CONSERVATION OF OUR OIL AND COAL RESOURCES.

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CONTENTS.

INTRODUCTION.

The enormous increase in production of petroleum during recent decades has given rise to considerable study as to the

*The writer has drawn freely on reports of the U. S. Geological Survey, Van Hise's book on Conservation of Natural Resources, and Rice's paper on Mining Costs and Wastes: Bull. Ill. State Geol. Survey, No. 14.

total reserve in the earth, and the probable length of time before it will be exhausted. Petroleum serves so many unique functions in modern life that it seems indispensable; but in all probability its exhaustion is a matter of only a few years. It is said that if the present rate of increase in production continues, our known fields will be exhausted in twenty-three years; and even if the present production continues without increase the known supply will be gone within ninety years. These views are startling, but they are based on the best knowledge of the present time, with reference to the supply and demand at home and abroad.

PETROLEUM OUTPUT OF THE WORLD.

Since petroleum is an important element of the world's commerce, being easily transported by rail or water, the conservation problem at home is influenced by conditions in other producing countries. In 1910, thirteen countries produced a total amount exceeding 327 million barrels. The output in the United States equaled 64 per cent of the total; the Russian production equaled 21 per cent; and no other country produced as much as 4 per cent. Thus, the United States is by far the dominant producer in the world. The world's output in each year since 1906 has exceeded that of the previous year by 52, 21, 13, and 29 million barrels, or by an average of 29 million barrels.

PRODUCTION OF PETROLEUM IN THE UNITED STATES.

Output and Probable Duration.

Since the United States is by far the largest producer of petroleum, the conditions of production in our own country are the most important in connection with conservation. Since 1861, when the production was a little more than two million barrels, the output has doubled repeatedly within the following short yearly intervals: 9, 4, 7, 10, 12, 6.

The fields of the United States are shown in Plate I. The phenomenal increase in production is indicated by Plate II, which shows also the year in which new fields influenced the total production.

In order to know the effect of such increasing production on the duration of supply it is necessary to calculate the probable content of the oil sands in the known fields. The best estimates in 1907 indicated that the original supply was between 10 and 25 billion barrels. Calculation showed that the oil would be gone

