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Coal Recovery From Bituminous Coal Surface Mines in the Eastern United States, A Survey

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16. Abstracts

A 1975 survey of bituminous coal surface mines in the eastern United States has shown their average coal recovery to be 83.0 percent in strip mines and 35.9 percent in auger mines. Strip mining losses were caused by (1) land use conflicts over which operators have little or no control, and (2) problems inherent to coal mining, primarily separation of coal from waste rock. Recovery by State varied from 72.3 percent in Tennessee to 91.3 percent in Maryland. Recovery varied only slightly for the two regions studied--82.7 percent for Appalachia and 84.3 for the Midwest--whereas recovery grouped by mining method--contour, area, and mountaintop removal--was 79.8, 84.7, and 85.3 percent, respectively.

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By Edwin S. Secor, Gary M. Larwood, Arvind B. Gupta, and Arthur S. Lees

UNITED STATES DEPARTMENT OF THE INTERIOR
Cecil D. Andrus, Secretary

BUREAU OF MINES

As the Nation's principal conservation agency, the Department of the Interior has responsibility for most of our nationally owned public lands and natural resources. This includes fostering the wisest use of our land and water resources, protecting our fish and wildlife, preserving the environmental and cultural values of our national parks and historical places, and providing for the enjoyment of life through outdoor recreation. The Department assesses our energy and mineral resources and works to assure that their development is in the best interests of all our people. The Department also has a major responsibility for American Indian reservation communities and for people who live in Island Territories under U.S. administration.

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COAL RECOVERY FROM BITUMINOUS COAL SURFACE MINES IN THE EASTERN UNITED STATES, A SURVEY

by

Edwin S. Secor,[1] Gary M. Larwood,[2] Arvind B. Gupta,[3]
and Arthur S. Lees[4]

ABSTRACT

The Federal Bureau of Mines conducted a field survey of 153 bituminous coal strip and auger mines to estimate coal recovery from surface mines in the Eastern United States. Recovery was calculated from field data by measuring coal losses resulting from mining coal and leaving barriers.

Mean total recovery for strip mining in States east of the Mississippi River was 83.0 percent and ranged from 72.3 percent for Tennessee to 91.3 percent for Maryland. Mining losses and barrier losses were 10.1 and 7.7 percent, with standard deviations of 4.8 and 10.4 percent, respectively, indicating that barrier losses, although less than mining losses, were more variable.

Mean total coal recovery varied only slightly for the two regions studied; 82.7 percent for Appalachia and 84.3 for the Midwest. Total recovery grouped by mining method--contour, area, and mountaintop removal--was 79.8, 84.7, and 85.3 percent, respectively.

Mean auger recovery was 35.9 percent; of the total average loss of 64.1 percent, over one-half resulted from design limitations while the remainder was attributed to operating losses.

The wide recovery range at individual mines indicates the variability of the eastern surface coal mining industry. Because of this, care should be exercised in applying the results of this report to reserve estimates other than those of a general nature.

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INTRODUCTION

Coal provides about 19 percent of the total energy used in the United States. Over one-half of the Nation's domestic supply of coal is mined by surface methods. In recent years, the Nation has become increasingly dependent on imported petroleum. The dangers of dependence on imported petroleum and the prospect of petroleum price increases have stimulated renewed interest in our vast reserves of coal. Accurate assessments of the coal reserve base and the ability of the mining industry to develop it are of great importance.

Estimates of 80 percent coal recovery in strip mining and 50 percent recovery in auger mining are commonly used in reserve base studies. These recovery rates are assumptions based on investigations and observations over a period of years. The present study was initiated to determine if these assumptions are supportable by measuring surface mining losses at active operations in the Eastern United States.

