

State of Washington
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Department of Conservation and Development
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DIVISION OF MINES AND GEOLOGY
Sheldon L. Glover, Supervisor

Information Circular No. 14

Excerpts from

WASHINGTON FUEL REQUIREMENTS AND SUPPLIES

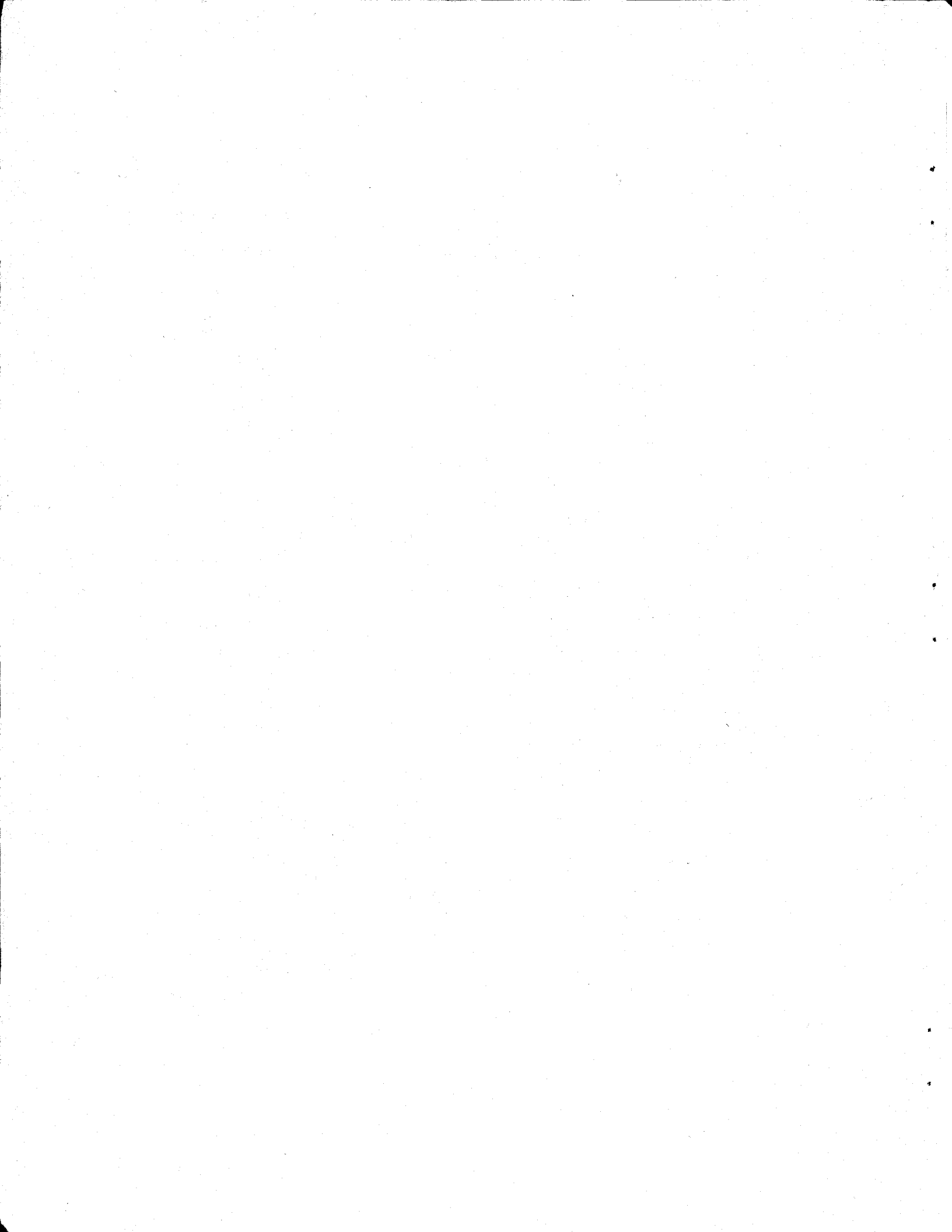
Battelle Memorial Institute
Survey Report

to

Washington State
Department of Conservation and Development

Compiled by
R. J. Lund and John D. Sullivan

Olympia, Washington
March 20, 1947



FOREWORD

During the past year or two the State Division of Mines and Geology, in conjunction with other agencies, citizen groups, coal-mine operators, and individuals, has been concerned with plans for possible investigations and operations that would aid in the development and utilization of the Southwest Washington subbituminous coal. This coal, occurring extensively in Cowlitz, Lewis, and Thurston Counties - possibly to the amount of some 25 billion tons - is a major potential resource but one that in the past and at present finds only a restricted market.

