

ALASKAN

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*All material on
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Strippable Reserves of Bituminous Coal and Lignite in the United States

By Staff, Bureau of Mines

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STRIPPABLE RESERVES OF BITUMINOUS COAL AND LIGNITE
IN THE UNITED STATES

by

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ABSTRACT

The strippable reserves of bituminous coal and lignite in the United States were calculated in accordance with the prevailing conditions of seam thickness and depth of overburden in each of the several coal-producing areas of the Nation. Within defined limits of seam thickness and depth of overburden, it is estimated that there was a remaining strippable resource of 118 billion tons of raw bituminous coal and lignite as of January 1, 1968. Because of topography, natural and manmade features, and other limitations, only 45 billion tons of the resource are strippable reserves. Of this, 32 billion tons is considered low-sulfur (less than 1 percent), 4 billion tons is medium-sulfur (1 to 2 percent), and 9 billion tons is high-sulfur (over 2 percent) coal. Owing to a cleaning loss affecting that portion of strip coal that is mechanically cleaned, the 45 billion tons of strippable reserves are reduced to 39.6 billion tons of marketable coal.

A brief discussion is given for each coal-producing State, summarizing past and present production, historical background, and outlook. Appendix A contains reserve data by State, county, seam, and sulfur content. Appendix B contains the general information and requirements necessary to comply with the current strip mining laws covering 20 States.

INTRODUCTION

During 1969, 35 percent of the bituminous coal and lignite produced in the United States was from strip mining operations. By 1980, the demand for coal is expected to be 53 percent greater than it was in 1967, and by the year 2000 the projected demand will be 78 percent greater, probably resulting in more and larger strip mines. Of particular significance is the increasing demand for coal of low sulfur content to comply with present or proposed air quality standards.

This study, a joint undertaking of several Bureau of Mines offices, was undertaken to establish the location and extent of coal of varying sulfur content available for strip mining. In each of these offices, coal reserves were estimated in accordance with the locally prevailing criteria and mining techniques.

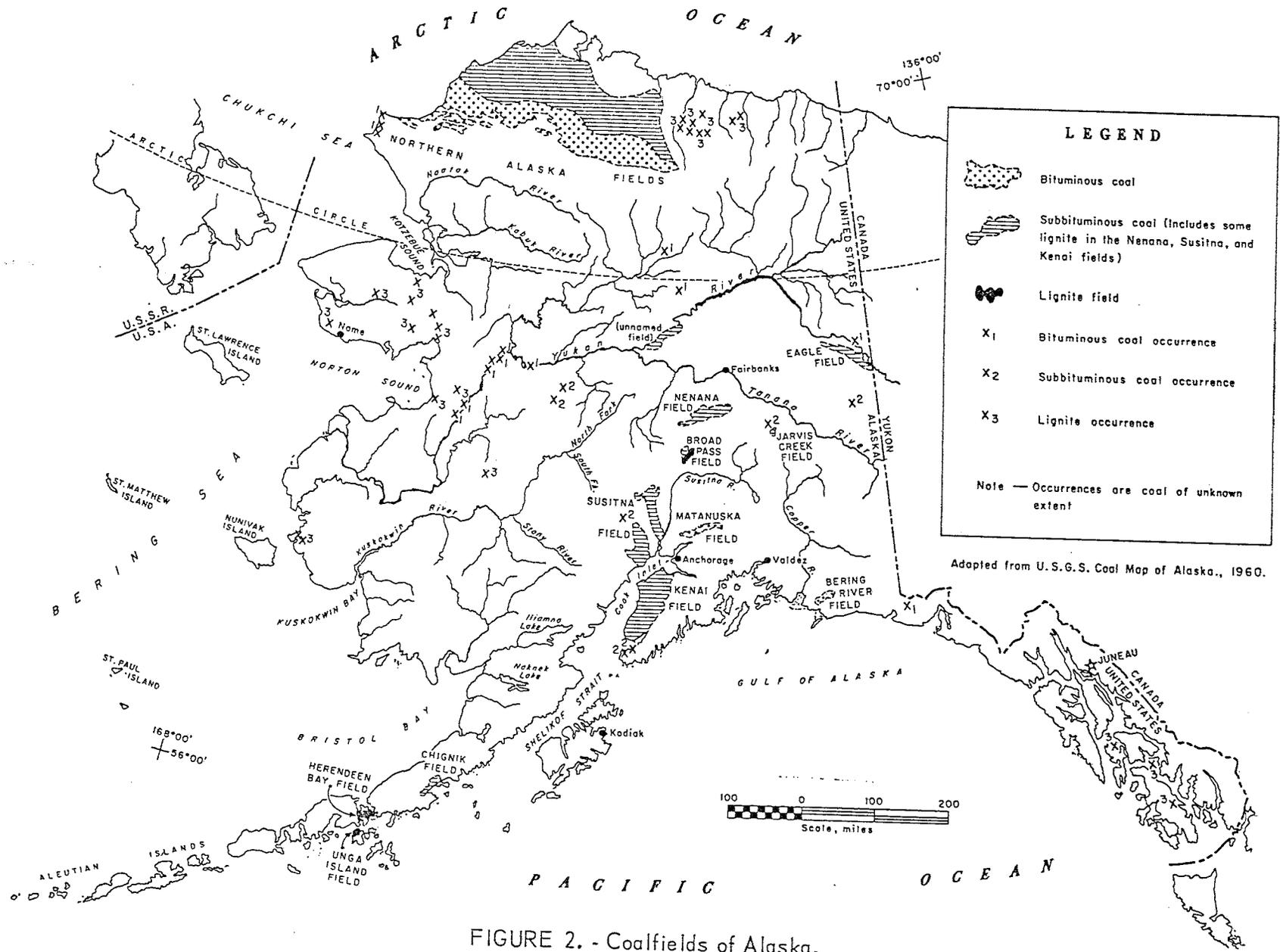


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The Northern Great Plains Province