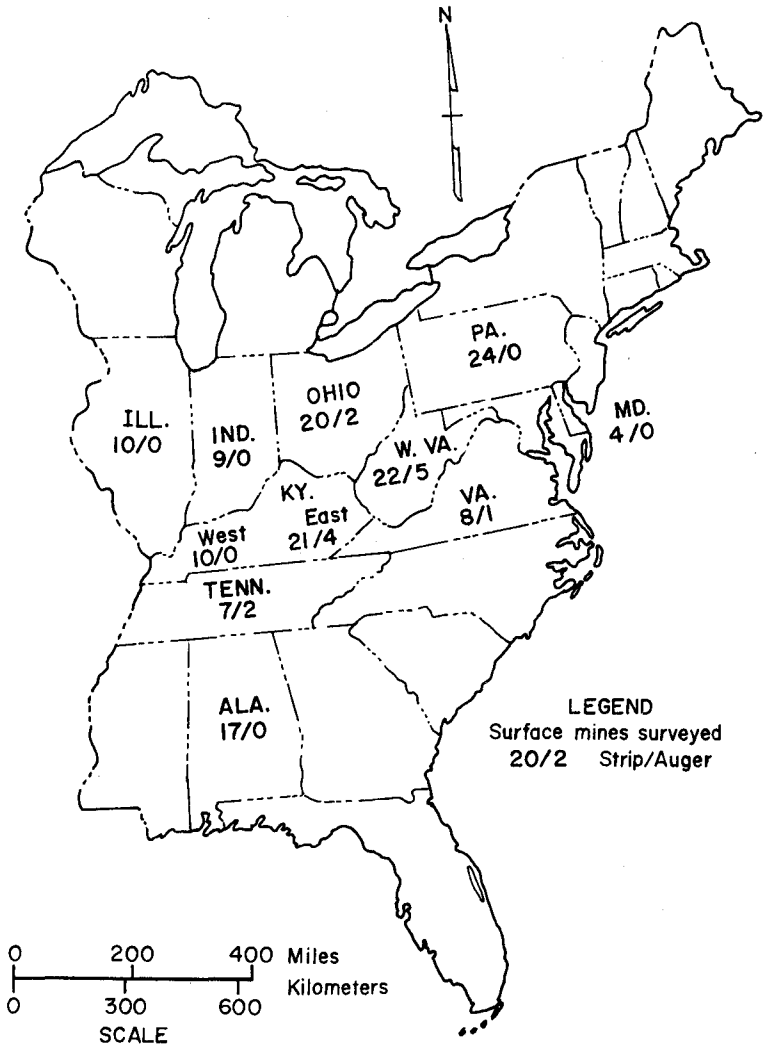

FIGURE 1. - Location and type of surface mines surveyed. (Combination strip and auger mine equals 1/1.)

DATA COLLECTION

A sample of 153 mines (139 strip, 1 auger, and 13 combination strip and auger)[5] was selected from the more than 3,000 surface mines operating in all States east of the Mississippi River (fig. 1). The sample comprised approximately 5 percent of the total number of active surface mines and 21 percent of the surface mine production in these States.

[5] For ease of analysis, each combination strip and auger mine was divided into its respective components and treated as two separate operations, one strip and one auger. On this basis, the study entailed analysis of 152 strip and 14 auger operations; all results in this report reflect this distribution.

Sample selection was mainly based on geographic distribution and method of mining. Table 1 shows the distribution of the strip mine sample by State and production.

TABLE 1. - Distribution of strip mine sample, by State and production

State	Total number of surface coal mines, 1974[1]	Mines in sample		Coal production from all surface mines, 1974, thousand short tons	Production of mines in sample	
		Number	Percent of total		Tonnage, thousand short tons	Percent of total
Alabama.....	117	17	14.5	12,771	3,563	27.9
Illinois.....	32	10	31.3	26,959	11,808	43.8
Indiana.....	39	9	23.1	23,587	8,137	34.5
Kentucky.....	986	31	3.1	73,700	11,497	15.6
Maryland.....	61	4	6.6	2,247	587	26.1
Ohio.....	229	20	8.7	31,044	3,912	12.6
Pennsylvania..	929	24	2.6	38,213	3,745	9.8
Tennessee.....	75	7	9.3	4,435	945	21.3
Virginia.....	332	8	2.4	11,559	994	8.6
West Virginia.	307	22	7.2	20,242	5,222	25.8
Total....	3,107	152	4.9	244,757	50,500	20.6

[1]According to individual State records. Some States list the number of surface mine permits rather than the number of surface mines.

Source: Coal--Bituminous and Lignite in 1974, U.S. Bureau of Mines, Mineral Industry Surveys, pp. 39-41.

The strip mining methods analyzed were as follows:

1. Area.--Mines in which coal was mined in a series of long, adjacent cuts.

2. Contour.--Hillside mining that proceeded horizontally along an outcrop.

3. Mountaintop removal.--Any method used to mine an entire mountaintop (includes area and contour methods).

Table 2 shows the distribution of strip mines by mining method and State.

A secondary consideration for sample selection was the type of stripping equipment used, with emphasis on the more common types of equipment (draglines, front end loaders, and shovels), but also including some of the lesser-utilized machines (bulldozers, scrapers, and bucketwheel excavators).

Finally, mine and company size were considered in the sample selection. Mines of medium-to-large size were emphasized, under the assumption that they were more representative of the eastern stripping industry than were small mines (the 20 largest surface mines in the study area accounted for 23 percent of the area's surface production). However, some small mines in each State were

surveyed to provide data from all sizes of operations. Company size was considered in a like fashion; large companies predominated, but a few small ones were included.

TABLE 2. - Distribution of strip mine sample by mining method and State

State	Area	Contour	Mountaintop removal	Other[1]	Total	Percent of sample
Alabama	17	0	0	0	17	11.2
Illinois	10	0	0	0	10	6.6
Indiana	9	0	0	0	9	5.9
West Kentucky	10	0	0	0	10	6.6
East Kentucky	0	12	9	0	21	13.8
Maryland	2	1	1	0	4	2.6
Ohio	14	2	3	1	20	13.2
Pennsylvania	12	8	4	0	24	15.8
Tennessee	2	4	0	1	7	4.6
Virginia	0	6	2	0	8	5.3
West Virginia	1	13	8	0	22	14.5
Total	77	46	27	2	152	[2]100.0
Percent of sample	50.7	30.3	17.8	1.3	[2]100.0	

[1]These mines utilized unusual methods and were excluded from comparisons between mining methods. They were included in all other analyses.
[2]Totals may not add to 100 percent because of independent rounding.