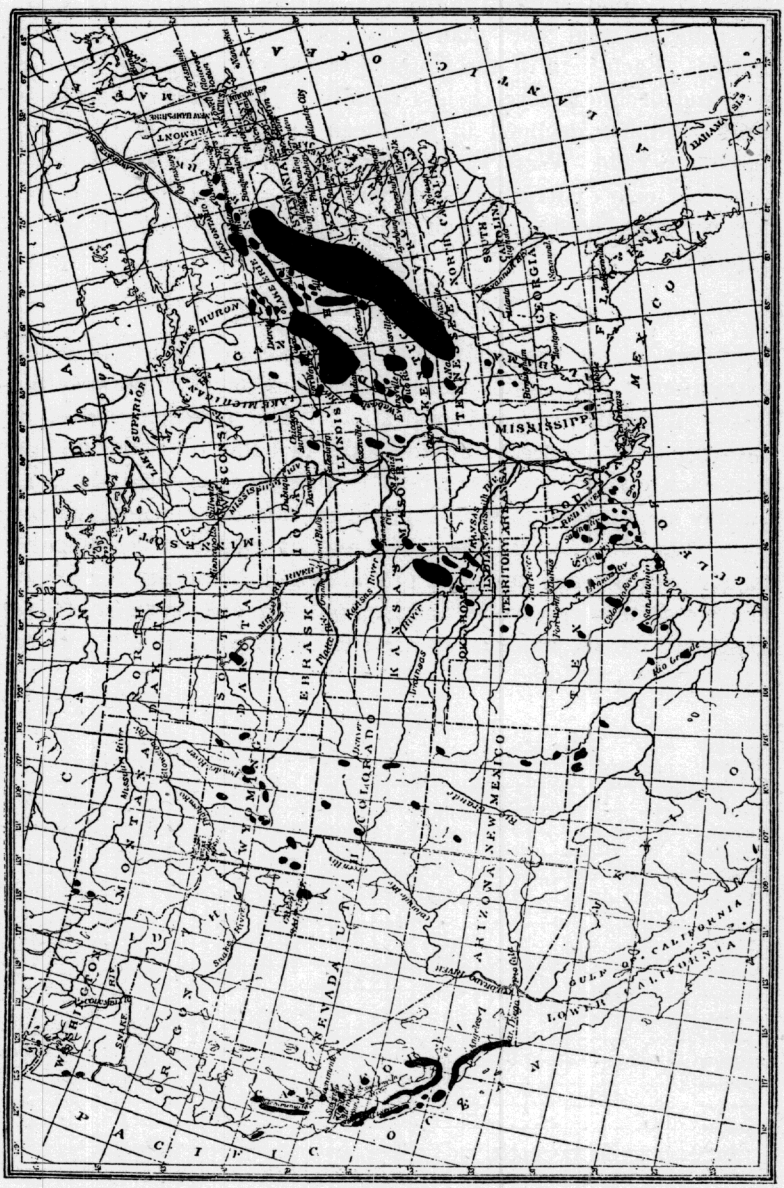


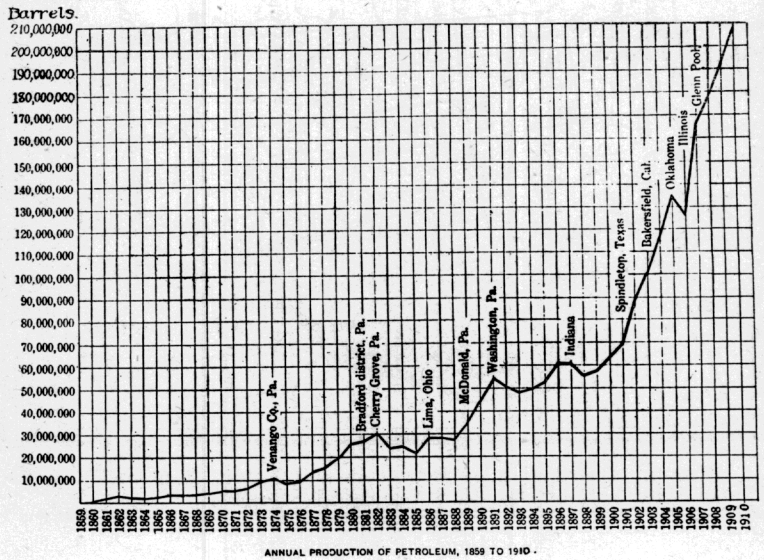
Plate I. Distribution of Petroleum and Natural Gas Fields in the United States. After Day, U. S. Geological Survey.

in 23 years if the production continued to increase at the same rate. It is interesting to notice that during the past three years the rate has been more than maintained, as shown by the illustration. Each field of the country reaches a maximum production and declines more or less rapidly. The Pennsylvania-New York field has declined in seventeen years to one-third of its maximum yield. West Virginia production has already declined to 56 per cent of its greatest output. Unless new fields are frequently discovered, an inevitable decline in total production is imminent.

Wastes of Petroleum.

In view of the irreparable loss of petroleum which follows its extraction, it is desirable to reduce as completely as possible the losses in production and utilization. The principal losses in extraction are indirectly caused by the fact that oil is mobile and that each owner in a given field is obliged to get his share as quickly as possible. Thus, facilities are not always provided for controlling the flow of new wells and of gushers. Frequently, no adequate storage tanks are provided and the oil lies for weeks in great earthen reservoirs, and is exposed to evaporation. These losses are indeed serious, but are subject to correction. A third

Plate II.



ANNUAL PRODUCTION OF PETROLEUM, 1859 TO 1910.

important loss comes from the fact that transportation for oil cannot always be provided promptly, and so the output is used for purposes which are extravagant. Thus, great quantities of oil which contain valuable distillation products are used under steam boilers and for oiling roads.

In view of the fact that oil is much more efficiently used in internal combustion engines, it should not be used for raising steam; and in view of our dependence on petroleum for lubricants and for isolated lighting, the continued misuse is deplorable.

MEANS OF CONSERVATION.

Ways in which our petroleum supply can be conserved have already been suggested. It is considered important to withdraw from entry those government lands which are probably underlain by oil, and thus to prevent over-production. The present exportation of 20 per cent of our oil annually should probably be reduced gradually. The recommendation is also made that research should be stimulated so as to provide more satisfactory combustion engines, and also to provide substitutes, such as cheap alcohol. There is some promise of successfully converting low-grade oils into better grades by means of chemical processes. Thus, and by similar intensive effort of producers, refiners, and the consuming public, it may be that we shall succeed in reducing ordinary losses, greatly extending the period of production and reserving petroleum for those purposes for which it seems to be indispensable.