The Northern Great Plains province covers parts of Montana, North Dakota, South Dakota, and Wyoming. The coal deposits include both bituminous and subbituminous coal and lignite in formations of Tertiary and Cretaceous ages. Strippable reserves are estimated for only subbituminous coal and lignite. The subbituminous coal seams range up to 220 feet, and the lignite seams range up to 40 feet in thickness. Reserves were estimated for a minimum coalbed thickness of 5 feet. Present production is almost exclusively for electric power generation.

The Rocky Mountain Province

The Rocky Mountain province covers parts of Arizona, Colorado, Idaho, Montana, New Mexico, Utah, and Wyoming. Coal seams occur in formations of Cretaceous and Tertiary ages. The beds are generally flat to gently dipping, but local steepening is present in some districts. There is great variation in thickness and continuity. Seams range from 4 feet to 90 feet in thickness. For estimating reserves, only those of 5 feet or more were considered.

The strippable reserves include subbituminous and bituminous coal. The major market is electric utilities, with some coal going to coke production and very little to industrial or domestic use. Present transportation is by rail. Some utility plants are built at the deposit site.

The Pacific Coast Province

The Pacific Coast province covers parts of California, Oregon, and Washington. Minor deposits occur in California and Oregon and the largest strippable reserves of importance occur in Washington. All the coals of this province are in Tertiary formations. There is only one major strippable subbituminous coal deposit, which is located in the Tono Basin of the Centralia region of Washington. Strippable coal occurs in two seams, the Big seam and the Smith seam. The Centralia region contains many other coal seams for which no strippable reserves have been estimated. The coal seams range from 5 to 50 feet in thickness. Over 90 percent of the estimated reserve is in the Big seam. The coal is subbituminous in rank and is mined to supply an electric generating plant. Washington is the only State in the province with a sizable deposit of coking coal, none of which is considered strippable.

Alaska

Alaska has six coalfields for which strippable reserves of bituminous and subbituminous coal and lignite have been estimated. Figure 2 shows the known coalfields of Alaska. The coals are of Cretaceous and Tertiary ages, and rank from lignite to anthracite. The seams range from nearly flat to steeply dipping, and from relatively continuous to lenticular. Seam thicknesses range up to 50 feet; strippable reserves are estimated for a minimum thickness of 14 inches. The coal is low in sulfur, with generally less than 1 percent; much of it contains less than 0.5 percent sulfur.

Nearly all the coal currently produced is consumed within 150 miles of the mine. Transportation is by rail or truck. Although the markets are electric utilities and space heating, natural gas is becoming more competitive for heating purposes.

METHODOLOGY

The procedure in ascertaining strippable coal resources was dependent upon the type, quantity, and quality of information that was available. The criteria for evaluating these resources were based on economic consideration for each area under study.

The original in-place resource was obtained mainly as follows:

1. Where outcrop maps were available, the length of each minable coalbed outcrop was measured by map meter or the area was measured by planimeter. An average coalbed thickness was determined for each seam, and an average bench width from outcrop to maximum overburden thickness was estimated. From these data acres of strippable coal were calculated, and when multiplied by a tonnage factor, gave total original in-place resource. It was generally assumed that 1 acre-foot of coal in the ground was equivalent to 1,800 tons of bituminous coal. A lesser figure of 1,760 tons per acre-foot was used for subbituminous coal and lignite.

2. In other areas, original resource was based on latest estimates of the U.S. Geological Survey, State Geological Surveys, coal mining companies, and railroad companies.

In areas where coal demand was great and the supply rather limited, the minable seam thickness was generally less and the maximum overburden greater than for the country as a whole. For example, in the Appalachian area, only that coal greater than 28 inches in thickness under a 15-to-1 ratio of overburden thickness (at the final highwall) to seam thickness was considered strippable. In parts of the Rocky Mountain area, only coal in seams 5 feet or more in thickness are considered minable by stripping. Meanwhile, in Alaska, very large tonnages of coal, particularly on the North Slope, are considered more as a resource than a reserve because of the high cost of mining created by severe weather conditions and the lack of an export market. All coal that was considered uneconomic or unminable was excluded from the available reserve estimates. Table 1 summarizes the minimum coalbed thickness, maximum overburden thickness, and economic stripping ratio used to estimate the strippable reserves in the various States.

Sulfur content was generally derived from coal analyses published by either the Bureau of Mines or State agencies. Over 11,000 analyses were recorded and used. In the absence of sufficient information on sulfur analyses of coal from strip mines, published analyses of sulfur content from underground mines were applied to the stripping portion of the same coalbed.