Data were collected by personal interviews with mine officials and by observations and measurements in the pit areas, using a standard data collection guide to provide a uniform data base. Data forms were completed for each pit visited, and coal losses were estimated based on observations and measurements at the site. For example, the thickness of the coalbed was measured at several points; maximum, average, and minimum thicknesses were recorded.

A necessary step in the determination of total recovery was the definition of mining and barrier losses.

Mining losses were defined as the amount of coal exposed in the mining pit and available to the operator minus the coal actually recovered, expressed as a percentage of the total. Losses occurring in this area are due to economic and technological factors under the operator's control and are a measure of the operator's ability to extract that coal which is available to him.

Barrier losses, as used in this report, are a measure of that coal which is required to be left in place as a solid barrier because of legal or environmental land use constraints beyond the control of the coal mine operator; therefore, these quantities are unavailable. This concept of barrier losses was included in this study to measure the effect of such land use constraints on total recovery.

Mining losses, barrier losses, and total recovery are related in the following manner:

$$Lm = \frac{C_e - C_r}{C_e} \times 100,$$

$$L_b = \frac{C_t - C_e}{C_t} \times 100,$$

$$TR = \frac{(100 - L_m)(100 - L_b)}{100}, \qquad (1)$$

where C_r = coal recovered by mining,

C_e = coal exposed during mining,

C_t = coal in place prior to mining,

L_m = mining losses, percent,

L_b = barrier losses, percent,

and TR = total recovery, percent.

Thus, total recovery was determined through the collection and subsequent analysis of individual component loss categories. No attempt was made to measure coal losses incurred during the preparation and transportation phases of mining.

Mining losses were determined by using the mining pit as the basic unit of measure. The length and width of the pit were measured by taping, or by pacing if distances of 200 feet or more were involved. All measurements were based on conditions as they were on the date of visit on the presumption that, on the average, this would sufficiently describe the current mining situation. Measured losses were then converted to a percentage of total coal volume in the mining pit. Coal losses in mining were measured as follows: (1) Top coal removed with the overburden, (2) bottom coal left in place, (3) coal lost in ribs between cuts, (4) losses due to partings, and (5) losses due to other factors, such as equipment limitations and spillage.

Barrier losses were determined by planimetering maps of each operation and discussion with mine officials. The types of barriers considered were (1) outcrops, (2) utility, railway, and highway rights-of-way, (3) streams, (4) underground workings, (5) oil and gas wells, (6) property lines, (7) buildings, and (8) other, such as landslide areas and cemeteries. Areas not mined because of excessive overburden or stripping ratios, and thus not economically minable, were not treated as barrier losses.

For auger operations, losses were estimated from observations of auger diameter, auger spacing, average auger penetration, coalbed thickness, and length of coalbed available for augering.

ANALYSIS OF SURFACE MINE COAL RECOVERY

Strip Mining

Strip mining data were analyzed by computer for mean and standard deviation in each loss and recovery category. The sample mean for mining losses was 10.1 percent while mean barrier losses were 7.7 percent. Total recovery is a multiplicative function of mining losses and barrier losses, rather than an additive one, because mining losses are expressed as a percentage of the area actually mined, whereas barrier losses fall outside the mined area and are expressed as a percentage of the total area considered for mining. Thus, for the strip mine sample, total coal recovery was 83.0 percent with a standard deviation of 10.8.

Sample means and standard deviations were also calculated for three different data sortings; (1) State, (2) region,[6] and (3) mining method.

State

The sample means for the data sorted by State (table 3) indicate the effects of geographic location on types of mining and barrier losses. Mining losses by State, as shown in figure 2, range from 8.3 percent in Alabama to 13.7 percent in Tennessee. Except for Tennessee and West Kentucky, the greatest loss occurred in separating the overburden from the top of the coal. The remaining losses were, in descending order, bottom coal, ribs, partings, and other.

Figure 3 illustrates how the average barrier loss varied drastically by State--ranging from zero for Maryland to 16.5 percent for Tennessee. In most cases, standard deviation is greater than the mean, indicating the variance is large.

Region

Mining losses averaged 17 percent greater in the Midwest than those in Appalachia (fig. 4), primarily because of greater rib losses (3.7 versus 0.7 percent). Barrier losses in the Appalachian region, however, were nearly twice those in the Midwest, most of the difference resulting from outcrop and stream barriers (fig. 4).

Mining Method

Sample means by contour, mountaintop removal, and area mining methods are listed in table 4. Mining losses were 10.7 percent for area, 10.0 percent for contour, and 8.6 percent for mountaintop removal (fig. 5). Most of the coal lost in mining was top and bottom losses (7.2 percent). Rib losses were significant in area mining (2.1 percent) and parting losses were significant in contour mining (2.5 percent).

