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Region 8
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United States
Department of
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Economics Department
Colorado State University
Fort Collins, Colorado 80523

EPA

Colorado Coal Resources, Production and Distribution

Coal

COLORADO COAL RESOURCES, PRODUCTION AND DISTRIBUTION

by

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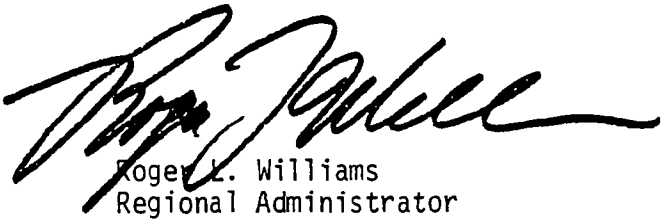
FOREWORD

On behalf of EPA and USDA I am pleased to provide you with a copy of a report on Colorado coal. This jointly prepared report discusses resources, production and consumption history, and future demand/supply.

The Coal Use and Development Project has been jointly funded by the U.S. Environmental Protection Agency's Office of Research and Development and by the U.S. Department of Agriculture's Economics and Statistics Service, since 1975. A major portion of the research has been located in the Economics Department at Colorado State University, Fort Collins, under the direction of Dr. John W. Green. Several data bases have been developed describing U.S. coal resources, production and distribution. It is one objective of the Project to organize these statistics into individual state reports and make them available to the public. This Colorado report is the first of the anticipated series and was completed with the cooperation of the Energy Policy Coordination Office, U.S. EPA, Region VIII, Denver, Colorado.

Additional copies of this report may be obtained from the National Technical Information Service.



Roger L. Williams
Regional Administrator

ABSTRACT

The primary demand for Colorado coal is for steam-electric power generation. Approximately 14.66 million tons of the 18.13 million tons of coal produced in Colorado in 1979 was used for this purpose. Over 36 percent of the coal required by Colorado power plants in 1979 was provided by Wyoming mines. Colorado utility coal demand will increase approximately 33 percent between 1980 and 1985. Colorado utilities will add 2,150 megawatts of coal-fired capacity in that same period. Northwest Colorado will produce nearly 80 percent of all coal produced in 1985 compared to 91 percent in 1975. Labor and land impacts will vary depending on the type of mining and the local topography.

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Introduction

The increased demand for coal as a fuel for steam electric power generation during the 1970's has significantly impacted Colorado coal production. The cost of transportation, combined with cheap oil and natural gas, previously made use of Colorado coal less economical. Recently, prices of oil and gas increased relative to coal. This, combined with more efficient transportation methods, has made western coal competitive.

Coal is used primarily for steam electric power generation. Historically, Colorado electric energy needs have been met by a comparatively small regional coal industry. This industry's status will change significantly in Colorado and throughout the West by 1985. Demand will continue to increase because of low production costs, low sulfur content, higher regional electrical demands stemming from rapid growth, and the establishment of a synthetic fuels industry.

Colorado Coal Resources and Reserves

Colorado contains some of the highest quality coals found in the western United States. Some of Colorado's coal deposits can and are being surface mined. Colorado's subbituminous coal is used in steam electric generating plants in the state and elsewhere, particularly in the Midwest. Several long-term contracts have been signed with both in-state and out-of-state

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utilities. Markets for Colorado's metallurgical grade coal should remain stable or possibly expand slightly.

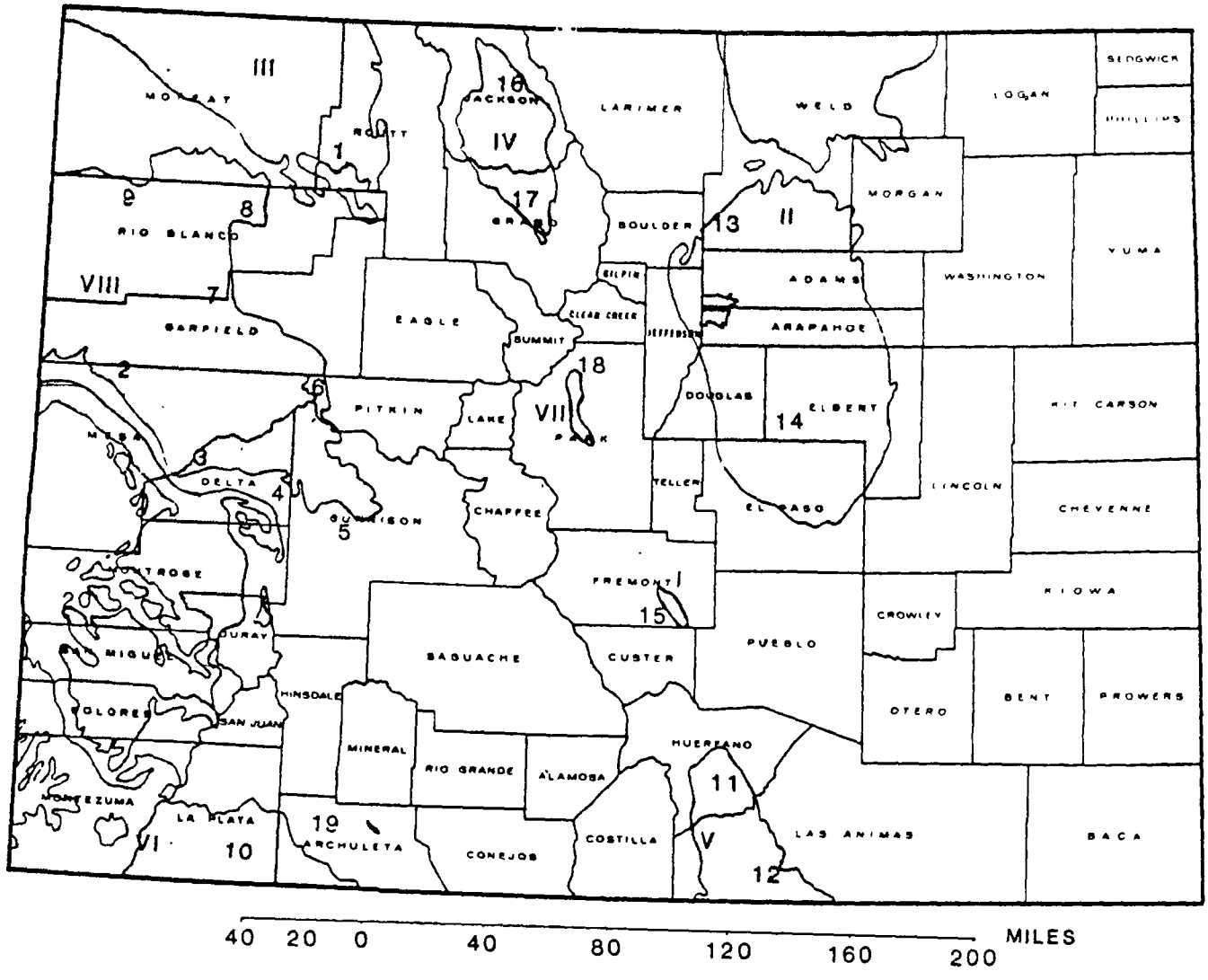
Colorado Coal Reserves

The States' coal-bearing lands are divided into five resource regions: Green River, Uinta, San Juan River, Raton Mesa, and Denver (Figure 1, 7). Separate fields exist within each region. Three additional fields are outside all regions. Detailed reserve estimates totaling 82 billion tons have been made covering about 5,300 square miles. Another 15,000 square miles contain undetailed reserves which are beneath 3,000 feet of overburden. Estimated reserves for the state total about 370 billion tons at depths to 3,000 feet.

According to the U.S. Bureau of Mines (1977), Colorado ranked seventh among states in the U.S. in the total demonstrated reserve base 1/ of coal (16.3 billion tons) and fourth in the reserve base of bituminous coal. These numbers are similar to those published by the U.S. Geological Survey (Table 1). 2/ Approximately 3.8 billion tons (23 percent) are surface mineable. Colorado ranks first in the U.S. in the reserve base of underground mineable, low sulfur, bituminous coal. The sulfur content generally varies from .2 to 1.1 percent and averages approximately .5 percent. Ash content typically varies between 2.1 and 15 percent, averaging about 6 percent. The moisture content in most Colorado coal ranges from 1.0 to 20 percent. Heating values vary between 11,440 and 14,500 Btu per lb. Average values are about 11,370 Btu per lb. as received and 13,905 Btu per lb. on a dry and ash free basis. A significant part of Colorado's bituminous coal reserve base is coking or metallurgical grade.

1/ The demonstrated reserve base includes all coals that occur to depths of 1,000 feet. Only bituminous coal and anthracite in beds 28 inches or more in thickness and subbituminous coal and lignite in beds 60 inches or more in thickness are included in the demonstrated reserve base.

2/ Reserve and resource estimates from alternative sources usually do not agree because of differing assumptions and/or incomplete knowledge.



COAL REGIONS AND FIELDS IN COLORADO

COAL REGIONS

I	Canon City (field)
II	Denver Basin
III	Green River
IV	North Park
V	Raton Mesa
VI	San Juan River
VII	South Park (field)
VIII	Uinta

COAL FIELDS

1. Yampa
2. Book Cliffs
3. Grand Mesa
4. Somerset
5. Crested Butte
6. Carbondale
7. Grand Hogback
8. Danforth Hills
9. Lower White River
10. Durango
11. Walsenburg
12. Trinidad
13. Boulder-Weld
14. Colorado Springs
15. Canon City
16. North Park
17. Middle Park
18. South Park
19. Pagosa Springs
20. Nucla-Naturita

Figure 1. Coal regions and fields in Colorado.