TABLE 1. - Summary of certain criteria used in estimating
strippable reserves of coal and lignite

Province and State	Minimum coal-bed thickness, inches	Maximum overburden thickness for computing reserves, feet	Economic stripping ratio (feet to feet) ¹
Eastern province-- Appalachian region:			
Alabama.....	14	120	24:1
Kentucky--east.....	28	120	14:1
Maryland.....	28	120	15:1
Ohio.....	28	120	15:1
Pennsylvania.....	28	120	15:1
Tennessee.....	28	120	19:1
Virginia.....	28	120	15:1
West Virginia.....	28	120	15:1
Interior and Gulf province:			
Arkansas (bituminous)....	14	60	30:1
Arkansas (lignite).....	30	100	30:1
Illinois.....	18	150	18:1
Indiana.....	14	90	20:1
Iowa.....	28	120	18:1
Kansas.....	12	120	15:1
Kentucky--west.....	24	150	18:1
Michigan.....	28	100	20:1
Missouri.....	12	120	15:1
Oklahoma.....	12	120	15:1
Texas.....	60	90	15:1
Rocky Mountain and Northern Great Plains provinces:			
Arizona.....	60	130	8:1
Colorado.....	60	² 50 to 120	4:1 to 10:1
Montana.....	60	² 60 to 125	2:1 to 18:1
New Mexico.....	60	² 60 and 90	8:1 to 12:1
North Dakota.....	60	² 50 to 75	3:1 to 12:1
South Dakota.....	60	100	12:1
Utah.....	60	² 39 to 150	3:1 to 8:1
Wyoming.....	60	² 60 to 200	1.5:1 to 10:1
Pacific Coast province:			
California.....	60	100	10:1
Oregon.....	48	40	4.75:1
Washington.....	60	100 and 250	10:1
Alaska.....	14	120	-

¹Based on maximum feet of overburden thickness at the highwall per foot of coalbed thickness.

²Maximum overburden thickness varies for different coalbeds.

Procedures used to evaluate the strippable coal resources are as follow:

1. Original in-place resource was either estimated or obtained from other sources.
2. Past production from earliest dates available to January 1, 1968, was tabulated by seams and by strip and auger, and the depletion was computed.
3. Remaining strippable resource was computed by subtracting depletion from original resource.
4. Recoverable strippable resource was computed by multiplying remaining strippable resource by a recovery factor. Recovery factors employed were 80 percent for strip and 50 percent for auger mining. The exception was western Kentucky where a 90-percent factor was used for strip.
5. Strippable reserves (raw mined coal) were computed by deleting the following from the recoverable strippable resource:
 - a. Coal with overburden greater than the economic stripping ratios listed in table 1,
 - b. coal under towns, rivers, highways, railroads, utilities, cemeteries, and gas and oil wells,
 - c. coal cropping out close to a stream channel,
 - d. coal known to be bony, dirty, faulted, or unusually high in sulfur,
 - e. coal known to be inaccessible, dipping steeply at the outcrop or burned at the outcrop,
 - f. coal mined out in previous years by underground methods and minable coalbeds lost to stripping because they lie too close to a coalbed that has been strip mined,
 - g. coal that may never be sold or leased for strip mining,
 - h. any other unminable coal.
6. An average sulfur content was determined, generally on a county and seam basis, and used to categorize strippable reserves into high-, medium-, and low-sulfur coal.

TABLE 2. - Estimated remaining strippable resources and strippable reserves of coal and lignite in the United States, January 1, 1968, by rank of coal, sulfur category, and coal province--Continued

Rank	Remaining strippable resource	Strippable reserves	Strippable reserves		
			Low sulfur	Medium sulfur	High sulfur
BITUMINOUS COAL--Continued					
Interior and Gulf provinces: ¹					
Arkansas.....	200	149	3	118	28
Illinois.....	18,845	3,247	0	80	3,167
Indiana.....	2,741	1,096	0	293	803
Iowa.....	1,000	180	0	0	180
Kansas.....	1,388	375	0	0	375
Kentucky--west.....	4,746	977	0	0	977
Michigan.....	6	1	0	0	² 1
Missouri.....	3,425	1,160	0	0	1,160
Oklahoma.....	434	111	10	44	57
Subtotal.....	32,785	7,296	13	535	6,748
Rocky Mountain and Northern Great Plains provinces: ³					
Colorado.....	870	500	476	24	0
Utah.....	252	150	6	136	8
Subtotal.....	1,122	650	482	160	8
Alaska.....	1,201	480	⁴ 480	0	0
Total bituminous.....	62,826	13,597	2,837	2,128	8,632
SUBBITUMINOUS COAL					
Rocky Mountain and Northern Great Plains provinces: ⁵					
Arizona.....	400	387	387	0	0
Montana.....	7,813	3,400	3,176	224	0
New Mexico.....	3,307	2,474	2,474	0	0
Wyoming.....	22,028	13,971	13,377	65	529
Subtotal.....	33,548	20,232	19,414	289	529
Pacific Coast province: ⁶					
California.....	100	25	0	0	25
Oregon.....	0	0	0	0	0
Washington.....	500	135	135	0	0
Subtotal.....	600	160	135	0	25
Alaska.....	6,190	⁴ 73,926	⁴ 73,926	0	0
Total subbituminous.....	40,338	24,318	23,475	289	554
LIGNITE					
Interior and Gulf provinces: ⁸					
Arkansas.....	32	25	25	0	0
Texas.....	3,272	1,309	625	684	0
Subtotal.....	3,304	1,334	650	684	0

See footnotes at end of table.