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[6] Regions are: Appalachia, containing Alabama, East Kentucky, Maryland, Ohio, Pennsylvania, Tennessee, Virginia, and West Virginia; and the Midwest, containing Illinois, Indiana, and West Kentucky.

TABLE 3. - Mean mining and barrier losses and total recovery for strip mines, by State and region

State and region	Number of mines	Mining losses, percent						Barrier losses, percent									Total recovery, percent
		Top	Bottom	Rib	Parting	Other	Total	Outcrop	Rights-of-way	Stream	Underground mine	Oil and gas well	Property line	Building	Other	Total	
Illinois	10	5.7	2.0	3.3	0	0.4	11.4	0	4.1	0.2	0	0	0.5	0	0.2	5.0	84.4
Indiana	9	4.5	2.1	2.9	0	2.8	12.3	0	0	.4	.1	0	3.7	0	3.8	8.0	80.5
West Kentucky	10	4.6	2.2	4.8	0	0	11.6	0	.5	0	.2	0	0	0	.3	1.0	87.5
Midwest subtotal or average	29	4.9	2.1	3.7	0	1.1	11.8	0	1.6	.2	.1	0	1.3	0	1.3	4.5	84.3
Alabama	17	4.1	2.8	1.3	0	.1	8.3	.8	.8	.1	.1	0	.3	0	0	2.1	89.8
East Kentucky	21	4.3	2.9	.2	1.3	.8	9.5	7.0	.1	2.1	.6	.2	.8	0	2.4	13.2	78.6
Maryland	4	4.0	3.6	0	0	1.1	8.7	0	0	0	0	0	0	0	0	0	91.3
Ohio	20	4.9	2.7	.4	.6	1.0	9.6	.8	3.6	0	0	0	2.5	1.0	1.6	9.5	81.9
Pennsylvania	24	4.4	3.6	1.6	.3	1.0	10.9	2.6	2.5	.7	.7	.1	.3	.9	.2	8.0	81.9
Tennessee	7	4.7	2.6	.4	6.0	0	13.7	5.1	0	6.3	2.9	0	.1	0	2.1	16.5	72.3
Virginia	8	4.2	2.1	.2	2.7	.3	9.5	6.7	.5	1.2	0	0	1.9	.2	0	10.5	79.9
West Virginia	22	3.4	2.9	.6	1.4	.6	8.9	2.8	1.0	.8	0	.7	1.0	0	.1	6.4	85.3
Appalachian subtotal or average	123	4.2	3.0	.7	1.1	.7	9.7	3.1	1.4	1.1	.4	.2	1.0	.4	.8	8.4	82.7
Total or average	152	4.4	2.8	1.3	.9	.7	10.1	2.6	1.5	.9	.4	.1	1.0	.3	.9	7.7	83.0
Standard deviations		(1.9)	(1.5)	(2.6)	(2.8)	(2.2)	(4.8)	(4.6)	(3.8)	(3.5)	(2.0)	(1.1)	(3.7)	(0.3)	(5.4)	(10.4)	(10.8)

TABLE 4. - Mean mining and barrier losses and total recovery for strip mines, by mining method

Mining method	Number of mines	Mining losses, percent						Barrier losses, percent									Total recovery, percent
		Top	Bottom	Rib	Parting	Other	Total	Outcrop	Rights-of-way	Stream	Underground mine	Oil and gas well	Property line	Building	Other	Total	
Contour	46	4.0	3.0	0.3	2.5	0.2	10.0	6.0	1.0	1.0	0.7	0.5	0.3	0.1	1.5	11.1	79.8
Mountaintop removal	27	3.7	2.5	.7	.4	1.3	8.6	2.3	.6	1.7	0	0	1.7	.5	0	6.8	85.3
Area	77	4.8	2.8	2.1	.2	.8	10.7	.6	1.7	.5	.3	0	.9	.3	.9	5.2	84.7
Total or average	150	4.4	2.8	1.3	.9	.7	10.1	2.6	1.5	.9	.4	.1	1.0	.3	.9	7.7	83.0
Standard deviations		(1.9)	(1.5)	(2.6)	(2.8)	(2.2)	(4.8)	(4.6)	(3.8)	(3.5)	(2.0)	(1.1)	(3.7)	(.3)	(5.4)	(10.4)	(10.8)