CONSERVATION OF OUR COAL RESOURCES.

Our Interest in the Problem.

The whole world is vitally interested in conservation of coal resources. The total production for the year 1910 was approximately 1⅓ billion tons. Of this enormous amount the United States produced 500 million tons, or practically 39 per cent. The importance of Illinois mining is indicated by our production of approximately 10 per cent of the total for the country. Since America leads the world in production and apparently possesses the largest reserves, and since coal is mined here at a much lower

cost than abroad, it is probable that the world will demand exports from the United States at an increasing rate unless Federal laws prevent it. Although this demand will doubtless be met chiefly by the eastern States, Illinois coal in small part may sometime reach the Gulf by a deep waterway. It is evident, however, that we shall have more important and rapidly increasing demands for the States which comprise the heart of the country, and which are destined to support an enormous population engaged in manufacture and commerce.

Coal Fields of United States and of Illinois.

The coal fields of the country as shown by the accompanying map (Plate III), include 310,296 square miles and contained originally about three trillion tons of all grades. The Eastern Interior Region, of which Illinois comprises about three-fourths, included about 70 per cent of the coal of the interior States when mining began. The Illinois field includes 35,600 square miles, and is the largest area of bituminous coal known to exist in any State. The original coal in Illinois has been estimated at 200 to 240 billions of tons, though it will be many years before a close estimate can be made.

Growth of Coal Production and Mining Wastes.

Coal production in the United States is interesting because it affects the future in Illinois; and the inter-dependence of States unites us in the cause of conservation. Recorded commercial production began in the East in 1822 and amounted to 54,000 tons. The slow increase during early times and the enormous growth in recent years is pictured by Plate IV. This illustration is based on totals by decades, to the close of 1910.

Illinois production began about 1835, with a total of 6,000 tons for the year. In 1907 it exceeded 51 million tons, and since then has fluctuated between 48 and 51 million tons, chiefly because of labor troubles. The accompanying illustration (Plate V) shows totals by decades and resembles the previous diagram for the United States.

Total mining wastes have doubtless increased in manner similar to production; for it is estimated that for the country as a whole one-half ton of bituminous coal is wasted for each ton marketed. In Illinois it is probable that the waste is greater and approximates a full ton for each ton mined.