TABLE 2. - Estimated remaining strippable resources and strippable reserves of coal and lignite in the United States, January 1, 1968, by rank of coal, sulfur category, and coal province--Continued

Rank	Remaining strippable resource	Strippable reserves	Strippable reserves		
			Low sulfur	Medium sulfur	High sulfur
LIGNITE--Continued					
Rocky Mountain and Northern Great Plains provinces:					
Montana.....	7,058	3,497	2,957	540	0
North Dakota.....	5,239	2,075	1,678	397	0
South Dakota.....	399	160	160	0	0
Subtotal.....	12,696	5,732	4,795	937	0
Alaska.....	8	5	5	0	0
Total lignite.....	16,008	7,071	5,450	1,621	0
Grand total United States	117,987	44,986	31,762	4,038	9,186

¹ Bituminous coal resource and reserve not estimated for Texas and Nebraska.

² There may be isolated areas of some seams which might be classed in the medium-sulfur category.

³ Bituminous coal resource and reserve not estimated for Montana, New Mexico, Idaho, and Wyoming.

⁴ 478 million tons of bituminous and 3,387 million tons of subbituminous coal reserves in the northern Alaska fields (North Slope) are included in the estimates even though an economic export market, which is essential for exploitation, does not currently exist.

⁵ Subbituminous coal resource and reserve not estimated for Colorado.

⁶ Bituminous coal resource and reserve not estimated for Washington; the subbituminous coal resource and reserve estimated for Oregon is less than 1 million tons.

⁷ Includes 179 million tons of undifferentiated subbituminous coal and lignite.

⁸ Lignite resource and reserve not estimated for Kansas, Mississippi, Louisiana, and Alabama.

According to Bureau of Mines statistics for 1967 through 1969, an average of 80 percent of the total U.S. coal production (underground, strip, and auger) was mechanically cleaned. The loss in cleaning (refuse) averaged 22 percent of the raw coal entering preparation plants. For the same years, the statistics do not indicate the quantity of strip-mined coal that was sent to cleaning plants, but records do show that an average of 46 percent of total strip-mine production was clean coal, that is, coal leaving preparation plants. By applying this information to future strip production of bituminous and subbituminous coal, the 45 billion tons of raw strippable reserves are reduced to 39.6 billion tons of marketable coal.

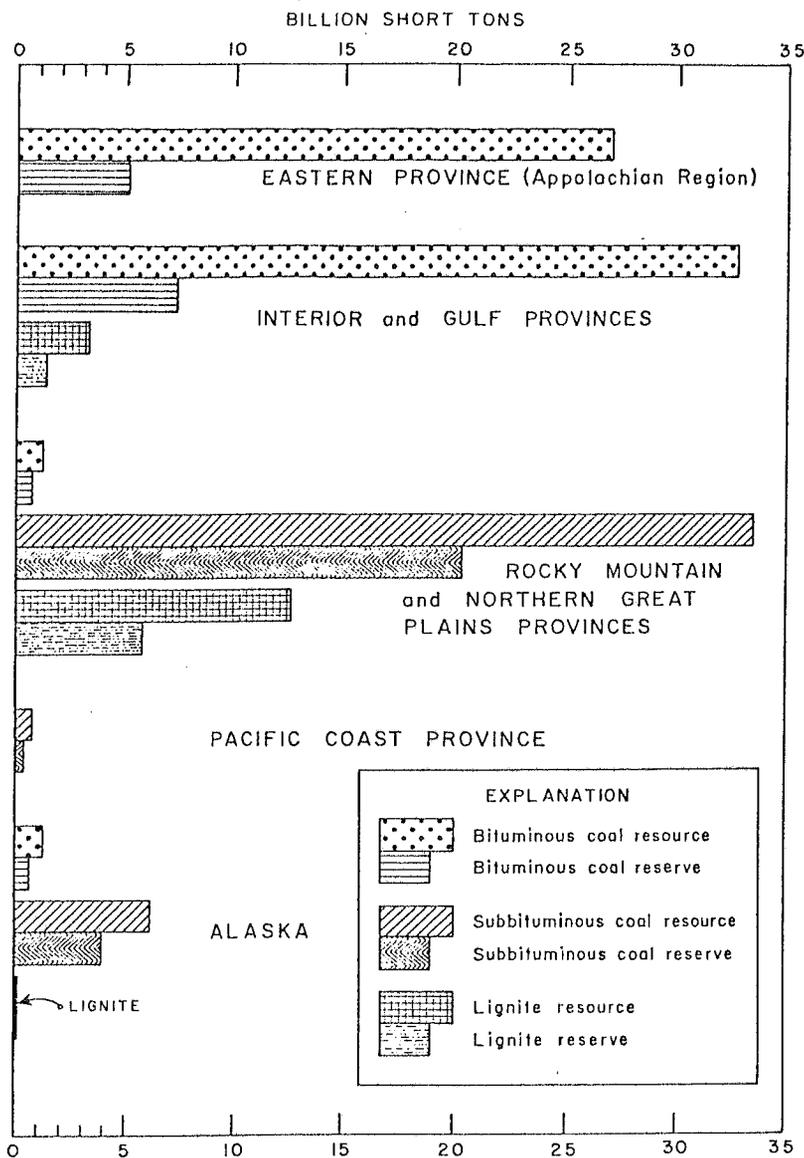


FIGURE 4. - Remaining Strippable Resources and Reserves of Coal and Lignite in the United States by Coal Province as of January 1, 1968.

indicated in table 2. Of the total 45 billion tons of strippable reserves, 71 percent is low-sulfur, 9 percent is medium-sulfur, and 20 percent is high-sulfur coal.

Figure 6 graphically shows total tons of coal by sulfur category and by geographical area. The names of coal seams and their sulfur category by States are given in appendix A.