It has long been evident that any greatly increased demand could be expected only when the coal should be utilized as a source of gas, oils, tars, and other by-products rather than as raw coal in its natural state. One possibility that was considered was the more-or-less complete gasification of the coal and subsequent distribution of the gas for fuel to principal centers of industrial and domestic use in western Washington and northwestern Oregon. It was natural, then, for questions to arise regarding the entire subject of fuel requirements in this region. Finally, it was deemed essential that some thoroughly competent and entirely disinterested research organization should be employed to conduct a survey of fuels and fuel requirements, so that future plans could be founded on facts instead of on the then available base of undifferentiated fact, fancy, rumor, and opinion.

As a result, most of the principal industrial research organizations of the United States were contacted with regard to the problem at hand, and the Battelle Memorial Institute of Columbus, Ohio, was eventually selected to carry out the investigation. As the Institute is a non-profit organization, the cost to the State was relatively low, particularly when compared to other submitted estimates. The actual work was done by eminently qualified engineers who were already quite familiar with the Pacific Northwest and its industry and fuel sources. The funds for the survey were made available by Mr. Art Garton, Director, Department of Conservation and Development, from a special appropriation set up by the 1945 Legislature for studies to aid natural resource development.

The resultant report, submitted by the Battelle Memorial Institute on February 12, 1947, is a mimeographed document of 369 pages, including 73 illustrative figures and 32 tables. The Introduction, Summary and Conclusions, and Table of Contents of the report are copied herewith without change and made the subject of this Information Circular. It is thought that the general distribution of this portion of the report will fill the needs of those who are interested in Washington's fuel requirements and supplies but who do not have the time or inclination to delve deeply into the highly detailed factual matter upon which the Summary and Conclusions are based. The Table of Contents (of the unabridged report) is included herein to indicate the Comprehensiveness of the original report and for the convenience of those who may wish to consult it at one of the places listed below where complete copies will be on file.

The small number of available copies of the complete report prohibits the free distribution to individuals, but so long as the supply lasts copies may be obtained for \$10.00 each from the Department of Conservation and Development, Olympia, Washington.

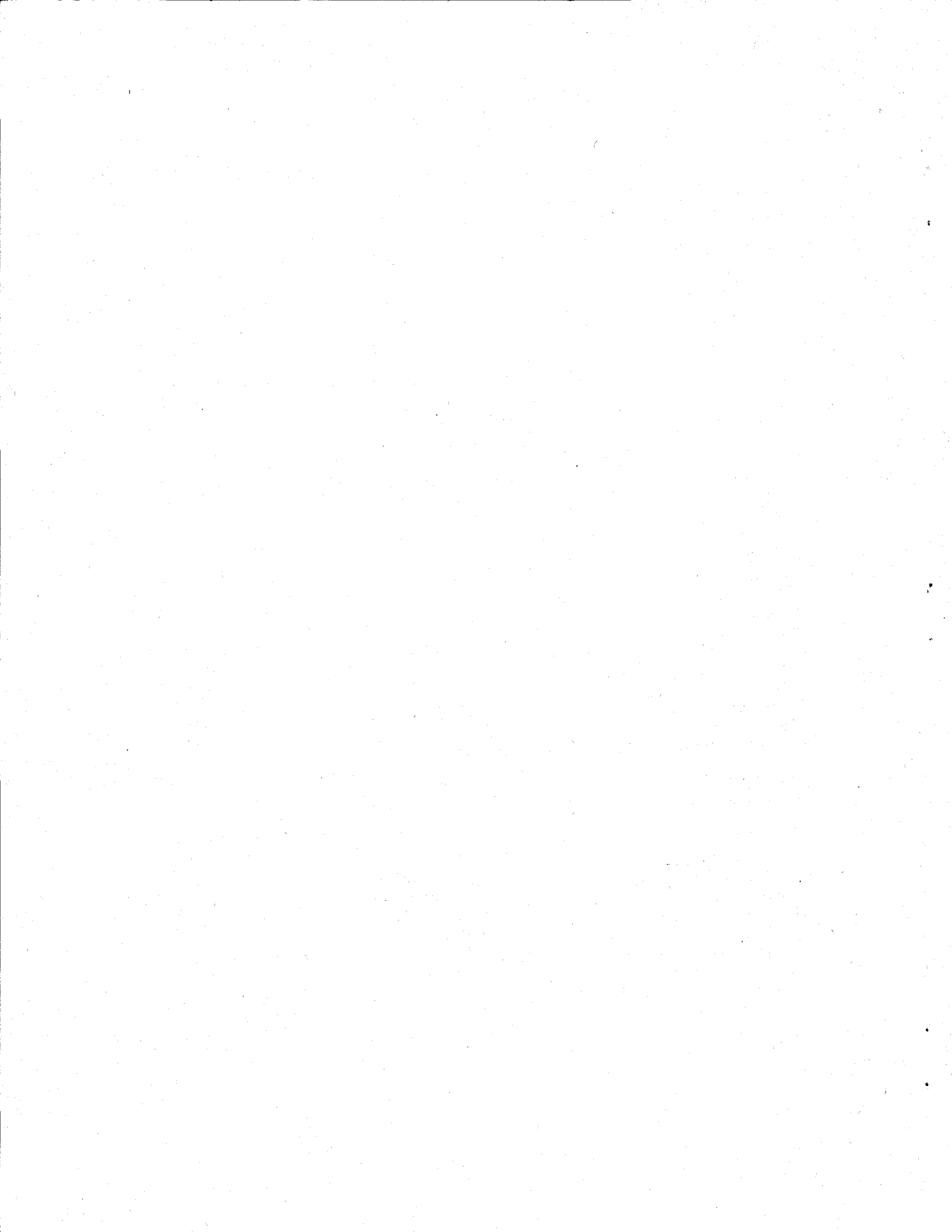
Sheldon L. Glover, Supervisor
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SURVEY REPORT
on
WASHINGTON FUEL REQUIREMENTS AND SUPPLIES
to
WASHINGTON STATE
DEPARTMENT OF CONSERVATION AND DEVELOPMENT
from
BATTELLE MEMORIAL INSTITUTE