Table 1--Demonstrated reserve base, January, 1976

County	Seams	Deep	Strip	Total	S	Ash	H_2O	Heat content
	No.	Millions of short tons				Percent		Btu per lb.
Adams	3	122.64	0	122.64	0.3	6.0	23.7	8,670
Arapahoe	1	70.12	0	70.12	N/A	N/A	N/A	N/A
Archuleta	1	92.10	0	92.10	0.6	13.0	3.7	12,370
Boulder	7	163.24	0	163.24	0.3	5.8	19.1	9,940
Delta	9	270.76	0	270.76	0.5	6.1	9.7	11,910
Douglas	1	5.07	0	5.07	N/A	N/A	N/A	N/A
Elbert	1	248.81	0	248.81	0.4	8.0	32.9	6,330
El Paso	1	123.89	0	123.89	0.2	6.1	22.4	8,890
Fremont	7	180.32	0	180.32	0.4	8.8	10.1	11,030
Garfield	19	552.99	0	552.99	0.8	7.4	6.6	12,130
Gunnison	19	916.62	0	916.62	0.4	6.1	5.9	12,690
Huerfano	28	278.32	0	278.32	0.6	10.8	5.2	11,920
Jackson	11	823.51	127.00	950.51	0.3	5.9	16.5	10,120
Jefferson	1	175.91	0	175.91	0.3	4.6	18.9	9,850
La Plata	2	322.06	0	322.06	1.4	7.2	3.9	13,120
Las Animas	49	831.96	0	831.96	0.5	13.3	2.1	12,640
Mesa	5	238.34	0	238.34	0.6	8.9	8.1	11,790
Moffat	56	2,570.55	270.00	2,840.55	0.2	3.8	11.5	11,510
Montezuma	1	19.11	0	19.11	0.5	7.9	5.5	12,750
Montrose	5	143.05	60.00	203.05	0.6	9.4	5.4	12,390
Ouray	1	762.59	0	762.59	0.5	7.5	15.7	10,140
Park	4	25.31	0	25.31	0.4	6.3	15.5	9,770
Pitkin	12	88.60	0	88.60	0.5	8.1	2.8	13,660
Rio Blanco	70	1,067.37	0	1,067.37	0.4	6.0	11.7	11,210
Routt	27	3,413.89	413.00	3,826.89	0.8	6.4	9.4	11,560
Weld	7	464.31	0	464.31	0.3	4.8	21.2	9,810
State Total -1974		13,971.44	870.00	14,841.44	0.5	7.2	11.8	11,610
1976 Updated Data		12,465.5	3,791.1	16,256.6	0.5	7.2	11.8	11,160

Source: (26, Appendix II-2; 13, p. A-2)

The Colorado Geological Survey estimates over 80 percent of the state's total coal resources are mineable only by underground methods. Recovery of the coal in place probably will be much less than 50 percent unless major breakthroughs in mining technology are achieved.

Most of Colorado's potentially surface mineable coal is located in the Denver coal region (75 percent), in the San Juan River region (16 percent), and in the Green River region (5 percent). Approximately 20 billion tons of lignite, in beds at least four feet thick occurring at less than 1,000 feet in depth, may exist in the central part of the Denver basin. Urban growth pressures in the front range corridor, as well as increasing oil and gas drilling activity in the region, will affect the amount of lignite coal that will ultimately be mined.

History of Colorado Coal Production

Significant coal production commenced in the western U.S. in the late 1960's as use by electric utilities and industry increased. New air quality regulations induced a shift from high to low sulfur coals. Also important was the fact that much of the coal in the West can be surface mined. Nearly 84 percent of the low sulfur (less than 1.0 percent sulfur, by weight) coal reserves in the U.S. are found in the Western States. Colorado contains 4.5 percent of western low sulfur coal. (14) The EPA Region 8 States (Colorado, Wyoming, Utah, Montana, North Dakota) produced approximately 147.9 million tons of coal in 1979. Colorado annual production has increased every year since 1971. (2, 7)

1971 5.31 million tons
1972 5.53 million tons (4 percent increase)
1973 6.23 million tons (13 percent increase)
1974 6.96 million tons (12 percent increase)
1975 8.27 million tons (19 percent increase)
1976 9.46 million tons (14 percent increase)
1977 11.97 million tons (27 percent increase)
1978 14.36 million tons (20 percent increase)
1979 18.13 million tons (26 percent increase)

Top production of about 12.7 million tons was recorded in 1918 from Colorado mines (Fig. 2, 7). Prior to 1917 production, which began in 1864 and passed one million tons in 1882, rose irregularly to this peak. Following 1917 coal production declined irregularly to 5.6 million tons in 1948. Only in 1933 and 1934 had production been lower.

A further era of decline began in 1948 as traditional home heating and railroad markets withered away. Production had fallen by 1954 to a low of 2.9 million tons, the lowest since 1889. The trend then turned gradually upward until, by the mid-1960's, a production plateau of about 5.5 million tons had been achieved. Since 1864, the year of the first production, to 1980 about 640 million tons of coal have been produced.

Surface mining in Colorado began in 1931. It became significant in 1948 when over 5 percent of the production came from this source. This trend continued through 1979, accounting for about 68 percent of Colorado's production.

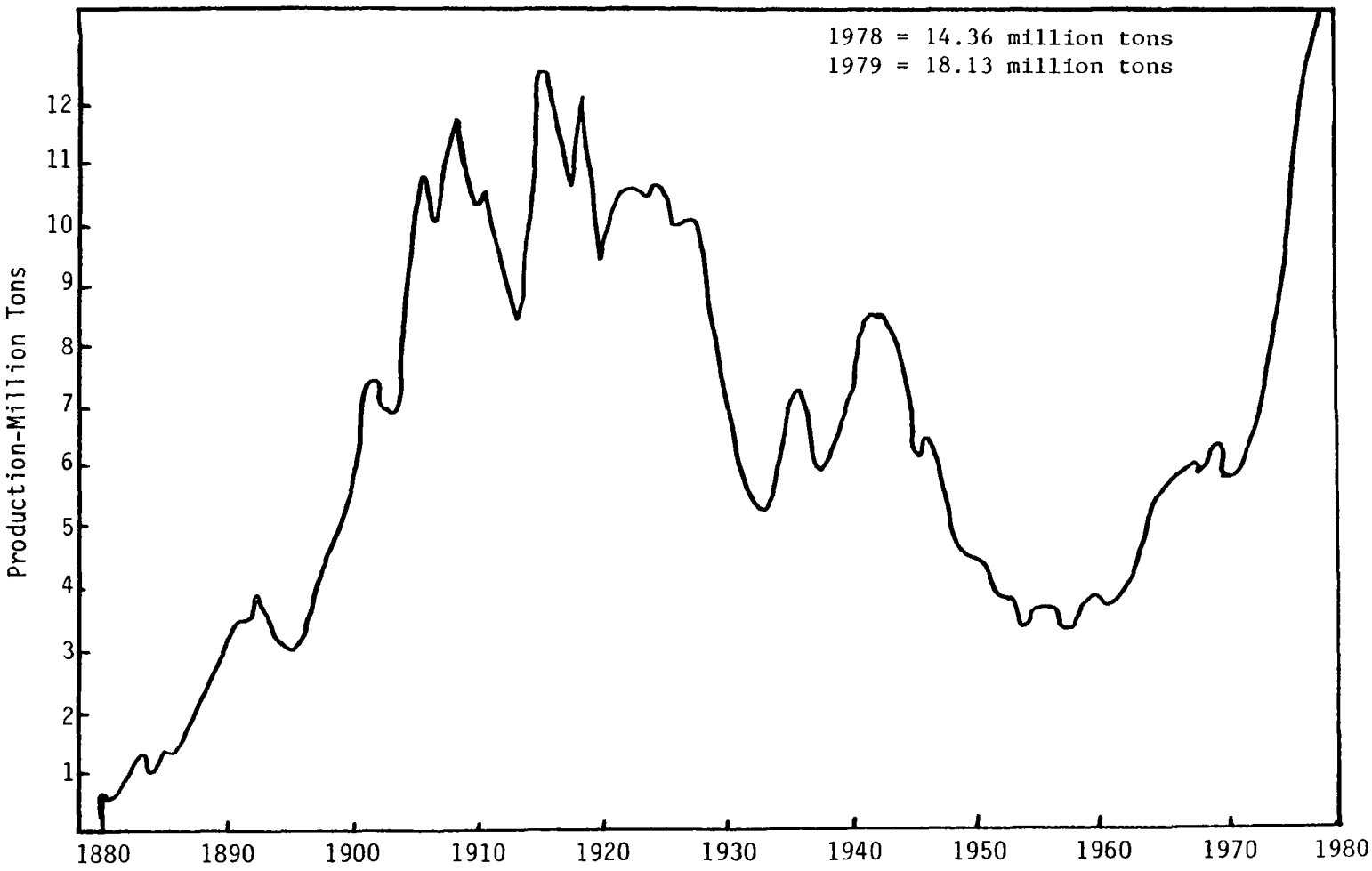
Utility coal has expanded its market share to about 81 percent of the state's production (22). Industrial coal constitutes about 16 percent and the remaining 3 percent goes to other markets.

Existing Colorado Coal Mines

This section provides a summary of coal mines in Colorado current as of August, 1980. The data was verified with the Denver Office of Surface Mining. The information reflects recent startups and closings. Also indicated are mines that are currently idle but which may resume production at some future date.

Table 2 describes the categories of Colorado coal mines. There are 23 surface and 28 underground active mines and 7 surface and 12 underground idle mines. There are 5 surface and 11 underground planned mines. Thus there is a total of 51 active, 19 idle, and 16 planned mines in Colorado.

Figure 2. Colorado Coal Production, 1880-1979



Colorado Coal Production 1880-1979

Cumulative Production to 1-1-80
640,490,000 Short Tons

Table 2--Colorado coal mine summary

Existing		Idle		Planned		Total	
S	U	S	U	S	U	S	U
Number							
23	28	7	12	5	11	35	51
51		19		16		86	

Source: (16)
S=surface
U=underground

Colorado had 37 mines in 1972, 67 in 1975, and 72 in 1979 as opposed to over 110 operations in 1961 (annual publications, Colorado Division of Mines). The gradual decline in the number of operations before 1972 was probably a result of economic forces rather than Federal regulations. The number of mines has been increasing since 1972 as markets for Colorado coal have expanded.

Table 3 describes each existing coal mine in Colorado, by county, including the mine name, type of operation, operator name, type of lease, annual production for 1976 through 1979, the 1980 status of closed and idle mines, and market for the coal. Figure 3 gives a general indication of the location of coal mines in Colorado. The mine locations are keyed by number to mine names in Table 3. Planned mines are shown in Table 4, including estimated production for 1980 through 1985 and 1990.

Colorado operators face traditional industry problems including distance from market and costly production. In fact, Wyoming thick-seam, surface-mined coal is used in some coal-fired electric generation plants in Colorado.