Large strippable reserves of subbituminous coal are present in Alaska, while considerable reserves of lignite occur in the Gulf province. The Pacific Coast province has few reserves of coal, regardless of rank.

Strippable Reserves by Coal Provinces

Reserve data for the Nation are summarized by coal province and rank of coal in table 2 and figure 5. The largest concentration, 59 percent of the Nation's 45 billion tons of strippable reserves, is in the Rocky Mountain and Northern Great Plains provinces. The second largest concentration, 19 percent of the reserves, is in the Interior and Gulf provinces. Twelve percent of the reserves is in the Appalachian region, and 10 percent is located in Alaska. The Pacific Coast province has only 0.4 percent of the total strippable reserves.

Strippable Reserves by Sulfur Content

Strippable reserves of low-, medium-, and high-sulfur coal by rank and geographical area are indi-

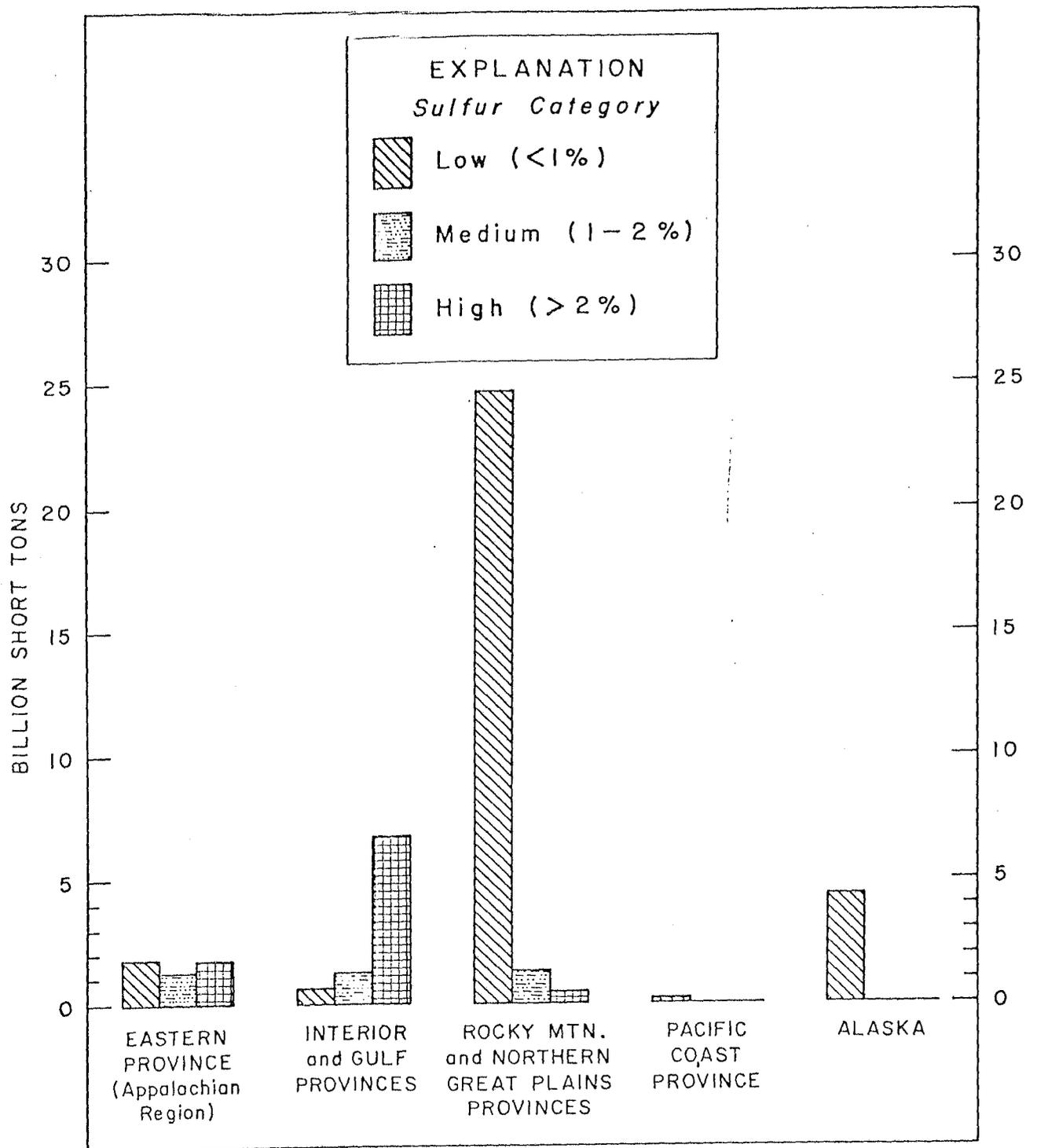


FIGURE 6. - Strippable Reserves of Coal and Lignite in the United States by Sulfur Category as of January 1, 1968.

Low-Sulfur Coal

Almost three-fourths of the 31.8 billion tons of low-sulfur reserve is subbituminous in rank, 17 percent is lignite, and 9 percent is bituminous coal.

Over 80 percent of the total of 23.5 billion tons of low-sulfur subbituminous coal is in the Rocky Mountain and Northern Great Plains provinces, with almost 70 percent (13.4 billion tons) in Wyoming. Most of the remainder is in Montana, New Mexico, Arizona, and Alaska. Because of weather conditions, strip mining much of the Alaska reserve would be extremely difficult except for a relatively brief period each year.