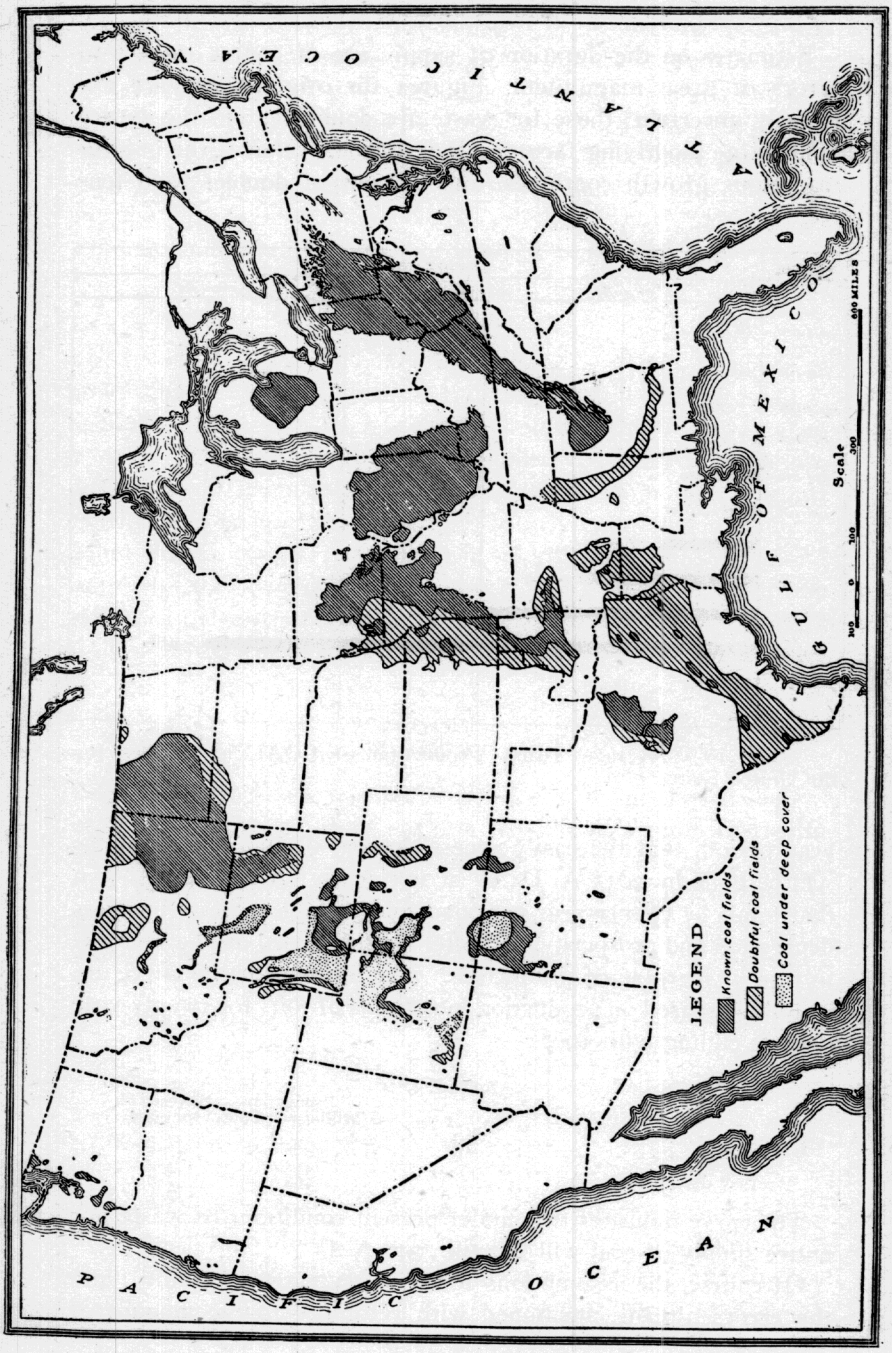


Plate III. Distribution of Coal Fields in the United States. After Campbell and Parker, U. S. Geological Survey.

Duration of Supply.

Estimates on the duration of supply are of course subject to errors of great magnitude. Figures for original coal are extremely uncertain; those for waste are doubtful; and the future holds large modifying factors. It is estimated that if the present marvelous growth continues, and the output doubles each ten-

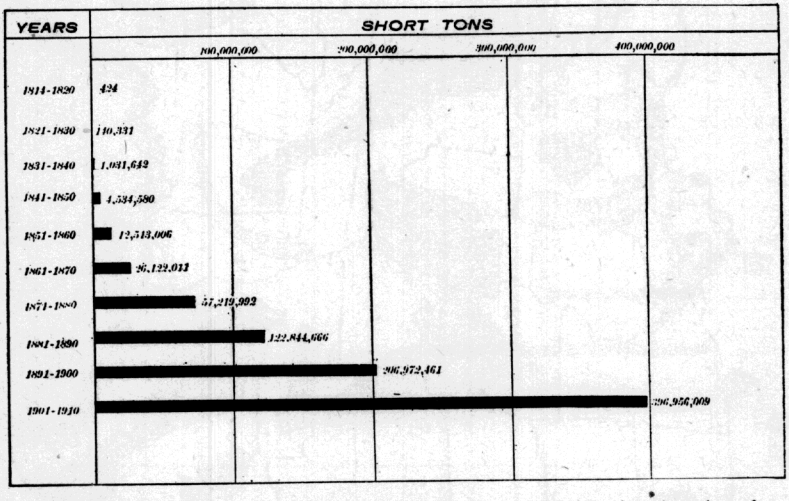


Plate IV. Average Yearly Production of COAL in decades for the United States.

year period, that the easily accessible coal of the United States will be gone by 2015 A. D., or in 103 years. It has been shown that totals by twenty-year periods avoid variables due to business depression and prosperity, and offer a curve based on the decrease in rate of increase of production. The figures for the curve are as follows, based on production in millions of tons for twenty-year periods ending with 1907:

TABLE I.

	Production, Millions of Tons.	Per cent of Increase.
1828-47	37.3	...
1848-67	306.0	720
1868-87	1451.0	374
1888-1907	5068.0	249

The curve indicates that under present conditions of waste our entire supply of coal will last till 2040 A. D.