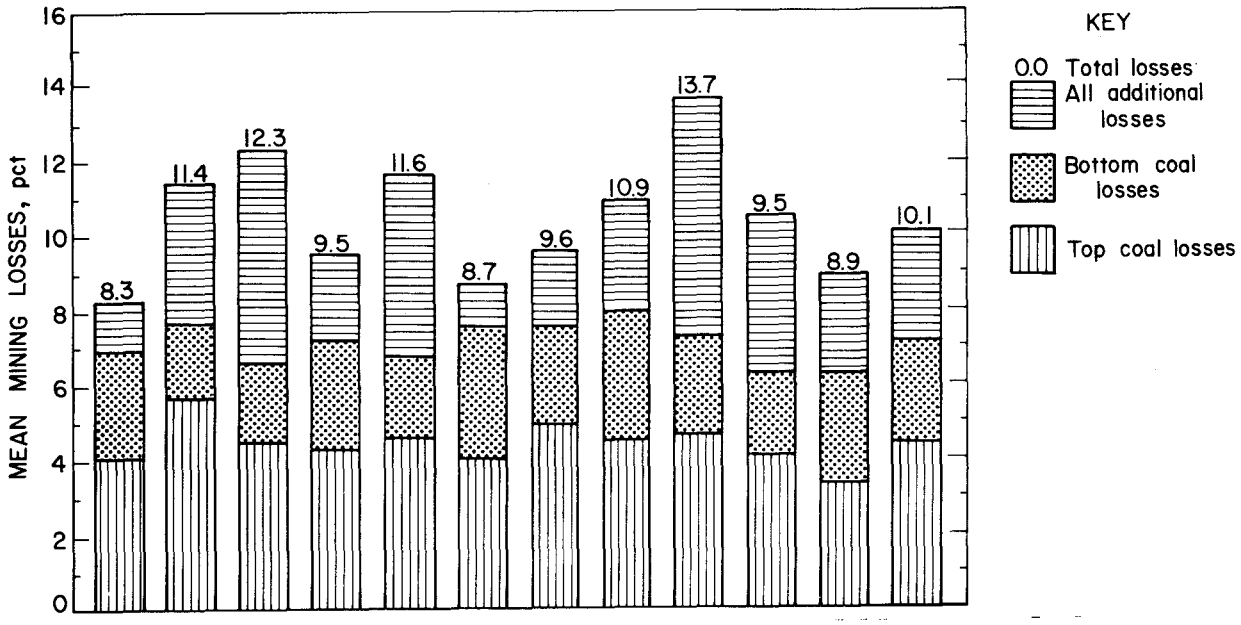

FIGURE 2. - Mean mining losses for strip mines, by State.

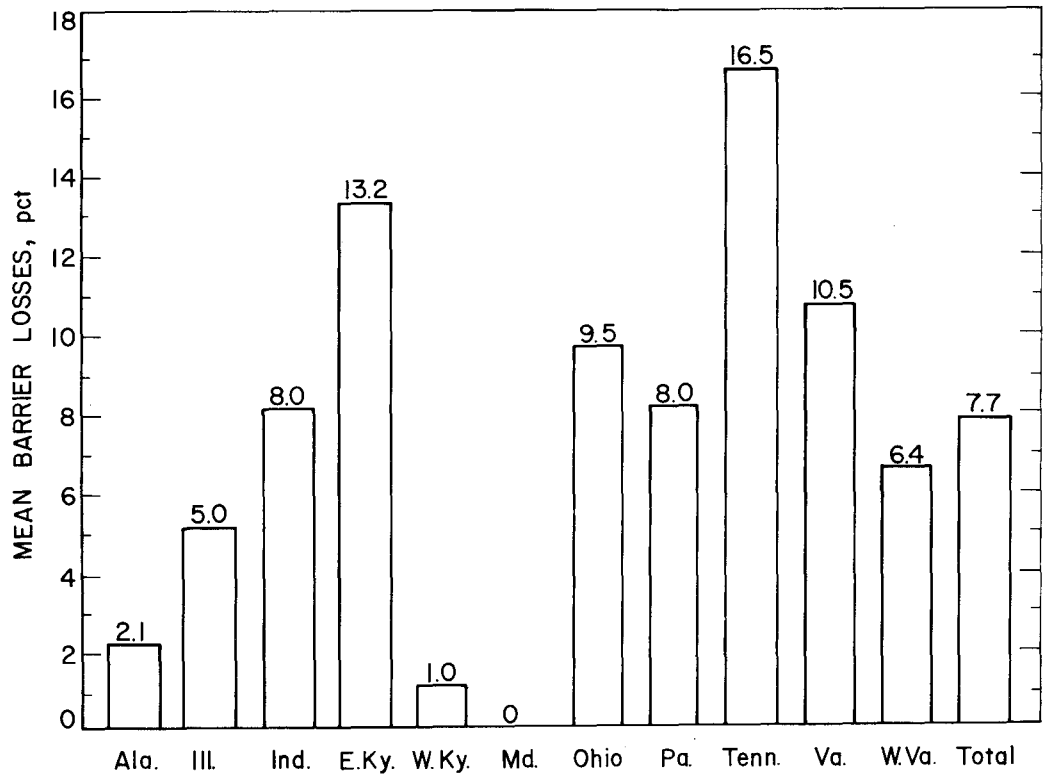

FIGURE 3. - Mean barrier losses for strip mines, by State.