Table 3--Coal mines in Colorado

County and mine	Type of mine[3]	Operator	Type of lease[1]	Production 1976	Production 1977	Production 1978	Production 1979	1980 status[4]	Map No.[2]
				Thousand tons					
Archuleta									
Martinez	S	Perma Resources	P	0	4.1	35.2	78.8	A	1
Delta									
Blue Ribbon	U	Sunflower Energy	P	0	16.6	15.3	89.4	A	2
Coalby #2	S	Coalby Mining Co.	X	0.1	0	0	0	C	
Orchard Valley	U	Westmoreland	F	14.0	286.1	435.9	722.5	A	3
Red Canyon #1	U	Grand Mesa Coal	P	0	0.4	0.4	9.8	A	4
Red Canyon #2	U	Grand Mesa Coal	P	0	0	0	0	I	4
Tomahawk	S	Quinn Coal Co.	P	0	24.2	41.2	70.7	A	5
El Paso									
Bacon	S	Capstan Mining	P	0	0	0	0	S	6
Fremont									
Dorchester #1	U	Dorchester Colomine	P	0	0	0	14.3	A	7
Black Diamond	S	GEC Minerals	P	44.9	30.1	0	0	C	
Corley S & A	S	GEC Minerals		3.3	0	0	0	C	
GEC Strip	S	GEC Minerals	P	0	19.5	80.0	85.6	A	8
Cedar Canyon	S	Cedar Canyon	P	2.2	2.3	0	0	C	12
Hasting's Strip	S	Robert Hastings	P	0	0.1	2.6	10.4	I	9
Newlin Creek	S	Newlin Creek Coal	P	0	1.6	5.3	17.7	A	10
Twin Pines	U	Twin Pines Coal	P	40.7	37.1	36.7	37.1	A	11
Garfield									
Eastside	U	Eastside Coal	P	0	0.3	0.3	0	I	13
McClone Canyon	U	Sheridan Enterprises	F	0	46.0	1.6	3.4	I	14
Munger Canyon	U	Sheridan Enterprises	F	0	20.5	80.4	0	I	15
Nu Gap #3	U	Henry Bendetii	P	0.4	0.4	0.3	0.1	I	16
Sunlight	U	Eastside Coal	P	1.0	1.8	0.5	0.5	I	17

Continued

Table 3--Coal mines in Colorado--continued

County and mine	Type of mine[3]	Operator	Type of lease[1]	Production 1976	Production 1977	Production 1978	Production 1979	1980 status[4]	Map No.[2]
				Thousand tons					
Gunnison									
Bear	U	Bear Coal	F	109.2	226.2	226.7	250.2	A	18
Hawk's Nest East	U	Western Slope Carbon	F	26.8	190.3	331.0	436.7	A	19
Hawk's Nest West	U	Western Slope Carbon	F	155.7	155.7	12.4	0	I	19
Ohio Creek #2	U	Henry L. Weaver	F	3.3	3.7	1.5	0.3	A	20
Somerset	U	U.S. Steel	P,F	950.2	914.6	650.2	900.8	A	21
Windjammer #1	U	Anchor Coal	X	0	0	0	0	S	22
Huerfano									
Viking	S	Viking Coal	P	0	0	16.3	49.7	A	23
Jackson									
Canadian	S	Sigma Mining	P	20.3	148.6	193.8	97.9	A	24
Marr	S	Kerr Coal	P	249.8	347.4	513.9	687.6	A	25
La Plata									
Coal Gulch	S	Arness-McGriffin	P	0	1.2	13.8	3.6	I	26
King Coal	S	National King Coal	F	16.8	22.6	66.0	93.7	A	27
Peacock #2	S	Peacock Coal	P	0.1	1.8	0	0.1	I	28
Shalako	U	Menefe Land Co.	P	0	0	0	0	S	29
Las Animas									
Allen	U	CF & I Steel	F	618.9	582.3	495.1	634.7	A	30
Baldy Canyon	S	National Energy Res.	P	0	0	0	2.6	I	31
Delaqua #1	S	Delaqua	P	0	6.7	35.0	0	I	32
Delaqua #2	S	Delaqua	P	0	0	4.0	39.0	A	32
Healey Strip	S	Horner Coal	P	12.8	96.0	18.3	0	I	33
Helen	U	Animas Coal	P	0	0	0	19.0	I	34
Jewell	S	Horner Coal	P	17.8	25.6	6.1	0	I	35
Maxwell	U	CF & I Steel	P	0	31.8	86.9	125.4	A	36

Continued

Table 3--Coal mines in Colorado--continued

County and mine	Type of mine[3/]	Operator	Type of lease[1/]	Production 1976	Production 1977	Production 1978	Production 1979	1980 status[4/]	Map No.[2/]
				Thousand tons					
Mesa									
Cameo 1 & 2	U	GEX Colorado	P	0.1	0	0	31.8	A	37
Fruita 1 & 2	U	Dorchester Colomine	P	0	0	0	1.1	I	38
Roadside (CMC)	U	GEX Colorado	P,F	57.1	300.2	449.7	827.8	A	39
Moffat									
Colowyo	S	Colowyo Coal	F	0	290.5	1109.6	1699.4	A	40
Trapper	S	Utah International	S,C,F	0	345.9	1333.0	2328.7	A	41
Williams Fork #1	S	Empire	P	54.1	0	0	0	C	42
Williams Fork #2	S	Empire	P	0	0	242.1	42.9	A	42
Williams Fork #3	S	Utah International		70.6	0	0	0	C	42
Eagle #5	U	Empire	S	382.3	447.5	539.6	556.1	A	43
Eagle #9	U	Empire	F	0	0	79.1	173.0	A	43
Montrose									
Nucla	S	Peabody Coal	P	97.9	94.4	102.4	121.8	A	44
Pitkin									
Bear Creek	U	Mid-Continent	F	115.5	58.4	38.7	46.1	A	45
Coal Canyon	U	Mid-Continent	P	108.9	123.2	137.9	139.3	A	45
Dutch Creek #1	U	Mid-Continent	P	132.4	232.5	161.2	147.1	A	45
Dutch Creek #2	U	Mid-Continent	P	268.9	208.1	225.5	208.2	A	45
L.S. Wood #3	U	Mid-Continent	P	263.1	298.4	318.2	268.3	A	45
Thompson Creek #1	U	Snowmass	P	0.5	7.5	15.7	18.9	A	45
Thompson Creek #3	U	Snowmass	P	0.2	8.4	19.6	14.0	A	45
Rio Blanco									
Northern #1	U	Northern Coal	P	0	0	0	6.2	A	46
Rienau #2	U	Sewanee Mining	F	0	8.8	36.0	83.0	A	47

Continued

Table 3--Coal mines in Colorado--continued

County and mine	Type of mine[3]	Operator	Type of lease[1]	Production 1976	Production 1977	Production 1978	Production 1979	1980 status[4]	Map No.[2]
				Thousand tons					
Routt									
Apex #2	U	Sunland	F	14.2	10.4	14.4	0	I	48
Denton		Melner Coal		8.3	0	0	0	C	
Edna	S	Pittsburg & Midway	P,F	1140.2	1094.3	962.8	1165.9	A	49
Energy #1	S	Energy Fuels	P,F	1478.2	3048.6	2909.3	2353.3	A	50
Energy #2	S	Energy Fuels	F	1009.5	416.5	261.8	654.3	A	50
Energy #3	S	Energy Fuels	P	518.9	385.5	334.7	425.4	A	50
Grassey Creek	S	Rockcastle	P	0	0	17.0	127.4	A	51
Hayden Gulch	S	H-G Coal	P	0	0	0	378.8	A	52
Johnnies Mine	U	Lombardi Jr.	P	0	0	0	0	S	53
Meadows #1	S	Sun Coal	P	0	62.9	207.8	201.1	A	54
Middle Creek	U	Ener							
Seneca II	S	Peabody Coal	S	1283.5	1291.0	1372.3	1611.8	A	56
K-400 Strip	S	KCF Associates	P	0	0	0	0	S	57
San Miguel									
Elder	U	Holland & Sons	P	0	0	0.2	0.4	I	
Mad Jack	U	Tri-Island Mining	P	0	0	0	0.2	I	58
Weld									
Eagle		Imperial Coal Co.	P	32.2	0	0	0	C	59
Lincoln	U	Imperial Coal Co.	P	34.6	105.1	72.9	0	C	60

1/ P= private
F= federal
S= state
C= county
X= not available

2/ See Figure 3

3/ S= surface
U= underground

4/ A= active
C= closed
I= idle
S= started

Source: (1, 13, 16)