Of course, the assumptions for such estimates are faulty; and the errors already mentioned with reference to the amount of

coal, together with doubt as to future demands at home and abroad, reduce the estimates to guesses. Nevertheless, in considering the lives of nations and the habitation of the globe, an

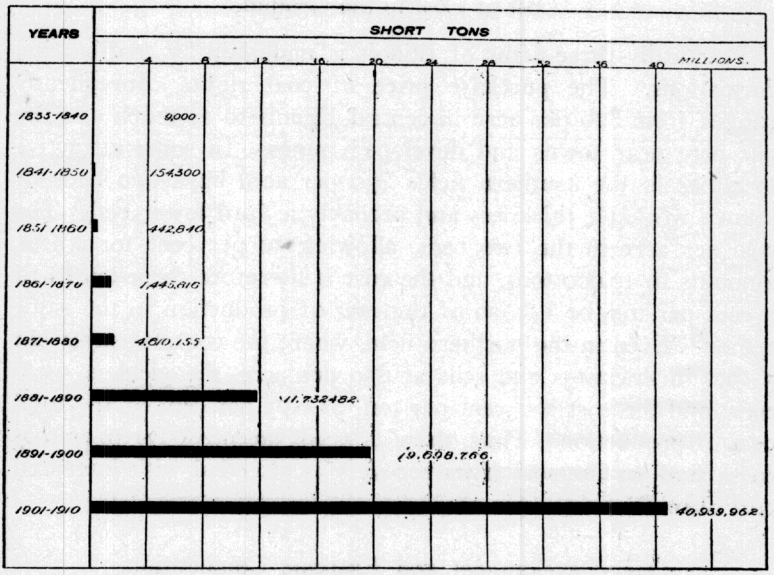


Plate V. Average Yearly Production of COAL in decades for Illinois.

error of one or two hundred years is negligible. It therefore behooves Illinois, as rapidly as possible, to take careful stock of our coal and to minimize wastes in mining and utilization.

WASTE OF COAL IN ILLINOIS.

General Statement.

Waste of coal in Illinois takes place chiefly in its mining and utilization. To a lesser degree the coal is wasted through non-use of cheaper substitutes.

Mining the coal is simple from the engineering viewpoint. The beds are unusually regular in distribution and thickness; and they lie practically horizontal. Nevertheless, the variations in recovery range from about 95 per cent to less than 50 per cent. Additional loss assumes importance locally, where subsidence due to mining may break overlying coals, and render easy recovery of the higher bed impossible. The chief reasons for the loss are

not engineering difficulties, but, rather, the cheapness of coal in the ground, and the low profits resulting from over-production and extreme competition.

Cost of Coal in the Ground.

Practically three-fifths of Illinois is underlain by coal-bearing formations. The purchase price of coal rights consequently ranges from $20 per acre in central Illinois to as much as $100 per acre near towns and developed mines. In some attractive localities in the southern fields $30 per acre buys two beds of known workable thickness and probably a third lower bed. The coal per acre in the two beds, allowing 50 per cent for waste, amounts to 10,000 tons, and the cost is therefore three-tenths of a cent per ton, or 1/1000 of the cost of production in the same region. Even in the northern field, where the coal measures but 3 feet in thickness and sells at $50 per acre, the yield is 5,000 tons, and the cost is 1 cent per ton, or 0.75 per cent of the total cost of production. Thus, there is small incentive for operators to save all of the coal if its recovery is attended with increased cost of mining.

Over-Development and Extreme Competition.

In 1909 there were 597 mines of commercial importance, which produced 50,529,370 tons. Practically the same mines in 1910 produced 46 million tons, with only 160 working days. It is customary for Illinois mines to meet the demand by operating only two-thirds of the year. The over-capacity of the mines is somewhat necessary because of the heavy demands of the cold winter months, but it leads to over-production and ruination of prices in months of lesser demand. It is then cheaper to operate without profit, or at a small loss, rather than to permit deterioration of plant and loss of important employees.

A great factor in prices has been the public demand for unnecessary variety in sizes of prepared coal. At given times, therefore, each mine finds itself obliged to sell uncalled-for sizes at an actual loss. Screenings, especially have been sold at a loss, but their increased use in automatic stokers promises improved prices. Large consumers have usually bought the sizes which are a drug on the market and small consumers necessarily pay the small profit which reaches the mine operator.

