiernan Div
 Lime agitator, 1 ..... Pennwalt Corp, Wallace & Tiernan Div

Lime-slurry feedpumps, 2 ..... Goulds Pumps Inc
One required for normal operation, one on standby; each 5 gpm at 100-ft differential head, 5-hp motor drive

3-ton lime storage bin, 1 ..... Graver Water Conditioning Co
This spare bin comes equipped with its own dust collector, lime feeder, and lime agitator; it shares a feed tank with the soda-ash storage bin (see below)

3-ton soda-ash storage bin, 1 ..... Graver Water Conditioning Co
 Soda-ash dust collector, 1 ..... Donaldson Co
 Soda-ash feeder, 1 ..... Pennwalt Corp, Wallace & Tiernan Div
 Soda-ash agitator, 1 ..... Pennwalt Corp, Wallace & Tiernan Div
 Soda-ash feed tank, 1 ..... Pennwalt Corp, Wallace & Tiernan Div

Soda-ash feedpumps, 2 ..... Goulds Pumps Inc
One required for normal operation, one on standby; each 5 gpm at 100-ft differential head, 5-hp motor drive

Reactor-sludge recirculation pumps, 2 ..... Goulds Pumps Inc
One required for normal operation, one on standby; each 260 gpm at 75-ft differential head, 15-hp motor drive

Brine-solution pumps, 2 ..... Goulds Pumps Inc
Each rotary type, 10 gpm at 50-psi differential head

Sample coolers, 3 ..... Calgon Corp

Compressed-air system

Air compressors, 2 ..... Elliott Co
One required for normal operation, one on standby; each 2100 cfm at 110 psig using 11.45-psia inlet air at 100F (or lower) and 56 gpm of cooling water at 95F (or lower). Packaged system comes complete with inlet filter, silencer, intercoolers, aftercooler, lube-oil system, etc

Air dryer, 1 ..... Ajax Magnathermic Corp, Lectrodryer Div
Twin-tower type discharges 3500 cfm of air with -60F dewpoint

Air-dryer heater, 1 ..... Brown Fintube Co
 Air-dryer cooler, 1 ..... R P Adams Co
 Afterfilters, 2 ..... Dollinger Corp

Source: Power Magazine, A McGraw-Hill Publication, November 1976.

CASE STUDIES OF CONVERTED PLANTS

This section provides references of examples published in the literature of power plants converted from oil or gas to burn coal.

REFERENCES

1. J. P. Carey, R. G. Romsdell, Jr., C. F. Sauter and W. B. White
"Ravenswood Conversion to Coal"
American Power Conference XXIX, 495 (1967).

SUMMARY: A detailed account is presented of the conversion from oil or gas to coal of the Ravenswood Station, Consolidated Edison Co., N.Y., and one of the largest operating units in the world.

2. A. Bagot & R. C. Sherrill
"Switch Back to Coal is Less than Ideal"
Electric Light & Power, March 24, 1975 p. 17

ABSTRACT: This paper presents a case-history of a unit designed and initially operated for coal, converted to oil firing, then reconverted to coal firing, with oil-burning capability retained.

NOTICE

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Available from
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