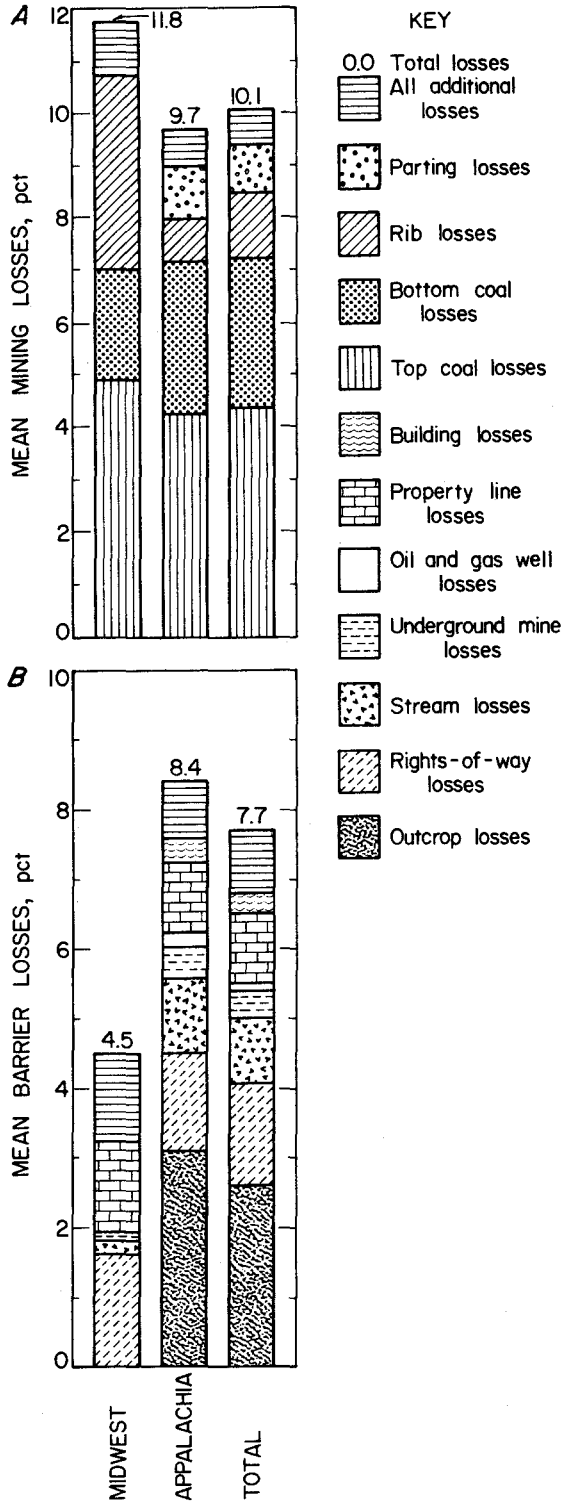

FIGURE 4. - *A*, Mean mining losses for strip mines, by region; *B*, mean barrier losses for strip mines, by region.