Although there are extensive deposits of lignite in Texas, 85 percent of the Nation's low-sulfur lignite reserve of 5.5 billion tons is in Montana and North Dakota. Lesser amounts are in Arkansas, South Dakota, and Alaska.

Of the total low-sulfur bituminous coal reserves of 2.8 billion tons, 66 percent is in the Appalachian region, 17 percent in the Rocky Mountain and Northern Great Plains provinces, and 17 percent in Alaska. The Interior province has less than 1 percent of the Nation's low-sulfur strippable reserves.

The low-sulfur bituminous coal in the Appalachian region, totaling 1.9 billion tons, is found in five States--Alabama, eastern Kentucky, Tennessee, Virginia, and West Virginia. West Virginia has an estimated 1.1 billion tons, or about 61 percent of that region's and 4 percent of the Nation's low-sulfur reserve. Eastern Kentucky has the next largest reserve, estimated at 532 million tons. The remaining 192 million tons are located in Alabama, Tennessee, and Virginia.

The Rocky Mountain province States of Colorado and Utah have an estimated 482 million tons of low-sulfur bituminous coal. An additional estimated 480 million tons are in Alaska. The reserve of 13 million tons in the Interior province is not considered large enough nor sufficiently concentrated to support a large-capacity mine.

Medium-Sulfur Coal

Sixty-seven percent of the 2.1 billion tons of medium-sulfur bituminous coal reserve is concentrated in the Appalachian region. Almost one-half of the Appalachian reserve is in West Virginia. Other States with significant strippable reserves of medium-sulfur bituminous coal include Pennsylvania and Kentucky with 225 million and 189 million tons, respectively.

The Interior province contains the second largest concentration of medium-sulfur bituminous coal reserves, 535 million tons. Indiana has over half of this reserve.

Most of the 289 million tons of medium-sulfur subbituminous coal reserve is in Montana, 224 million tons; the remaining 65 million tons is in Wyoming.

TABLE 3. - Estimated strippable reserves of coal and lignite in the United States, January 1, 1968, by States

(Millions of short tons)

State	Bituminous coal ¹	Subbituminous coal ²	Lignite ³	Total
Alabama.....	134	0	(³)	134
Alaska.....	⁴ 480	⁴ ⁵ 3,926	5	4,411
Arizona.....	0	387	0	387
Arkansas.....	149	0	25	174
California.....	0	25	0	25
Colorado.....	500	(²)	0	500
Illinois.....	3,247	0	0	3,247
Indiana.....	1,096	0	0	1,096
Iowa.....	180	0	0	180
Kansas.....	375	0	(³)	375
Kentucky--east.....	781	0	0	781
Kentucky--west.....	977	0	0	977
Maryland.....	21	0	0	21
Michigan.....	1	0	0	1
Missouri.....	1,160	0	0	1,160
Montana.....	(¹)	3,400	3,497	6,897
New Mexico.....	(¹)	2,474	0	2,474
North Dakota.....	0	0	2,075	2,075
Ohio.....	1,033	0	0	1,033
Oklahoma.....	111	0	0	111
Pennsylvania.....	752	0	0	752
South Dakota.....	0	0	160	160
Tennessee.....	74	0	0	74
Texas.....	(¹)	0	1,309	1,309
Utah.....	150	0	0	150
Virginia.....	258	0	0	258
Washington.....	(¹)	135	0	135
West Virginia.....	2,118	0	0	2,118
Wyoming.....	(¹)	13,971	0	13,971
Total.....	13,597	24,318	7,071	44,986

¹ Bituminous coal reserves not estimated for Idaho, Montana, Nebraska, New Mexico, Texas, Washington, and Wyoming.

² Subbituminous coal reserves not estimated for Colorado and Oregon.

³ Lignite reserves not estimated for Alabama, Kansas, Louisiana, and Mississippi.

⁴ 478 million tons of bituminous and 3,387 million tons of subbituminous coal reserves in the northern Alaska fields (North Slope) are included in the estimates even though an economic export market, which is essential for exploitation, does not currently exist.

⁵ Includes 179 million tons of undifferentiated subbituminous coal and lignite.

An undetermined portion of the total strippable reserves are "captive" owned and are not available for sale in the open market. According to 1967 statistics of production by the 50 biggest bituminous underground and strip

mines in the United States, "captive" coal produced at these mines amounted to only 2.8 percent of the national total production of bituminous coal and lignite (115).

LOW-SULFUR BITUMINOUS COAL

The Nation's strippable low-sulfur coal reserves are estimated to total 31.8 billion tons. Of this, only about 9 percent, 2.8 billion tons, consists of bituminous coal. Subbituminous coal and lignite account for the other 29 billion tons. Practically all subbituminous coal and lignite strippable reserves, over 92 percent, are low sulfur. Only 21 percent of the 13.6 billion tons of total strippable bituminous coal reserves are low sulfur, the rest being medium and high sulfur.

The largest part of the 2.8 billion tons of total strippable low-sulfur bituminous coal reserves, over 65 percent, is in the Appalachian region. Almost all of the remaining strippable low-sulfur bituminous coal reserves are evenly divided between the Rocky Mountain province (Colorado and Utah) and Alaska.

The 1.9 billion tons of low-sulfur bituminous coal in the Appalachian region is located in five States--Alabama, eastern Kentucky, Tennessee, Virginia, and West Virginia. About 61 percent of these reserves are in West Virginia, followed by eastern Kentucky with almost 30 percent.