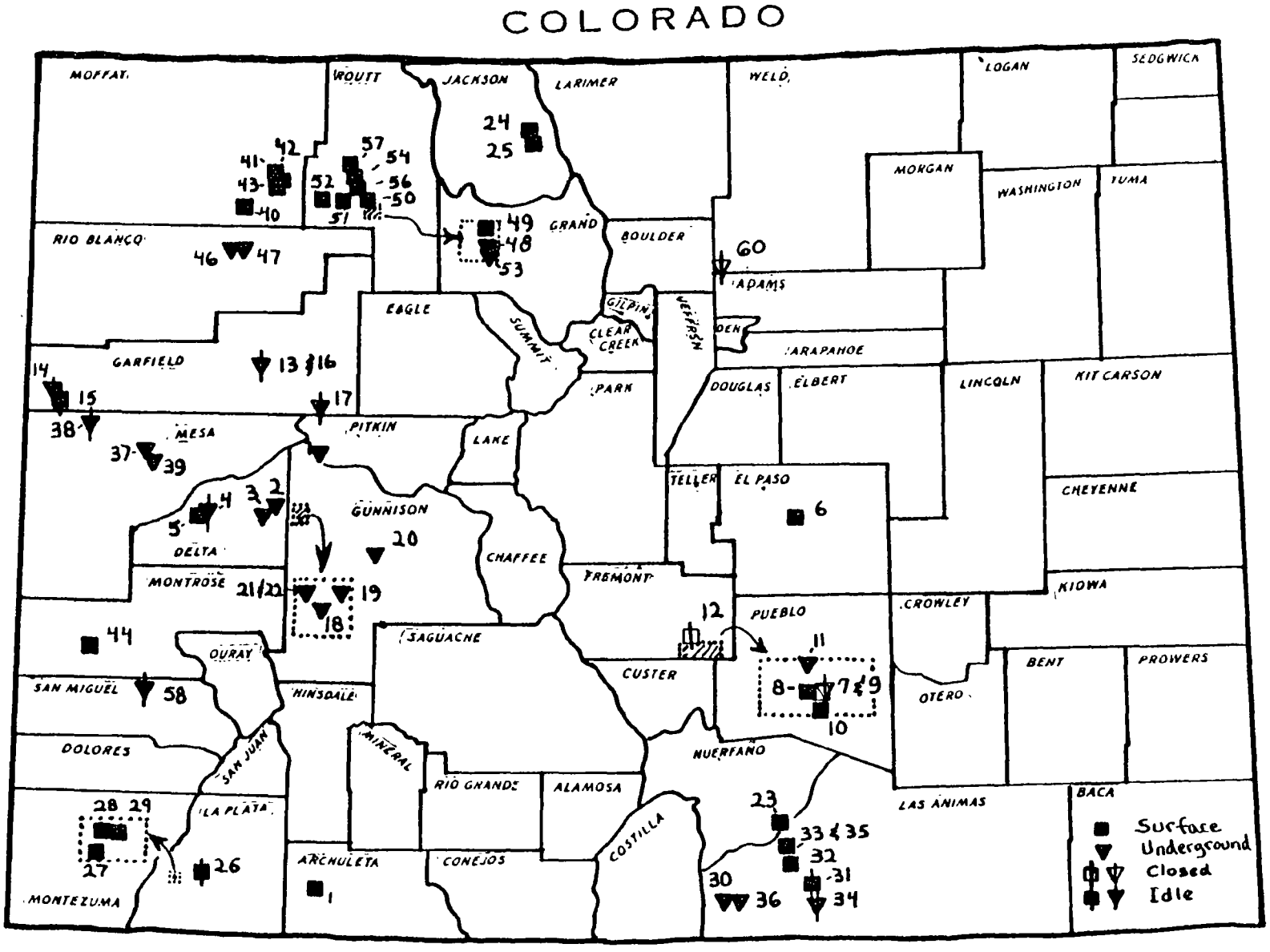


Figure 3. Map of coal mines in Colorado

Table 4--Future Colorado coal mines

County & mine	Type of mine	Operator	Planned production 1980	1981	1982	1983	1984	1985	1990
						Million tons			
Delta									
Farmers	U	Pittsburg & Midway	--	--	--	--	--	1.0	2.0
Garfield									
Unnamed (2 mines)	U	Sheridan Enterprises	--	--	--	--	--	--	4.0
Gunnison									
Mt. Gunnison	U	Arco	--	--	--	--	--	0.2	2.8
Jackson									
Bourg	S	Flatiron Paving				no information			
Unnamed	S	AMCA	--	--	--	--	2.0	2.0	2.0
Las Animas									
Lorencito	S/U	Freeport	--	--	--	--	0.2	0.6	0.6
Mesa									
Cottonwood Creek #1, 2	U	Mid-Continent				no information			
Coal Canyon	U	Mid-Continent				no information			
McGinley	U	Village Land	0.1	0.1	0.2	0.2	0.2	0.3	--
Moffat									
Eagle #6 & 7	U	Empire Energy	--	--	0.8	0.9	1.0	1.5	1.5
Sugarloaf		Energy Fuels	--	--	--	--	1.0	2.0	2.5
Rio Blanco									
Deserado	U/S	Western Fuels	--	--	--	--	1.2	1.2	1.2
Meeker		Consol	--	--	--	--	--	0.8	1.6
Routt									
Fish Creek	U	Pittsburg & Midway	--	--	--	0.3	0.1	0.3	1.3
Trout Creek	U	Pittsburg & Midway	--	--	0.1	0.3	0.4	0.4	0.4
Trout Creek	U	Sun Coal	0.2	0.2	0.3	0.3	0.3	0.3	0.3
TOTAL			0.3	0.3	1.4	2.0	6.4	10.6	20.2

Source: Keystone Industry Manuals, Office of Surface Mining files, 17

The trend toward siting coal consuming plants near raw material sources, rather than at electric load centers, will ease Colorado's distance and cost problems. Most expansion in Colorado's coal industry will take place west of the front range.

Mine Employment

Table 5 summarizes mine employment, production and productivity for Colorado from 1975 through 1979. The number of mines increased significantly between 1975 and 1976 but has remained relatively stable since. The number of underground mines increased by 19 in 1975-79 while there were 11 new strip mines.

The number of employees has increased rather steadily from 1,914 in 1975 to 4,366 in 1979, a 128 percent increase. Most of the increase came in strip mining which increased from 399 employees in 1975 to 1,751 employees in 1979, a 339 percent increase. Nearly one-half (46 percent) of the total number of employees were employed in underground mining in 1979 but only 32 percent of total production came from underground mines.

Table 5 also indicates that mines in Colorado are getting bigger. The average number of employees per mine increased from 43 in 1975 to 59 in 1979. Average production per mine increased from 186,000 tons in 1975 to 245,000 tons in 1979, a 32 percent increase. Almost all the increase came in the strip mining portion of the industry. The number of employees in strip mining more than doubled between 1975 and 1979 while the average production per strip mine increased 40 percent.

Total average productivity per employee decreased by 216 tons over the 1975-79 period. This was a 4.9 percent decrease, nearly 0.5 per year. This total average figure masked a substantial decrease in productivity in strip

Table 5--Colorado coal mine employment and productivity, 1975-79

Category	1975	1976	1977	1978	1979
Number of Mines	45	60	68	67	74
Underground	30	38	47	41	49
Strip	14	20	19	26	25
Auger	1	2	2	0	0
Employees (number)	1,914	2,259	2,944	3,645	4,366
Underground	1,209	1,382	1,637	1,856	2,025
Surface	306	330	343	429	590
Strip	399	547	964	1,360	1,751
Production (tons)[1/]	8,364,326	9,461,513	11,971,143	14,359,399	18,134,726
Underground	3,468,148	3,348,634	4,243,375	4,542,864	5,860,866
Strip	4,896,178	6,109,626	7,726,604	9,816,535	12,273,860
Auger	0	3,253	1,164	0	0
Average days worked per mine	161	149	169	179	177
Man-hours worked	3,627,135	4,339,966	5,632,504	6,306,176	8,912,455
Daily production per miner (tons)	27	28	24	22	23
Daily capacity of all mines (tons)	44,382	63,500	70,835	80,220	102,456
Average employees per mine (number)	43	38	43	54	59
Underground	40	36	35	45	41
Strip	28	27	51	52	70
Average production per mine (tons)	185,874	157,692	176,046	214,319	245,064
Underground	115,605	88,122	90,285	110,802	119,610
Strip	349,727	305,481	406,663	377,559	490,954
Auger	0	1,626	582	0	0
Average production per employee (tons)	4,370	4,188	4,066	3,939	4,154
Underground	2,869	2,423	2,592	2,448	2,894
Strip	12,271	11,169	8,015	7,218	7,010

1/ These production numbers, obtained from State sources, do not agree with the numbers obtained from Federal sources, shown in Table 7. The unexplained disparity is wide for 1975, 1976 and 1977. Differences for 1978 and 1979 are not great.

Source: (1, 2, 3, 4, 5)

mining; from 12,271 tons per employee in 1975 to only 7,010 tons in 1979, a 43 percent decrease. Underground mine productivity per employee remained relatively stable over the period. An average employee in an underground mine produced slightly less than one-half what his counterpart in a strip mine produced in 1979 (2,894 tons vs. 7,010 tons).

Mine Land Disturbance and Reclamation

The acres of land disturbed per unit of production varies greatly between underground and strip mines, and even between mines of the same type, because of coal quality, depth of overburden, and thickness of the seam. The U.S. Department of Agriculture Coal Use and Development Project at Colorado State University has estimated land disturbance per million tons of production (Table 6). The Project has determined that strip mines disturb roughly three times as many acres per unit of production as underground mines. Projections of coal production in Colorado indicate that about 750 acres will be disturbed annually by 1985. Each acre of land disturbed to produce coal usually requires an acre of reclamation.

Table 6--Estimated land disturbance by Colorado coal production

Area	Land disturbance Acres per million tons
Strip mines	
Northwest	49
West	46
Southwest	58
Underground mines	
Northwest	18
West	20
Southeast	18
Projected, 1985, statewide	48

Source: U.S. Department of Agriculture Coal Use and Development Project

Distribution of Colorado Coal

Colorado coal was distributed to 12 states in 1975 (Table 7). By 1979 it was being distributed to 21 states. During that period Colorado coal production doubled. Distribution within the state increased from 5.76 million tons in 1975 to 9.95 million tons in 1979. California, Colorado, and Utah each used over one million tons of Colorado coal in 1975. By 1979 Illinois and Indiana had joined that trio as the use of Colorado coal in the electric utility industry increased. Arizona, Iowa, Mississippi, Nebraska, and Texas were also big users of Colorado coal by 1979. Most Colorado coal used in California and Utah was metallurgical grade.

Colorado Coal Consumption

Total consumption of coal in Colorado was 13.25 million tons in 1979 (Table 8). This was an increase of 10.30 million tons or 449 percent over the 1960 consumption of 2.95 million tons. The majority of coal consumed in Colorado in 1979 went to electric utilities (11.58 million tons or 87 percent). Electric utilities consumed 41 percent of the total in 1960. Coal use by electric utilities increased 948 percent from 1960 to 1979 and 376 percent from 1971 to 1979. The industrial-commerical sector was the second largest user in 1979. In 1960 it was the largest user, accounting for 55 percent of total state consumption. The consumption in the industrial sector has remained constant in the years from 1960 to 1978. Figure 4 indicates the location of the major coal-burning facilities in 1979.

Residential, commercial, and transportation coal use was a small portion of total coal use in 1960. Residential and commercial uses nearly disappeared by 1975 but have since returned to nearly their 1960 levels. Transportation

Table 7--Distribution of Colorado coal, 1975-1979

Destination	1975	1976	1977	1978	1979
			Thousand tons		
Arizona	--	1	--	8	518
California	1,070	1,175	1,171	925	1,029
Colorado	5,760	5,850	5,252	7,114	9,946
Idaho	--	--	11	17	11
Illinois	14	1,084	1,712	2,030	1,767
Indiana	2	20	259	524	1,210
Iowa	160	220	353	814	606
Kansas	--	--	19	92	--
Mexico	221	18	--	22	12
Michigan	42	--	--	--	3
Minnesota	101	--	--	11	5
Mississippi	--	--	--	256	664
Missouri	--	--	--	672	--
Montana	28	38	31	12	31
Nebraska	205	189	353	381	414
Nevada	--	13	50	37	71
New Mexico	--	18	1	30	87
Ohio	63	276	--	--	--
Oklahoma	--	--	--	--	9
Oregon	--	1	3	3	2
Pennsylvania	5	--	--	--	--
South Carolina	--	--	--	2	--
South Dakota	--	12	9	10	5
Tennessee	--	--	--	2	1
Texas	--	--	--	39	639
Utah	1,407	1,388	1,494	1,224	1,247
Washington	--	6	3	5	11
Wisconsin	--	--	--	9	--
Wyoming	--	--	10	1	--
Destinations not revealable	9	2	7	--	--
Destination not available	11	--	--	--	--
Coal used at mines	13	11	--	3	7
Net change in mine inventory	43	14	--	--	--
Total[1/]	9,064	10,363	10,738	14,243	18,295

1/ These production numbers, obtained from Federal sources, do not agree with the numbers, obtained from the State sources, shown in Table 5. The unexplained disparity is wide for 1975, 1976, and 1977. Differences for 1978 and 1979 are not great.

Source: (8, 9, 10, 19, 20)
-- = no shipments reported

Table 8--Consumption of coal energy by type, Colorado, 1960-1978

Year	Total	Residential	Commercial	Industrial	Transportation	Electric utilities
			Thousand short tons			
1960	2,951	90	167	1,448	25	1,221
1961	3,293	95	177	1,628	8	1,386
1962	3,395	115	214	1,511	6	1,549
1963	3,811	94	174	1,714	7	1,823
1964	3,847	102	190	1,644	6	1,904
1965	4,242	112	207	1,736	6	2,181
1966	4,765	120	222	1,699	5	2,719
1967	4,781	95	176	1,530	4	2,977
1968	4,960	98	183	1,692	4	2,983
1969	4,610	110	204	1,418	2	2,877
1970	5,112	80	149	1,668	3	3,212
1971	4,611	78	145	1,309	2	3,077
1972	5,307	78	145	1,678	2	3,404
1973	6,301	63	116	1,742	1	4,379
1974	6,492	35	66	1,650	1	4,740
1975	7,602	7	14	1,870	0	5,710
1976	9,022	19	35	1,688	0	7,280
1977	10,692	28	53	1,774	0	8,837
1978	10,535	75	139	1,377	0	8,945
1979	13,252	58	--- 1,617 ---		0	11,576

Source: (9, 11)

sector coal use declined to zero in 1975 when coal-fueled locomotives were phased out. It is not expected to reappear. (However, both the Cumbres-Toltec and Durango-Silverton recreational scenic railroads are fueled by Colorado coal).