Illinois coal meets severe competition from other States as

well as from our own producers. The miners are better organized and secure higher wages in Illinois than in the principal competing States. In West Virginia, where the men are practically unorganized, coal was sold at the mine in 1910 at a price averaging 20 cents less per ton than in Illinois. This condition, together with low freight rates to Chicago and superior quality of the eastern coal, enables it to sell in our natural markets.

The latest available data for years not affected by wage disturbance, indicate an average selling price of $1.41 at the mines in northern Illinois and $0.88 to $1.15 in other districts. The average cost, including general and selling expense and amortization, averages $1.20 to $1.30 for the northern long-wall district and $0.70 to $0.95 in the other districts. The best gross profit probably does not exceed 20 cents, and when interest on the invested capital is deducted the net profit is reduced to 10 or 15 cents per ton; the average net profit throughout the State is probably much less than these figures. It is readily seen, therefore, that under present conditions it is nearly impossible to increase the percentage of mining extraction when this will increase mining costs.

Wasteful Mining Methods.

The above considerations show the controlling causes for the waste of about 50 per cent of our coal in mining. It is desirable next to consider the ways in which the coal is lost beyond recovery. They are due, in order of importance, to

1. System of mining.
2. Carelessness in operation.
3. Irregular boundaries of property.

Losses Due to System of Mining. Two general systems of mining prevail, as determined chiefly by the character of strata overlying the coal. The long-wall method of northern Illinois yields 90 to 95 per cent of the coal; but the room-and-pillar method, which is elsewhere in practice, commonly yields only 40 to 60 per cent.

Where the long-wall method is used, the coal averages 3 feet in thickness, and the roof is composed of shale, which settles gradually as the coal is removed. The miner undercuts the coal to a distance of 4 to 6 feet and the pressure of the roof breaks it down. Meanwhile props are set parallel to the face, so as to maintain a working place, along which fresh air circulates. Fallen shale and other refuse are continually piled behind the

miner, and the roof is taken down where necessary to maintain roadways. Under this system all of the coal can be recovered, but as a matter of fact shut-downs occasion some loss, because of falling roof and irregular alignment of the mining face. Remote corners of property may also be lost. However, recovery of 95 per cent is possible in spite of such losses. If the same method were applicable to all Illinois mines our conservation problem would be largely solved.

Unfortunately, the strata above the thicker coals of the State are so varied in character and strength that the room-and-pillar method is commonly necessary. Narrow passages are cut in the coal to serve for haulage and air circulation. Wider rooms are then mined out with the aid of coal pillars and room props to sustain the roof. It has been the common practice to abandon pillars when the rooms are finished.

One reason for leaving the pillars is that under prevailing systems, which prescribe narrow pillars and wide rooms, it is expensive, if not impossible, to recover the pillars. It may be pointed out that, if the mines were worked on a panel system with separate units surrounded by thick barrier pillars, and if rooms were narrow and room pillars thick, practically all of the coal could be recovered. It is encouraging to know that some of the large companies are now installing this system.

Another reason for leaving pillars is that surface subsidence frequently causes damage suits. The actual loss from surface subsidence should be negligible; for even with land values of $125 per acre, and with total loss of 80 per cent, or $100, the money loss would be only 1 per cent per ton of the coal in a 6-foot bed. As a matter of fact, the land would be as good as ever after full settlement takes place and deranged surface drains and tile systems are restored.

An important loss in some parts of the State where thick coal prevails comes from leaving 1 to 2½ feet of coal to form a roof. It is needed to strengthen weak shale during advance work. Although such coal can be recovered after rooms are worked out, it is not uncommonly wasted.

It is usually assumed that the room-and-pillar method yields 60 per cent of the coal, but it is probable than when unexpected losses, due to carelessness, are included, the average recovery for the State is not more than 50 per cent. A satisfactory remedy has been advocated for the present losses with room-and-pillar methods, but it is hard to introduce because it would increase the

preliminary period of mine development and defer profits three or four years longer than usual. The plan contemplates locating the shaft at the common corner of four sections of land, and cutting haulage ways to one side and thence to a corner. The coal could be completely recovered by retreating long-wall method, and the total cost of mining doubtless would be less than under present methods. The difficulty lies in the fact that two and one-half years would be required to drive the entries and make ready for profitable mining. The heavy cost during early years would rapidly decrease, and the closing years of mining would be more profitable, in contrast to the reverse conditions under present practice.