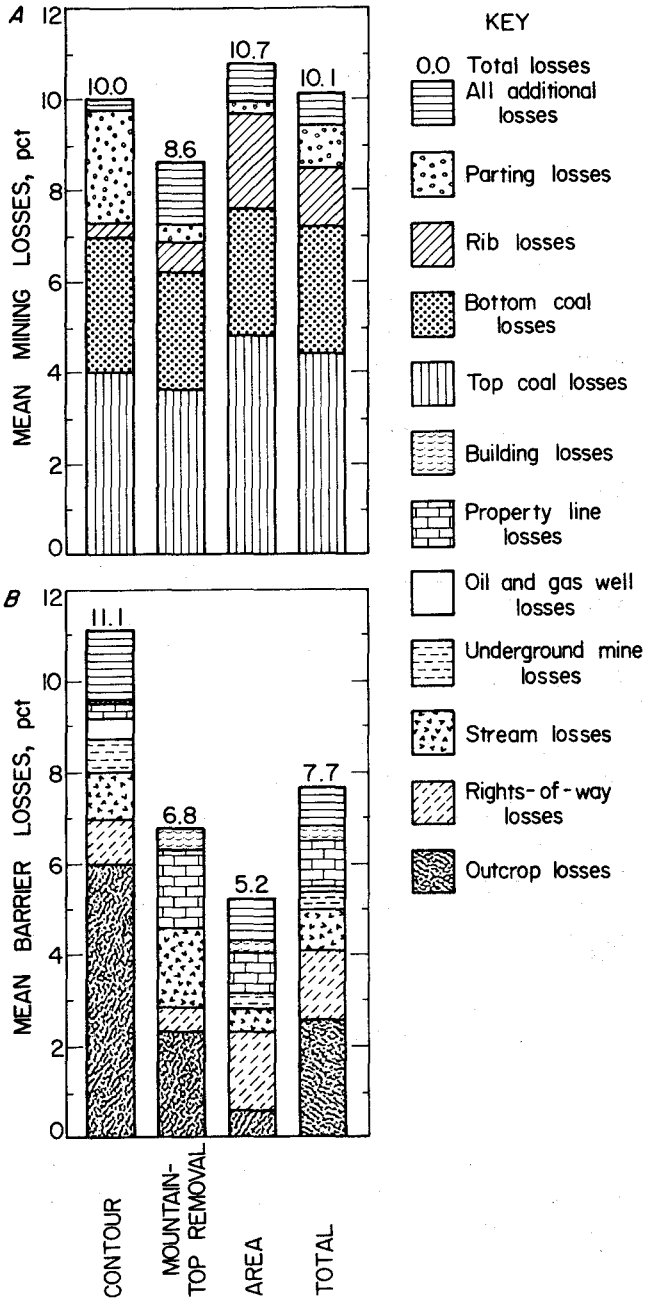

FIGURE 5. - *A*, Mean mining losses for strip mines, by mining method; *B*, mean barrier losses for strip mines, by mining method.

Mean barrier losses (fig. 5) for contour mining were considerably higher (11.1 percent) than either mountaintop removal (6.8 percent) or area methods (5.2 percent). Again, this difference is almost entirely due to the large outcrop losses incurred in contour mining.

Auger Mining

Recovery from augering operations was calculated directly from measurements of the augered area using the formula:

$$R = \frac{\text{coal recovered by augering}}{\text{coal available for augering}} = \frac{A \times AD \times Holes \times 100}{TH \times MD \times L}, \quad (2)$$

where R = recovery, percent,

A = area of auger hole = $\frac{1}{4}\pi d^2$,

TH = bed thickness,

AD = average depth of auger holes (estimated),

MD = maximum depth of auger holes,

L = length of face augered,

and Holes = number of auger holes in length L.

Auger recovery varied from 25.5 to 43.7 percent, with a mean of 35.9 percent and a standard deviation of 5.5 percent. Operators' estimates of recovery ranged from 10 to 75 percent, and were usually too large.

The three major operating factors which adversely affected coal auger mining recovery were (1) auger diameter too small for coalbed thickness, (2) poor average depth of penetration, and (3) excessive spacing between holes. To determine the effect of these factors, it was necessary to define the ideal coal auger mining recovery for conditions observed in the field. The average coalbed thickness for the auger mines surveyed was 49.8 inches and the maximum depth of penetration averaged 150.8 feet. Under these conditions, the ideal auger recovery should have been 63.6 percent if:

1. All auger holes penetrated to the maximum depth (average depth = maximum depth).

2. Auger hole diameter was 6 inches less than coalbed thickness (manufacturers' recommendation).

3. Auger hole spacing exceeded hole diameter by 4 inches (ribs were 4 inches thick at the midpoint).

4. A single head auger was used.

Under the ideal condition described, the design coal loss is 36.4 percent. The average coal loss observed was 64.1 percent; the difference (27.7 percent) is attributed to major operating loss factors. The average loss for each of the three major operating factors was calculated from data collected in the field on average versus maximum depth of penetration, average auger diameter, and the average spacing of holes observed in the field. The coal loss percent attributed to each of the factors and reasons for the loss are as follows:

Auger undersize for coalbed thickness.--An average coal loss of 9.6 percent was attributed to this factor. Coalbed thickness is variable and mine operators have a limited number of auger sizes. It is not practical or economical to have on hand a full range of auger sizes, or to frequently change augers when coalbed thickness is highly variable.

Poor average depth of penetration.--The coal loss attributed to this factor averaged 11.5 percent. The number of holes penetrating to the maximum depth depends to a large extent on the skill of the auger operator, but other factors such as thinning of the coalbed, hard partings, and roof falls can limit penetration. If the hole is not straight, penetration will stop when top or bottom rock or the void left by a previous auger hole is encountered.

Excessive spacing between holes.--This factor accounted for an average coal loss of 6.6 percent. It is a function of operator skill, highwall integrity, and roof support requirements.

SECONDARY ANALYSIS FACTORS

A secondary analysis was undertaken to determine relationships between recovery and factors other than States, regions, and mining methods. Factors which were considered to affect coal recovery were stripping ratio, coalbed partings, mining multiple coalbeds, size and type of mining equipment, coal washing, size of mine or company, and coal ownership. These factors were subjected to comparative analyses described later. In addition, multiple regressions of all factors were performed by computer, in an attempt to develop a descriptive model for coal recovery. No statistically significant correlations were obtained; therefore, this line of analysis was unsuccessful.

Observed Stripping Ratio

Stripping ratio is defined as the height of the highwall in feet divided by the thickness of the coalbed in feet. The observed stripping ratio[7] ranged from 4.0 to 69.2, with a mean of 17.4 for the sample surveyed. Mean observed stripping ratios and total recovery by State are shown in table 5. Alabama had the highest average observed stripping ratio, and Maryland had the lowest. Table 6 shows the variation of observed stripping ratio to mining recovery by mining method. Average stripping ratios of 14.1 to 15.1 were observed for the

[7] Observed stripping ratio is the ratio of highwall height to coalbed thickness at the time of observation.

three mining methods when Alabama was excluded from area mining (the average observed stripping ratio for Alabama was 32.0). Average mining recovery did not vary significantly with changes in observed stripping ratios.