Existing Coal-Fired Electric Generating Plants

Coal-fired electric generating plants are generally estimated to burn about 3 million tons of coal per 1,000 megawatts of installed capacity. Table 9 lists current coal-fired electric generating plants in Colorado. Their locations are shown in Figure 4. The power plant sizes given are the

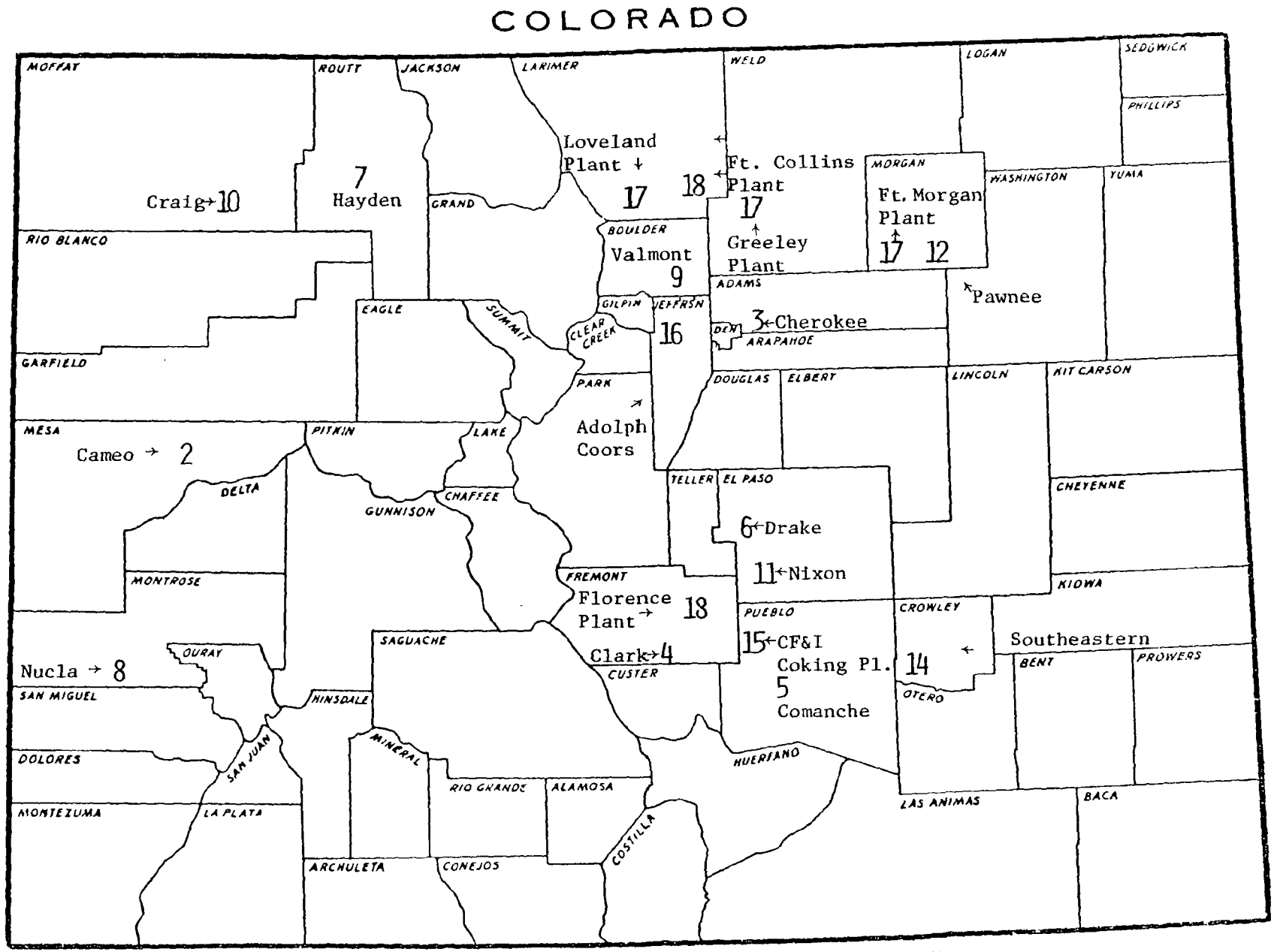


FIGURE 4. MAJOR COAL-FIRED FACILITIES IN COLORADO 1979

Table 9--Existing coal-fired electric generating plants in Colorado

Power plant, town, utility and location	Nameplate capacity	Year	Amount received	Amount burned	Mine source 2/	Water source
	MW		Thousand tons	Percent		
Arapahoe	232	1975	575.2	66	Edna	South Platte River
Denver		1976	607.9	72	Energy	
Public Service Co. of Colorado		1977	931.2	94	Eagle	
Denver County		1978	635.3	93	Lincoln	
		1979	853.1	1/	Rosebud (WY)	
Cameo	66	1975	157.4	60	Edna	Highline Canal
Palisade		1976	168.7	58		
Public Service Co. of Colorado		1977	176.6	52	Energy	
Mesa County		1978	152.6	63	Bear	
		1979	162.2	1/	Apex #2	
					King	
					Edna	
Cherokee	710	1975	2,517.5	79	Energy	South Platte River
Commerce City		1976	1,681.7	87	Belle Ayr (WY)	
Public Service Co. of Colorado		1977	2,031.8	93	Eagle	
Adams County		1978	1,919.4	98	Rosebud (WY)	
		1979	1,973.6	1/	Big Horn (WY)	
Clark	42	1975	97.0	52	Cedar Canyon	Arkansas River
Canon City		1976	110.5	59	Twin Pines	
Central Telephone Utility		1977	123.6	68		
Fremont County		1978	137.3	81		
		1979	182.3	1/		
Comanche	700	1975	1,607.5	99	Belle Ayr (WY)	St. Charles River
Pueblo		1976	2,638.5	100	Eagle Butte (WY)	
Public Service Co. of Colorado		1977	2,537.5	100		
Pueblo County		1978	2,817.3	100		
		1979	2,734.1	1/		

Continued

Table 9--Existing coal-fired electric generating plants in Colorado--continued

Power plant, town, utility and location	Nameplate capacity	Year	Amount received	Amount burned	Mine source 2/	Water source
	MW		Thousand tons	Percent		
Drake, Martin	262	1975	458.5	67	Edna	Colorado Springs
Colorado Springs		1976	685.3	89	Empire	
Colorado Springs Public Utilities		1977	891.0	90	Sunflower	
El Paso County		1978	727.5	99	Colowyo	
		1979	1,016.6	1/	Corely S & A	
					Eagle #5	
Hayden	460	1975	645.1	100	Seneca	Yampa River
Hayden		1976	934.2	100		
Colorado-Ute Electric Assn.		1977	1,068.0	100		
Routt County		1978	1,553.0	100		
		1979	1,692.0	1/		
Nucla	37	1975	101.9	100	Nucla	San Miguel River
Nucla		1976	96.7	100		
Colorado-Ute Electric Assn.		1977	93.1	100		
Montrose County		1978	101.3	100		
		1979	119.0	1/		
Valmont	274	1975	230.9	33	Energy	City of Boulder
Boulder		1976	265.5	43	Rosebud (WY)	
Public Service Co. of Colorado		1977	462.4	66	Eagle	
Boulder County		1978	508.8	71		
		1979	435.3	1/		

1/ Not available

2/ The mine source does not apply to any specific year and may not be an exhaustive list for each plant.

Source: Federal Energy Regulatory Commission Form 423 data for 1975-79. The utility companies report slightly different data. Plants with units totaling less than 25 MW are not included. Examples are the Bullock, Oliver and Walsen plants.

nameplate ratings. The actual generation capacity varies with quality and type of fuel used, elevation and temperature, and pollution control technology.

Most coal-fired power plants in Colorado are 100 percent coal burning. Some use supplementary gas or oil. The amount of coal burned annually in 1975 through 1979 is given in Table 9. The Colorado mines listed as the coal sources were described earlier in this report. The transportation system for coal distribution is discussed subsequently. Water consumption is also described below and is generally estimated between 6 and 7 lb. of water per lb. of coal.

According to Table 9, in 1979 the Public Service Company of Colorado burned approximately 6,158,300 tons of coal. Colorado-Ute Electric Assn. burned 1,811,000 tons, Colorado Springs Public Utilities burned 1,016,600 tons, and Central Telephone Utilities burned 182,300 tons of coal. Approximately 9.2 million tons of coal were burned during 1979 by Colorado utility companies in large units to generate electric power.

New Coal-Fired Electric Generating Plants

There are four new coal-fired electric generation plants planned for Colorado in 1980-1985 (Table 10 and Figure 4). These power plants will all be 100 megawatts or greater in nameplate capacity. Six units are scheduled for operation at the four power plant location sites.

The Colorado-Ute Electric Association, Inc. is planning two more units to join the Craig 1 unit located at Craig in Moffat County. Unit 2 began operation in early 1980 and has a nameplate capacity of 400 megawatts. Unit 2 will require 1,225,000 tons of coal per year. All its coal is to be supplied by the Utah International Trapper Mine located in Moffat County, making this

Table 10--Proposed new coal-fired electrical generation capacity 100 megawatts or greater, Colorado, 1980 to 1990.