Losses Due to Carelessness in Operation. Besides wastes due to faulty system of mining, careless or inefficient operation is important. Failure to keep maps up-to-date frequently causes small blocks of coal to be passed by until too late for recovery. Surveys are not complete when mines are finally abandoned, and so future operators on adjoining properties are required to leave barriers of unnecessary size in order to be free from danger of gas and water in the abandoned workings. Again, pillars are left so small, or are "robbed" to such an extent, that roof and floor begin to "squeeze," and the coal is so crushed that large areas are abandoned. Fires, similarly, require the sealing off of large portions of the mines, and recovery is neglected. Another species of prevailing bad practice is the excessive use of explosives to blast down the coal. This causes an undue amount of fine coal, which either is not loaded out or is of low market value. In addition, this practice causes fatal explosions directly, or so weakens the roof that fatal accidents and the abandonment of parts of the mine follow indirectly.

Losses Due to Irregular Property Boundaries. A growing source of waste of coal is due to the purchase of land in checkerboard fashion, and to similar competitive tactics which isolate areas of coal, which are too small to warrant independent mining.

Waste of Coal by Improper and Unnecessary Utilization.

Generation of Power, Heat, and Light. Although it is difficult for one who is not a mechanical engineer to appreciate the wasteful utilization of coal, enough has been written on the subject to emphasize certain important features. Thus, the ordinary boiler utilizes only 5 per cent to 10 per cent of the fuel energy. Even

with mechanical stokers and best types of boilers only 15 per cent is used. Similarly, the ordinary steam engine utilizes only 5 per cent of the steam energy. The use of producer gas and gas engines has been shown to yield one brake horsepower hour with only 37 per cent of the fuel required under water-tube boilers. Large gas-engine installations have been made recently at Gary, Indiana, and the improvement is being slowly introduced into other large plants.

Another serious loss in the country is seen in coke ovens of the beehive type, which waste enormous quantities of volatile by-products. Modern retort ovens would save $50,000,000 annually.

Use of coal for domestic heating and lighting purposes is even more wasteful. Thus ordinary electric light utilizes only 1 per cent or less of the energy in coal. It is stated that 8 per cent, or 20,000,000 tons, of the coal used in making light, heat, and power goes up the chimney. Locomotives, of course, waste a much larger percentage.

It is obvious that the development of central plants for light, heat, and power is very desirable, for it will give smokeless combustion of low-grade coals, with the highest possible efficiency. Where possible, such stations should be located in the coal fields and the energy should be transmitted as electricity and coal gas. It is understood that long-distance transmission from the anthracite region to New York City is under consideration, and that the plan is also considered for Chicago.

Water Power and Solar Engines. The unnecessary use of coal where other forms of energy are available is, of course, deplorable. Attention has been called so emphatically to the enormous waste of water power that we may confidently look forward to the utilization of its full energy, to the limit of economical transmission.

The solar engine has been so far perfected, I understand, that an installation at Stanford University has operated economically in comparison with coal-fed boilers for a long period of testing. The apparatus comprises a large box covered with glass, and partitioned so that water circulates through it slowly, and is heated by the sun. All interior surfaces are black so as to assist absorption. The water becomes remarkably hot and is then vaporized slightly below atmospheric pressure for use in a steam turbine. The hot water is stored in buried reservoirs and operates the engine night or day.

It is not impossible that the use of solar engines of this simple

type will greatly reduce the consumption of coal in regions which are favored by plentiful sunshine.

Conclusions.

In view of the stupendous waste in mining and utilizing coal, it is evident that our utmost effort is needed to correct the conditions. Mining wastes can be checked by the adoption of long-wall system or by panel systems which provide for extraction of the pillars. Wastes in utilization can be cut down by the more rapid introduction of central plants equipped with the most efficient apparatus, and by the use of substitutes for coal.

It is evident that we need increased research by private concerns, and by State and Federal schools and bureaus, in order to display the clear facts in the problem and create closer relations between research and practice.

Coal operators for some time have advocated a law under which companies can combine and restrict ruinous competition. Some such means for increasing profit is doubtless necessary, to permit efficient mining and proper safeguards for life. Uniform interstate laws regarding extraction should be strongly urged in all producing States.