In the discussion that follows, the major coalbeds and counties in each State having low-sulfur bituminous coal reserves are identified. The major counties having the largest reserves are then followed by the low-sulfur coalbeds that are strippable in each county.

West Virginia

West Virginia's 1,138 million tons of strippable low-sulfur bituminous coal occurs in 28 minable coalbeds spread through 20 central and southern counties of which almost 94 percent is included in 13 southern counties. Sixteen of the coalbeds contain only low-sulfur coal. The other 12 coalbeds may present a selective mining problem as they also contain medium- and high-sulfur coal.

The 16 coalbeds having only low-sulfur coal contain 53 percent of the West Virginia total low-sulfur bituminous coal reserves. Four coalbeds--the Lower Kittanning (203 million tons), the Stockton (115 million tons), the Coalburg (216 million tons), and the Winifrede (128 million tons)--contain 58 percent of the low-sulfur reserve, in addition to medium- and high-sulfur reserves. These four coalbeds crop out and are available for strip mining in 13 central and southern counties of the State. In the southern counties, Boone County has the largest reserves of low-sulfur coal estimated at 275 million tons, followed by Mingo and Logan Counties at 146 and 124 million tons, respectively. Raleigh and Kanawha Counties have 109 and 103 million tons, respectively. These five counties have over 66 percent of the State's low-sulfur reserves. Coalbeds containing low-sulfur coal reserves in each of the five above-named counties are as follows:

should conform to present patterns. Electricity derived from atomic fuel is not expected to affect the market of coal for a decade or more.

All coalfields in the State are served by railroads and highways. In addition, the Warrior River flows through the Warrior coalfield, making possible the transport of coal to the electric utility plants along the Warrior-Tombigbee River by barge. In 1968, transportation of strip coal was 73 percent by railroad or barge, and 27 percent by truck. The largest quantity was delivered by railroad.

All coal-bearing strata are of early Pennsylvanian age. Together they cover more than 5,300 square miles. The State's four coalfields are located in the southwestern part of the Appalachian coal region. Fields are located in structural basins, and each is partly bordered on the southeastern edge by a thrust fault. Generally, dip of the strata is steep near the faults but flattens in the basins. This structure limits the amount of coal available for surface mining.

Alabama coalbeds are generally thin, and where thick, frequently carry thick rock partings. Large reserves are committed through "captive" ownership or contract to iron and steel companies and electric utilities. The strip-able reserves of bituminous coal under less than 120 feet of overburden are estimated at 134 million tons. Tables A-1, A-2, and A-3 show the reserves by seams, counties, and sulfur categories. The prevailing laws that apply to strip mining are summarized in appendix B.

Alaska

Strippable reserve estimates totaling 4.4 billion tons under less than 120 feet of overburden were made for the six following Alaskan coalfields: the Northern, Nenana, Broad Pass, Susitna, Matanuska, and Kenai Fields. The Northern Field, where coal is believed to underlie continuously about 30,000 square miles, contains 92 percent of Alaska's estimated total original resource of 130 billion tons. These coals are Cretaceous in geologic age, whereas coals of the other fields are Tertiary. The Nenana and Matanuska Fields, located near Fairbanks and Anchorage, respectively, and served by rail, are the only fields from which sustained production has been made. Total recorded Alaskan production through 1969 is about 20.6 million tons. Production, except for a single one- or two-man stripping operation, ceased during 1967 in the Matanuska Field. Strip production from the Nenana Field continues at the rate of about 670,000 tons per year. Analyses of Alaskan coals indicate that they nearly all fall into the low-sulfur category.

The first coal mine in Alaska was opened in 1855 by the Russians at Port Graham, but the mine was abandoned after only about 10 years of operation. Sustained coal production did not come about until completion of the Alaska Railroad to the Matanuska coalfield in 1916 and to the Nenana Field in 1918.

All Alaskan coal production is by strip mining. The Nenana Field coals are all subbituminous in rank. The greater proportion of Nenana Field coal is burned for power generation in and near Fairbanks, but a considerable amount

is still used directly for space heating and for space heat steam raising in central plants.

The small amount of coal still being produced from the Matanuska Field is hauled to market by truck and is consumed in entirety for space heating purposes. Electric utilities in the Anchorage area that formerly burned Matanuska Field coal have been converted to natural gas.

An export market for metallurgical-quality coking coals, and possibly some steam coal, exists in Japan and possibly elsewhere, but no such exports have taken place, basically owing to the apparent inability to make Alaskan coals economically competitive f.o.b. an Alaskan all-weather port. A factor which may enhance export possibilities is the apparent low-sulfur content of most Alaskan coals.

Some of the bituminous coking coals of Arctic northwestern Alaska (North Slope), where exposed, exhibit simple geologic structure that should be amenable to modern large-scale mechanized mining, either surface or underground; their permanently frozen condition can perhaps be used advantageously in the mining system. The greatest problem of exploitation is transport of the coal to an ice-free harbor for export. The Arctic Ocean near the coal deposits has only about 90 ice-free days per year.

All Alaskan coals that are or have been mined in quantity are Tertiary in geologic age. The Tertiary coals range in rank from lignite to anthracite, the Cretaceous coals from subbituminous to bituminous. Strip mining usually, but with the possible exception of some lignite beds and some northern field subbituminous beds, is confronted with dipping beds and some faulting.

The Tertiary coalfields are much less in areal extent than the northern Cretaceous field, and individual Tertiary beds are characteristically lenticular. Coalbeds of the northern field are believed to be less lenticular, but this premise is based on the observable persistence of more resistant beds rather than on actual knowledge of coalbed continuity.