Utility and plant	Operating date	County	Town	Capacity	Coal required	Coal source			Water source
						State	County	Mine	
	Year			MW	Tons				
Colorado-Ute Electric Association, Inc.									
Craig 1	1980	Moffat	Craig	400	1,225,000	Colorado	Moffat	Trapper	Yampa River
Craig 2	1980	Moffat	Craig	400	1,225,000	Colorado	Moffat	Trapper	Yampa River
Craig 3	1983	Moffat	Craig	400	1,225,000	Colorado	Moffat	Colowyo	1/
Southwestern	1988	Delta or Mesa	Delta or Mesa	800	3,000,000	Colorado	Garfield	Unnamed	1/
Craig 4	1990	Moffat	Craig	400	1,225,000	Colorado	Moffat	Trapper	1/
Colorado Springs Department of Public Utilities									
R.D. Nixon 1	1980	El Paso	Fountain	200	750,000	Colorado	Moffat	Colowyo	Ground water
R.D. Nixon 2	1988	El Paso	Fountain	350	767,000	Colorado	Moffat	Colowyo	Transmountain Diversion
Public Service of Colorado									
Pawnee 1	1981	Morgan	Brush	500	1,600,000	Wyoming	Campbell	Belle Ayr Eagle Butte	South Platte via new reservoir
Pawnee 2	1987	Morgan	Brush	500	1,600,000	1/	1/	1/	South Platte
Southeastern #1	1988	1/	1/	500	1,600,000	1/	1/	1/	1/
Southeastern #2	1990	1/	1/	500	1,600,000	1/	1/	1/	1/
Platte River Power Authority									
Rawhide 1	1985	Larimer	Wellington	250	800,000	Wyoming	Converse	NERCO Inc.	Colorado River via transmountain diversion

1/ Unknown

Source: Scenario tables are generated from multiple sources and maintained by researchers at Colorado State University. All units, especially those scheduled for more distant years, are subject to delay or cancellation.

a mine mouth operation. Units 1 and 2 get their cooling water from the Yampa River. The Colorado-Ute Electric Association is also planning a third unit for operation in 1983. This unit will also be 400 megawatts in capacity and will use approximately 1,225,000 tons of coal per year. Coal for this third unit, and additional coal for units 1 and 2, will be obtained from the Colowyo mine near Axial, Colorado. A water source for this third unit has not been identified. Colorado-Ute is also planning a fourth unit at the Craig Station for 1990 and a unit in Delta or Mesa County in 1988. The operating dates for these latter two units is very uncertain.

The Colorado Springs Department of Public Utilities is planning two units for the R.D. Nixon plant at Fountain, Colorado in El Paso County. The first unit is to be operational in 1980. It is a 200 megawatt unit using 750,000 tons of coal per year. This coal is scheduled to be obtained from the Colowyo mine located in Moffat County. The water source for the two units will be ground water wells and transmountain diversion return flows. Unit 2 of the Nixon plant is scheduled for operation in 1988. It will be a 350 megawatt unit using at least 767,000 tons of coal per year. The mine source has not been determined.

Public Service of Colorado is planning one new coal-fired electric generation plant in the 1980-1985 period. Unit 1 of the Pawnee plant will be located near Brush in Morgan County. It is scheduled for operation in 1981. It will be a 500 megawatt unit requiring 1,600,000 tons of coal annually. The coal is scheduled to come from the Belle Ayr mine in Campbell County, Wyoming and possibly from a mine in Utah. The water source will be the South Platte River via a new reservoir now being planned. The scheduled operating date for the second unit of the Pawnee plant is 1987. It will also be a 500 megawatt unit using approximately 1,600,000 tons of coal annually. The coal is also expected to come from the Belle Ayr mine in Campbell County, Wyoming.

Public Service of Colorado is also planning two units to be located somewhere in southeastern Colorado. Each unit will be 500 megawatts in capacity and use approximately 1,600,000 tons of coal annually. The coal is likely to come from Wyoming. The water source for these units is not known.

The Platte River Power Authority is planning a unit for the Rawhide Plant to be located near Wellington in Larimer County. This unit is scheduled for operation in late 1984 or early 1985 and will be 250 megawatts in capacity. It will use approximately 800,000 tons of coal annually from the Northern Energy Mine in Converse County, Wyoming. Water will be from the Upper Colorado River via a transmountain diversion.

Industrial Coal Use

Consumption of coal by the industrial sector has declined for several years (Table 8). This is the result of increasing dependence by the sector on electric utilities for energy. However, in 1976 and 1977, the industrial sector used 1,688 and 1,774 thousand tons,respectively (18.7 and 16.6 percent of total coal use). (11) Table 11 lists in-state and out-of-state industrial users of Colorado coal in 1976 and 1977. Table 12 lists the same information for institutional users.

Water Uses in Steam Electric Generation

Water is used in all aspects of the conversion of coal to electricity. It is a primary input to all processes from mining the coal to the electric energy end product. This section describes the major water uses involved in the coal-fired generation of electric power. There are three major uses in fossil-fired electric generation plants besides process conversion.

Cooling

Water serves as the primary medium for the transfer of heat from the conversion process to the outside environment. The ability of a given generation

Table 11--Industrial users of Colorado coal, 1976 and 1977

Company	Location	Mine source
Adolph Coors Company	Golden, CO	Lincoln, King, Eagle
Great Western Sugar	Fort Morgan, CO	Edna
Great Western Sugar	Greeley, CO	Edna
Great Western Sugar	Loveland, CO	Edna
Corn Products CPC International, Inc.	Pekin, IL	
Ideal Basic Cement	Florence, CO	
Ideal Basic Cement	Ft. Collins, CO	
CF & I Steel	Pueblo, CO	Hawk's Nest, Wise Hill #5
Colorado Fuel & Iron Co.	Pueblo, CO	Hawk's Nest, Wise Hill #5
U.S. Steel	Orem, UT	Somerset, Bear Creek, Coal Basin, Dutch Creek 1 & 2, L.S. Wood
CF & I Coke Plant	Pueblo, CO	Allen, Maxwell
U.S. Steel	Fontana, CA	Bear Creek, Coal Basin, Dutch Creek 1 & 2, L.S. Wood
American Smelting & Refining	Helena, MT	Bear
Holly Sugar	Delta, CO	Bear
Kennecott Copper	McGill, NV	Bear
Henderson Mill (AMAX)	Henderson, CO	Marr Strip #1
Cumbres-Toltec Railroad	Antonito, CO	King
Durango-Silverton Railroad	Durango, CO	King
Ash Grove Cement	Louisville, NE	Edna
Great Western Sugar	Gering, Bavard, NE	Edna
Celanese Chemical, W.R. Grace	Pampa, TX	Hayden Gulch (1979)

Source: (7)

Table 12 --Institutional users of Colorado coal, 1976

Company	Location	Mine source
Colorado State Penitentiary	Canon City, CO	Black Diamond
Colorado State Hospital	Pueblo, CO	Black Diamond
Pueblo Army Depot	Pueblo, CO	Bear
Iowa State University	Ames, IA	Canadian Strip
Colorado School for Deaf & Blind	Colorado Springs, CO	Healey Strip
Nucla School District	Nucla, CO	Nucla

Source: (7)

plant to effectively remove heat is a major determinant of the generating efficiency of the plant. If heat cannot be effectively removed the efficiency of the conversion process will be lower, thereby increasing the cost of generation.

There are four types of cooling systems presently in use.

1. Once-through-cooling where water is withdrawn from a source, used for cooling, then returned to the source.

2. Cooling ponds or canals where a stationary body of water is used as the source of withdrawal and the water, when returned to the source, dissipates the heat to the atmosphere.

3. Wet cooling towers where water is withdrawn from a body of water, circulated through condensers, pumped into towers, and allowed to fall in small droplets. The water is usually collected and recycled through the plant. The term "make-up" water applies to this method because a portion of the water evaporates during the process and must be replaced. Wet cooling towers consume more water than do once-through-cooling or cooling pond systems. Consumptive use varies with ambient weather conditions. A further distinction is made between mechanical and natural draft towers. Mechanical draft towers use fans to increase the movement of air through the tower while natural draft towers are designed to allow efficient movement of air without mechanical assistance.

4. Dry cooling towers employ the same concept as wet (evaporative) cooling towers except that air is used as the transfer medium. Towers can be mechanical or natural draft. Dry cooling also depends greatly on ambient air conditions which affect the ability of the generation plant to operate efficiently, i.e., the ability of warm air to "take-on" additional heat is limited.

Cooling systems may be used in combination, depending on local conditions. Wet and dry cooling towers may be used simultaneously in arid areas. The basic determinant of the cooling system installed is availability of water and its associated cost.

Ash Sluicing

The removal of ash resulting from the burning of coal provides another demand for water. Ash (slag) collects at the bottoms of the furnaces and water serves as a means of removal. Water also may be used to remove fly ash,

i.e., the ash that escapes with the hot gases of the stack after the coal is burned. The amount of ash removal (bottom and fly) depends on the ash content of the coal being burned.

The amount of water required for ash removal is significantly less than for cooling. Water is mixed with ash and the resulting sludge is piped to settling ponds. After the water evaporates ash is disposed. Several ash disposal systems allow for partial recovery of the water. There are also other systems of ash disposal with differing water requirements. Projections of water use for this purpose should reflect the method of ash disposal planned for the unit.

Flue Gas Desulfurization

Water is also used to remove particulates and sulfur dioxide gases generated as coal is burned. The efficiency of sulfur dioxide removal depends on the type of scrubbing process and the scrubbing agent.3/

Existing and Future Water Requirements

This section examines the water use and consumption of existing plants (Table 13) and the expected demands of coal-fired plants scheduled for operation by 1985 (Table 14). Primary water demands and consumptive uses, in addition to the conversion process, include cooling of waste heat, ash sluicing (ash removal from boilers and furnaces), and flue gas desulfurization (sulfur dioxide and particulate removal from stack gases). Table 13 identifies withdrawal, consumption, discharge, and sources of water for coal-fired power

3/ Knowledgeable industry executives indicate that the cost of removing the smaller quantity of SO_2 in low sulfur coal is much greater on a per unit basis than with high sulfur coal. Thus, 90 percent removal from high sulfur coal is cheaper and easier than 90 percent removal from low sulfur coal.

Table 13--Water use in coal-fired electric generation plants over 100 megawatts in Colorado, 1975.

Plant	Nameplate plant capacity	Water withdrawal	Water discharge	Water consumption	Source	Type of cooling system3/
	MW	Cubic feet per second				
Drake	268	2.3	0.4	1.9	Municipal	CP,CT
Hayden	190	5.4	1.0	4.4	Yampa R.	CT
Arapahoe	250	4.1	0.9	3.2	S. Platte R.	CT
Cherokee	801	31.4	14.9 1/	16.5 1/	S. Platte R.	CT
Comanche	765	6.3	2.1	4.2	St. Charles R.	CT
Valmont	281	4.5	2.4	2.1	Reservoir	CP
Total	2,555	54.1	21.6	32.5		
		Acre-feet per year 2/				
		39,158	15,634	23,523		

1/ The discharge and consumption of water varied considerably from the data reported for 1973 for the same plant.
2/ Based on conversion of cubic feet per second to acre-feet per year.
3/ CP = cooling ponds
CT = cooling towers

Source: Federal Energy Regulatory Commission, 1975 Form 67 computer data tapes and information provided by utilities.

plants 100 megawatts or greater in 1975. A cubic foot per second (CFS) is equivalent to 723.8 acre-feet per year. Total water withdrawal for the six existing plants (assuming that requirements and consumption do not vary greatly from year to year) is 39,150 acre-feet per year. Consumption is 23,500 acre-feet per year and discharge is 15,600 acre-feet per year.

Two of the six existing Colorado plants use cooling ponds in combination with wet cooling towers. The remaining four plants have cooling towers.