TABLE 5. - Mean observed stripping ratios and total recovery, by State

State	Mean observed stripping ratio	Total recovery, percent
Alabama	32.0	89.8
Illinois	15.9	84.4
Indiana	16.4	80.5
West Kentucky	12.0	87.5
East Kentucky	14.7	78.6
Maryland	11.8	91.3
Ohio	18.3	81.9
Pennsylvania	19.0	81.9
Tennessee	13.4	72.3
Virginia	12.9	79.9
West Virginia	13.5	85.3
Total or average	17.4	83.0

TABLE 6. - Mean observed stripping ratios, mining losses, and total recovery, by mining method

Mining method	Average observed stripping ratio	Mining losses, percent	Total recovery, percent
Contour	15.1	10.0	79.8
Mountaintop removal	14.2	8.6	85.3
Area	20.1	10.7	84.7
Area excluding Alabama	14.1	11.8	84.3
Total or average	17.4	10.1	83.0

Partings

Coal mines which had coalbeds with partings that were removed during mining had slightly lower mining recovery (89.0 percent) than those that did not (90.1 percent). This is because there is some coal lost when separating partings in the same way top and bottom losses occur during coal removal.

Mining Multiple Coalbeds

Stripping operations which removed multiple-bed coal deposits might be expected to experience greater top and bottom losses than single-bed mines. However, for the sample there was no discernible difference in average top and bottom losses or mining recovery.

Equipment Size and Type

Nearly one-half of the primary stripping equipment used in the sample was draglines, one-third front end loaders, and one-tenth shovels. The remaining types of equipment used were dozers, scrapers, and bucketwheel excavators. Generally, draglines are assumed to achieve higher mining recovery than

stripping shovels because draglines provide better control, and shovels are operated on the coalbed and tend to increase top losses by crushing. Table 7 illustrates the average mining loss by equipment type; losses are slightly less (10.0 versus 11.8 percent) for draglines than shovels. Average losses improve to about 10 percent for front end loaders and scrapers and averaged less than 9 percent for dozers.

TABLE 7. - Mean mining losses by overburden stripping equipment type

Equipment type	Number of mines	Total mining losses, percent
Dragline.....	72	10.0
Shovel.....	15	11.8
Bucketwheel excavator	2	12.0
Front end loader.....	50	10.0
Scraper.....	5	9.7
Bulldozer.....	8	8.8

Coal Washing

Nearly 60 percent of the coal mines surveyed sold unwashed coal (run-of-mine or crushed and sized). Operators assume that slightly higher coal mine recovery can be achieved when washing facilities are available. This is because partings occurring in the coal and areas of coal dilution could be loaded since noncoal materials are removed during the washing process. However, little difference in recovery was experienced in the sample for washed and unwashed coals.

Mine and Company Size

The size of individual mines and mining companies may affect coal recovery. Large mines, with larger equipment, support maintenance, and engineering staff, may operate more efficiently to recover greater percentages of total reserves. Large mining companies likewise may hold a competitive edge with greater financial and human resources. However, there were no quantifiable differences in the data collected based on the size of mines and companies.

Coal Ownership

Operators who mine leased coal may not have as much incentive to maximize recovery from reserves as do operators who mine their own coal. Again, the collected data showed no quantifiable differences in recovery when sorted by ownership.

CONCLUSIONS

The mean recovery in strip mines was 83.0 percent, with mean barrier and mining losses of 7.7 and 10.1 percent, respectively. By State, total recovery varied from 72.3 to 91.3 percent, barrier losses from 0.0 to 16.5 percent, and mining losses from 8.3 to 13.7 percent.

The recovery in auger mines ranged from 25.5 to 43.7 percent with a mean of 35.9 percent. Design losses were 36.4 percent and mean operating losses were 27.7 percent.

Secondary factors affecting recovery were the presence of partings and overburden equipment type. Factors studied which did not affect recovery were (1) stripping ratio, (2) mining multiple coalbeds, (3) coal washing, (4) mine and company size, and (5) coal ownership.

The historical practice of using 80 percent for purposes of estimating strip mine recovery appears to be relatively accurate. That figure falls well within the 10.8 percent standard deviation of this study's mean recovery of 83.0 percent, and is within 1.9 percent of the mean recoveries of half the States studied (East Kentucky, 78.6 percent; Virginia, 79.9; Indiana, 80.5; and Ohio and Pennsylvania, each 81.9 percent).

This study has identified the problems inherent in trying to fix a single recovery rate for an area as diverse as the Eastern United States. Barrier losses, a largely uncontrollable factor, varied greatly between States and mining methods, which in turn were commonly dictated by topography and, where necessary, were modified to utilize operators' existing equipment. Although the study supports the commonly used 80-percent-recovery figure as a measure of recoverable reserves when applied to a broad reserve study, this report does not recommend that this recovery rate, or any other generally derived rate, be applied to specific site determinations of recoverable reserves in the Eastern United States.

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