Coalbed thicknesses vary from a few inches to 50 feet. Nenana Field subbituminous beds currently being strip-mined are 25 feet and 50 feet thick and dip about 55°. A group of eight formerly mined Matanuska Field bituminous beds range in individual thickness from 3 feet to 16 feet, comprising a total coal thickness of about 50 feet within a total strata thickness of about 200 feet dipping approximately 40°. Coal burning ceased during the 1960's when Barrow was granted permission by Congress to use natural gas from a field just outside Barrow in Naval Petroleum Reserve No. 4.

Alaska has not enacted strip mining laws. Probably, when large-scale strip mining becomes imminent, regulations will be issued to control surface damage and to enforce reasonable reclamation practices.

A summary of the strippable coal resources and reserves is shown in tables A-4 and A-5.

There are no privately owned coal lands in Alaska; they all are either Federal Government or State held lands to which the leasing laws apply. State leasing laws are similar to the Federal laws. The Federal law is summarized in appendix B.

Arizona

Prior to 1970 there was no commercial strip coal mining in Arizona. However, the expanding southwestern market for electric power and the competitive position of coal for this energy market has led to the development of strip mining in the Black Mesa coalfield in the northeast corner of the State. Production is expected in 1970 from a new 5-million-ton-per-year strip mine. Based on delivery contracts made, or under negotiation, production for the next 40 years is expected to range from 5 to 10 million tons per year.

A shortage of cooling water in or near the Black Mesa coalfield restricts its development for local power generation. Black Mesa coal will therefore be shipped to powerplants located along the Colorado River. One plant under construction near Bullhead City, Nev., will be supplied through a 273-mile coal-slurry pipeline; a proposed plant at Page, Ariz., would receive its coal by unit train via a proposed 80-mile railway from Black Mesa.

Competition in the market for Arizona coal is provided by extensive coal deposits in New Mexico and Utah. However, Black Mesa coal has the advantages of closer proximity to the southern California energy market, higher Btu values than New Mexico coal, and presumably lower mining cost than southern Utah coal, which is expected to be mined almost exclusively by underground methods. Coal in the Black Mesa Field is believed unsuitable for coking purposes and probably will be used exclusively for electric power generation.

Commercial seams lie in the Dakota and Mesa Verde Formations of Cretaceous age. Seam thicknesses average between 4 and 22 feet, and for the most part coal seams dip approximately 2°. Owing to the extreme lenticularity of individual seams, difficulty is encountered in seam correlation and estimation of the volume of resource. Strippable reserves of subbituminous coal, under less than 130 feet of overburden, have been estimated at 387 million tons. (See tables A-6-A-8.)

The general requirements of the State's strip mining law are shown in appendix B.

Arkansas

The bituminous coalfield in Arkansas is located in the west-central part of the State. The coalfield is approximately 33 miles wide by 60 miles long and occupies parts of seven counties. All the coalbeds are in the lower part of the Pennsylvanian System. Economically significant low-volatile bituminous coal, low in ash, is found in the McAlester and Savanna Formations.

Four coal seams over 14 inches thick and covered by less than 60 feet of overburden originally contained a total of 231.3 million tons of coal (68).

TABLE A-4. - Strippable resources and reserves of coal and lignite in Alaska, January 1, 1968, by coalfield

(Thousand short tons)

Coalfield	Average thickness ¹ (inches)	Remaining strippable resource (0-120 feet overburden)	Recoverable strippable resource	Strippable reserves
BITUMINOUS				
Northern.....	-	1,197,000	957,000	² 478,000
Matanuska.....	-	4,000	3,000	2,000
Total.....	-	1,201,000	960,000	480,000
SUBBITUMINOUS COAL AND LIGNITE				
Northern (S) ³	-	5,293,000	4,234,000	² 3,387,000
Nenana (S) ³	-	571,000	457,000	360,000
Broad Pass (L) ⁴	-	8,000	6,000	5,000
Susitna (S,L) ^{3 4}	-	288,000	230,000	163,000
Kenai (S,L) ^{3 4}	-	38,000	31,000	16,000
Total.....	-	6,198,000	4,958,000	3,931,000
Grand total...	-	7,399,000	5,918,000	4,411,000

¹No average coal thicknesses are given, but thicknesses range from a minimum of 14 inches to over 120 inches.

²These Northern Field (North Slope) reserves are included in the estimates even though an economic export market, which is essential for exploitation, does not currently exist.

³S--subbituminous coal.

⁴L--lignite.

TABLE A-5. - Strippable reserves of coal and lignite in Alaska, January 1, 1968, by coalfield and sulfur category

(Thousand short tons)

Coalfield	Average thickness (inches)	Low sulfur	Medium sulfur	High sulfur
BITUMINOUS				
Northern.....	-	478,000	-	-
Matanuska.....	-	2,000	-	-
Total.....	-	480,000	-	-
SUBBITUMINOUS COAL AND LIGNITE				
Northern (S) ¹	-	3,387,000	-	-
Nenana (S) ¹	-	360,000	-	-
Broad Pass (L) ²	-	5,000	-	-
Susitna (S,L) ^{1 2}	-	163,000	-	-
Kenai (S,L) ^{1 2}	-	16,000	-	-
Total.....	-	3,931,000	-	-
Grand total.....	-	4,411,000	-	-

¹S--subbituminous coal.

²L--lignite.