Table 14--Projected coal-fired electric generation plants over 100 megawatts in Colorado.

Plant	Units	Plant capacity	Water withdrawal 1/	Water discharge 2/	Water consumption 2/	Type of cooling
	No.	MW	---Cubic feet per second------			
Nixon	1	200	4.1	1.6	2.5	tower
Craig	3	1200	20.3	0	20.3	tower
Pawnee	1	500	10.3	4.1	6.2	tower
Rawhide	1	250	4.7	1.9	2.8	tower
Total	6	2,150	39.4	7.6	31.8	
				Acre-feet		
			28,500	5,500	23,000	

1) Estimates of total water demands (from various published sources) of coal-fired plants utilizing wet cooling towers range from 9,300-15,200 acre-feet per MW of generating capacity. Plants utilizing cooling towers in Colorado in 1975 used approximately 15,000 acre-feet per MW.

2) Based on the current discharge and consumption rates of existing plants in Colorado, a gross estimate of discharge is 40 percent. The Craig units are zero discharge units.

Wet cooling tower techniques result in substantial quantities of water being consumed (approximately 60 percent of total withdrawal in 1975) relative to other cooling methods such as once-through-cooling. National rates do not reflect the high rate of consumption demonstrated in Colorado. Since the majority of coal-fired plants in the U.S. in 1975 utilized once-through-cooling (181 of 297 plants over 100 MW), national consumption rates are lower. However, future trends indicate increased use of cooling towers due to competing water uses and increased costs of acquiring sufficient water resources. Plants employing wet cooling towers are the greatest users of water in terms

of consumptive rates. Consumptive rate becomes an important issue because this water is removed from the source and not returned. Thus downstream users, such as agriculture, have less available for their use.

Current projections indicate that 6 coal-fired units with a total megawatt capacity of 2,150 will be constructed by 1985. Table 14 identifies each plant and unit and estimates the consumptive water use. All future plants are designed to utilize mechanical cooling towers.

Water, important in the process conversion of fossil fuels to electric power, also serves a primary role in cooling and removal of other wastes. Since the Clean Air Act of 1970 and the Water Act of 1972 electric power utilities and companies have had to comply with stringent Federal air and water quality standards. Utilities have been forced to install equipment to reduce or eliminate thermal and air pollution from new and existing plants.

The consumptive use of water associated with new coal-fired steam electric plants in Colorado depends on two interdependent factors. These factors, in order of importance, are thermal efficiency and plant design. All of the 6 new units projected for Colorado are expected to use wet cooling towers. When all 6 units are constructed, annual water withdrawal requirements for process conversion, cooling, ash disposal, and flue gas scrubbing is estimated to be 28,500 acre-feet. The amount of water evaporated (consumptive use) ranges between 60 and 80 percent and could reach 90 percent as technology advances (i.e., zero discharge designed units such as the Craig units). Estimated annual consumptive use ranges from 17,000 to 28,500 acre-feet, equivalent to annually applying 12 inches of water to 24,000 irrigated acres (assuming an 80 percent evaporative rate). [4/] Water consumption by thermal

4/ These estimates are based on criteria discussed in Davis, George H. and Leonard A. Wood, Water Demands for Expanding Energy Development, Geological Survey Circular 703, U.S. Department of Interior, Washington, D.C., page 8.

generation plants is expected to increase relative to withdrawal. Greater emphasis on thermal and air pollution control has contributed to increased consumption of water. Projected fresh water withdrawals are expected to reach a maximum about 1985 and then decrease slightly by the year 2000 as more plants utilize closed evaporative systems. 5/

Solid Waste Removal

Water also plays a major role in the removal and disposal of wastes generated at coal-fired electrical power plants. Table 15 indicates the major coal and chemical solids used for treatment of water in Colorado's six large coal-fired plants. It also lists quantities of disposable wastes. The primary inputs include coal, oil, and/or natural gas, and the chemicals used in cooling and boiler water makeup. The primary waste, for which water serves as a transfer medium, is ash (top-stack and bottom-boiler). Waste heat is a form of waste but difficult to capture. 6/

The total reported solid wastes from the six plants in 1975 was 450,400 tons of ash. Solid waste as a percent of total coal and chemicals used averaged 11.2 percent for the six facilities. Waste heat loss in 1975 was 19,350 billion Btu (excluding the Drake plant), equivalent to 967,500 tons of coal with an average energy content of 10,000 Btu per lb. (18 percent of the total coal utilized in 1975. If technology were available to capture the waste heat plant efficiencies would be increased substantially (estimated 14 to 15 percent). This could result in a plant efficiency rate of 45 to 55 percent compared to the present 30-40 percent rate.

5/ U.S. Water Resources Council, Supplemental Reports to the Second Annual National Water Assessment - Water for Energy, Number 1, 2120 L Street N.W., Washington, D.C., 1978, p. 3.

6/ Waste heat is unused heat which escapes through equipment, air, and water.

Table 15--Existing and projected solid inputs, wastes, and waste head for coal-fired power plants in Colorado

Category	Unit	Plant							Change 1975-85
		Drake	Hayden	Arapahoe	Cherokee	Comanche	Valmont	Total	Percent
Solid input 3/									
Coal	Thousand tons	441.6	648.1	645.1	2,151.1	1,218.4	179.8	5,284.1	
Oil	Thousand gallons	0	266	0	0	1,425.8	0	1,691.8	
Natural gas	Billion cubic feet	4.430	0	7.065	12.131	0.036	7.365	31.027	
Cooling makeup	Tons-chemicals	4.67	85.72	2.50	92.32	533.77	13.50	732.48	
Boiler makeup	Tons-chemical	0.15	59.90	4.68	9.51	174.89	1.06	250.19	
Solid wastes									
Ash disposal	Thousand tons	42.9	68.2	52.8	199.6	71.8	15.1	450.4	
	Thousand tons	(42.9)	(160.0)	(15.9)	(161.3)	(119.8)	(25.4)	(525.3)	+16.6
Air Emissions									
Sulfur oxides	Thousand tons	6.4	5.8	7.3	22.4	34.9	3.0	79.8	
	Thousand tons	(6.4)	(4.7)	(2.4)	(17.5)	(31.9)	(4.9)	(67.8)	-15.0
Nitrogen oxides	Thousand tons	4.0	2.1	7.3	21.7	11.1	3.1	49.3	
	Thousand tons	(4.0)	(5.2)	(1.9)	(15.8)	(17.1)	(2.8)	(64.5)	+30.8
Waste heat	Trillion Btu	N/A	1,037	3,478	8,307	4,332	2,196	19,350	
	Trillion Btu		(2,560)	(841)	(5,751)	(7,057)	(1,341)	(17,550)	-9.3

1/ The numbers in parenthesis represent estimates of wastes.
2/ Drake plant is excluded from total. Waste heat losses are via stack gases.
3/ Most input numbers do not agree with data furnished by the utilities during the manuscript review process.

Source: Federal Energy Regulatory Commission Form 67, 1975, and data provided by utilities.

Coal Preparation

Coal preparation, benefication, or cleaning refers to the removal of ash, sulfur (inorganic) and other impurities (rock, dirt, etc.) from coal. With the implementation of stringent emission standards the physical cleaning of coal has increased. Coal preparation is not a costly process when compared to retrofitting a power plant with pollution control equipment. Coal characteristics, however, vary tremendously from state to state, from seam to seam, and even within a seam. Therefore, each preparation facility must be designed specifically for coal with certain characteristics.

Water is a very important input in the coal preparation processes. Most coal cleaning utilizes water as a medium to remove impurities. Coal is lighter than most impurities and can be separated. Impurities chemically bound to coal cannot be removed by cleaning (such as organic sulfur). Therefore, the characteristics of certain coals may not be improved by cleaning.

Colorado has two coal preparation facilities. They are the Imperial Coal Company plant located at the Erie mine and Mid-Continent Coal and Coke plant located at Carbondale (Coal Basin Preparation Plant). Data is not available concerning the amount of coal being cleaned or the amount of water being used. The process used by the Erie mine plant is heavy media washers and centrifuges while the Coal Basin plant uses a heavy media washer and flotation units. Both plants require water to separate the impurities from the coal.

Coal Transportation in Colorado

Railroads are the dominant means of transporting coal in Colorado (Figure 5 and Table 16). In general, it is concluded that the railroad's capacity to haul

FIGURE 5

MAJOR COAL RAIL LINKS IN COLORADO

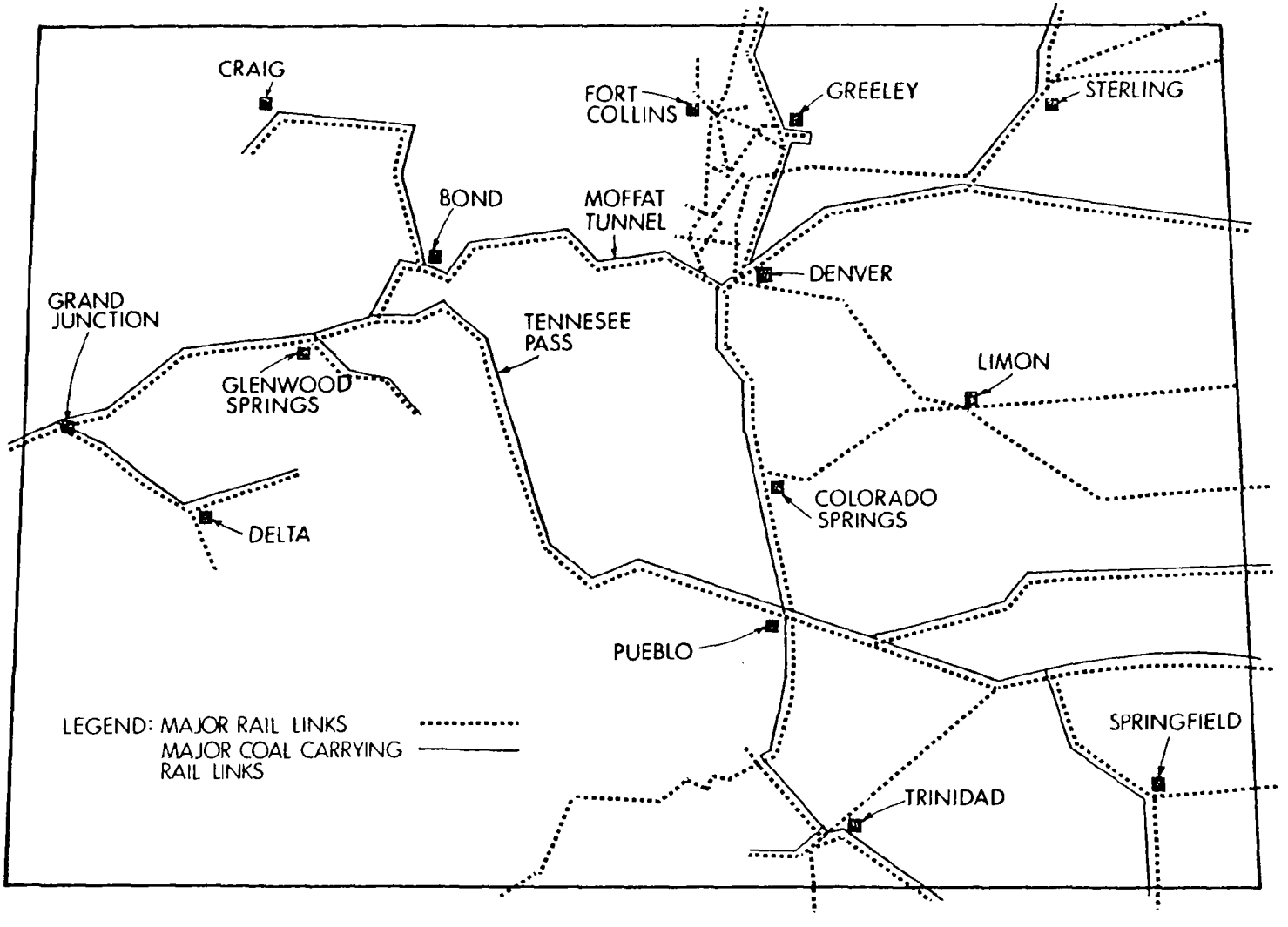


Table 16--Major coal transportation rail links in Colorado

Counties	Connecting Points	Number of Tracks	Signal System	Owning Railroad
Mesa	Utah-Grand Junction	1	CTC	DRGW
Mesa, Garfield	Grand Junction-Glenwood Springs	1	CTC	DRGW
Garfield, Eagle	Glenwood Springs-Dotsero	1	CTC	DRGW
Eagle	Dotsero-Bond	1	CTC	DRGW
Eagle, Lake Chaffee	Dotsero-Pueblo	1	CTC	DRGW
Fremont, Pueblo	(Dotsero/Canon City/Pueblo)	1	CTC	DRGW
Eagle, Grand, Gilpin, Jefferson	Bond-Denver	1	CTC	DRGW
Denver, Adams, Weld, Morgan, Logan	Denver-Brush	1	CTC	BN
Logan	Brush-Peetz	1	ABS	BN/UP
Washington, Yuma	Brush-Wray	1	CTC	BN
Denver, Arapahoe,	Denver-Pueblo			
Douglas, El Paso,	(70 miles)	2	ABS	DRGW/ATSF
Pueblo	(30 miles)	1	CTC	DRGW/ATSF
Pueblo	Pueblo-east of Avondale	2	CTC	MP/ATSF
Crowley, Kiowa	east of Avondale-Towner	1	ABS	MP
Otero	east of Avondale-La Junta	1	ABS	ATSF
Otero, Bent	La Junta-Las Animas	1	ABS	ATSF
Prowers	Las Animas-Kansas border	1	ABS	ATSF
Bent, Baca	Las Animas-Oklahoma border	1	none	ATSF
Pueblo, Huerfano	Pueblo-Walsenburg	2	none	CS/DRGW
Huerfano, Las Animas	Walsenburg-Trinidad	1	ABS	CS
Las Animas	Trinidad-Branson	1	none	CS
Weld, Adams, Denver	Carr-Denver	1	CTC	UP
Las Animas	Allen Mine-Trinidad	1	none	CS
Mesa, Delta	Oliver-Grand Junction	1	none	DRGW
Garfield, Pitkin	Woody Creek-Glenwood Springs	1	none	DRGW
Moffat, Routt	Craig-Bond	1	none	DRGW

NOTES: Abbreviations
ABS = automatic block signals
CTC = centralized traffic control

ATSF = Atchison, Topeka & Santa Fe Railway
BN = Burlington Northern Railroad
CS = Colorado & Southern Railroad (BN subsidiary)
DRGW = Denver & Rio Grande Western Railroad
MP = Missouri Pacific Railroad
UP = Union Pacific Railroad

Source: (26)

coal in and through Colorado by 1985 will be sufficient due to the excess capacity that currently exists and the financial capabilities of the relevant railroads. However, sufficient capacity does not imply a lack of serious impacts. Railroads cause delays at grade crossings, accidents, and right-of-way disturbances. Considerable grade crossing delays are currently being experienced along the front range and such delays will increase as coal use increases unless this problem is mitigated.

Highway trucking of coal is commonly used by small mines for moving coal distances averaging less than 50 miles. Less than 10 percent of Colorado's coal production involves highway trucking. Highway transportation of coal will continue to be a factor for small mines and users not located on rail lines. Electricity can also be generated in a plant at or near the mine site and transported to the consuming region via high voltage transmission lines.

Two coal slurry pipelines are currently in the planning stages which could have an impact on Colorado. One is the Energy Transportation Systems Incorporated (ETSI) pipeline which may pass through Colorado. The other is the San Marco pipeline. The ETSI pipeline is planned to transport Wyoming coal to utilities located in Arkansas and Louisiana. The San Marco pipeline is to transport primarily Colorado coal to Texas utilities. There is significant opposition to slurry pipelines by railroads, environmental groups, and labor groups. The two main issues concerning slurry pipelines are water usage and right-of-way problems.

Colorado is located on rail routes between several coal producing and consuming regions. The major east and southeast rail route serving coal regions in eastern Utah runs through Colorado, a major segment of

which is owned by the Denver and Rio Grande Western Railroad. In theory, Utah coal moving east could be transported via the Union Pacific railroad through southern Wyoming. This does not occur because the Denver and Rio Grande Western, which also services coal fields in eastern Utah, has a longer haul on its own lines by moving coal directly east rather than passing it off in Utah to the Union Pacific Railroad.

East and southbound coal movements from Northwest Colorado will move through Denver using the Moffat Tunnel instead of the Tennessee Pass route for several reasons. The Tennessee Pass route is longer and requires more trains and crews than the Moffat Tunnel route to points east and south and, secondly, the connection of the rail line from Craig to the main line at Bond is physically configured so that westbound movements from the branch line require numerous switching movements. The Moffat Tunnel route is currently more economical. As traffic increases on that segment, it may become more economical to route the empty coal trains returning to the Craig line via the Tennessee Pass.

Existing eastbound capacity should be sufficient to accommodate all levels of projected 1985 movements of Utah and Colorado coal. The existing capacity cushion of east-west trackage will be nearly exhausted under high development scenarios. However, it is reasonable to assume that rail improvements will be made permitting capacity to accommodate traffic requirements.

Existing main line capacity on currently used north-south coal routes will be exhausted on links north of Sterling and south of Walsenberg by 1985. But it is reasonable to conclude that Burlington Northern will expand the capacities of these two links as needed (26). The rail link between

Denver and Pueblo will bear all Montana and Wyoming coal traffic passing through Colorado. The existing capacity of this link can accommodate highest projected 1985 flows although a large number of coal trains will require some changes in present operating procedures.

Conclusions

The primary demand for Colorado coal is for steam-electric power generation. Historically, electrical energy needs of Colorado's residents has been met by a comparatively small regional coal industry. Production of Colorado coal for electrical generation, both in-state and out-of-state, in 1979 was approximately 14.66 million tons. The generation capacity of coal-fired plants within the state was 2,852 megawatts in 1979 requiring 11.576 million tons of coal. Over 26 percent of this demand was supplied by mines in Wyoming.

The status of the coal industry in Colorado will change significantly by 1985. The demand for Western coal will continue to increase because of low production costs, low sulfur content, higher regional electrical demand stemming from rapid growth, and the establishment of a synthetic fuels industry. Colorado utility coal demand will increase from 5.71 million tons in 1975 to approximately 15.4 million tons in 1985, an increase of 270 percent. Colorado utilities plan to add 2,530 megawatts of capacity of which 2,150 megawatts are to be coal-fired. The magnitude of this growth is evident when comparing the 1975 coal-fired capacity, 2,555 megawatts, with the projected 1985 capacity of 4,705 megawatts. In spite of the rapid growth in Colorado coal production, large quantities of coal are contracted from out-of-state sources, primarily Wyoming.

The major impacts of coal development in Colorado will be confined to the producing areas. Nearly 91 percent (3.211 million tons) of 1975 Colorado

steam-coal production originated in Moffat and Routt Counties in northwestern Colorado. In 1985, however, these counties will supply only 79 percent of state production as new mines begin production in other areas of the state. A majority of the increased production will be located in the west-central area of the state, primarily in Gunnison, Pitkin, Delta, Montrose, and Garfield Counties. These counties will increase their steam-coal production from 1,300 tons in 1975 to approximately 2.865 million tons in 1985. Another area projected to experience increased production is the northern front range.

A discussion of specific impacts is beyond the scope of this report. Generally, underground coal mining requires a large labor component. Therefore, those areas with large projected increases in underground mining (west-central Colorado) can anticipate substantial inflows of labor with accompanying increased demands for public services. Since only minor land disturbances are associated with underground mining, significant effects on agriculture or other competing land uses are not anticipated.

The impacts resulting from the surface mining of coal are quite different from those of underground mining. Because of the more capital intensive nature of surface mining and relatively small labor requirements, the employment impacts will not be as severe. Land disturbance, however, is of major concern. Present estimates are for approximately 750 additional acres to be disturbed annually by 1985. All but 63 of these acres are concentrated in Moffat and Routt Counties.

The factors affecting these projections are numerous. It is probable that steam plant operation schedules will suffer delays. These delays may lower 1985 production levels. Other factors such as rail rate changes, surface mine reclamation regulations, federal leasing policies and air and water quality

regulations could have major impacts on the rate of growth and importance of Colorado coal.

The Colorado Energy Research Institute has recently published energy production projections for the 1980's for Colorado. (21) They project 27 million tons of coal to be produced in 1985 and 28.6 million tons to be produced in 1990. They state that increases in Colorado's coal production during the next ten years are likely to be less than what some popular analyses have portrayed. This will be due mainly to a weak market for Colorado coal and the lag time between market shifts and production requirements. They believe there will not be enough demand in the 1980's to purchase the amount of coal presently available from existing Colorado coal mines, currently proposed mines, and federal lease sales.

The Institute also believes that underground production will surpass surface production by 1986. The major reasons for this reversal are the depletion of strippable reserves in northwest Colorado and the increase in underground production from both northwest and west-central Colorado. They believe that demand for metallurgical coal will remain stable through 1990.

The importance of Colorado coal has been clearly demonstrated by the statistics presented. However, Colorado coal does not appear to have an overwhelming competitive advantage when compared to Wyoming. Therefore, Colorado coal production is likely to increase but not as rapidly as production in other western states.

The demand for electricity in Colorado is likely to increase very rapidly as a result of growing population numbers and greater levels of industrial activity. Additions to electric generating capacity are likely to be coal-fired but not all new units will utilize Colorado coal.

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