Compiled By
R. J. Lund and John D. Sullivan

January 15, 1947

I. INTRODUCTION

By R. J. Lund

In August, 1946, Battelle Memorial Institute was asked by the Department of Conservation and Development, State of Washington, to conduct a comprehensive investigation of the fuel situation in the State. It was to comprise a complete market survey to estimate the availability and potential efficiencies of the various fuels; the economic utilization, comparative convenience, ease of use, cost, and desirability of such fuels; the potential effects of changes in the present fuel-oil situation; and the probable effects of cheap and abundant electric power on the development of Washington's coal resources. Not mentioned specifically, but inseparably linked to such a study, is a thorough analysis of fuels consumption, including electricity, and requirements and supplies of carbon for metallurgical and chemical uses.

This survey was to answer the fundamental question: "Is there a serious fuel problem facing the State of Washington within the next fifteen to twenty years?"

Leaders in industry and government in the State of Washington have noted with mounting concern: (1) the increasing dependence of the State's industrial, institutional and household users on petroleum as a source of heat and power, accompanied by a steady decline in activity of the State's coal mines as a supplier to these markets; (2) the dwindling supplies of hogged fuel and sawdust near enough to supply large markets economically; and (3) the increasing proportion of coal consumption in the State supplied by relatively distant sources - Utah, Wyoming, Montana, and Canada-, with consequent high costs brought about by the lengthy haul. Concern changed to alarm when two of the major fuel oil distributors stopped supplying most of their outlets in Washington and Oregon, during the heating season 1945-46.

Attention has long been given to the possibility of supplying greater quantities of Washington's fuel requirements from the extensive deposits of lower rank coal occurring in the broad, flat, relatively undisturbed structural basins in Lewis, Thurston, and Cowlitz counties - by processing these coals at one or more large, centrally located plants and piping gas thus manufactured by pipe line to consuming centers relatively close at hand, and providing carbon and liquid by-products needed by expanding metallurgical and chemical industries. During the past few years there has been mounting interest in this potential development as a solution to the fuel-supply problem in the State.

It was pointed out by the Sponsor that the entire investigation might therefore fall into two steps: (1) the comprehensive market survey on the fuel situation to reveal the nature of Washington's fuel-supply problem, and (2) in the event a serious problem is shown to exist, with the possibility that Washington's low-rank coals might solve it, a further detailed technical study be made of the various methods of processing these coals in order to determine the one or ones best suited to meet the demands of the particular situations existing in Washington.

It is recognized, of course, that the primary responsibility in the investigation is to the State of Washington, and every effort has been made to confine considerations to the problems existing in that specific area. However, the problems of neighboring areas, especially Oregon, are so much the same that references are made occasionally to such outside areas. Frequently, too, useful statistics are available on the region as a whole - the Pacific Northwest - which is coming to be recognized more and more as a geographic, commercial, and industrial unit.

Another point worthy of emphasis is the fact that the investigation is focused on the needs of the fuels consumer in Washington - both actual and potential - rather than having any primary objective of somehow solving the problems of Washington's coal mining industry and making its own future more secure.

Even though a review of processing methods and analysis of potentialities of carbonizing or gasifying Southwest Washington's lower rank coals might appear to be more a part of the second phase of the major investigation cited on page 3, than of the market survey, it is impossible to consider comprehensively the potential fuels available to Washington consumers without including this possibility. Considerable detail on carbonization, gasification, and gas transportation is therefore included in the report.

Scope of the survey is best revealed by the Table of Contents, which, for the convenience of the reader, has purposely been enlarged to show considerable detail. [See Appendix.]

Not included in the investigation is the motor-fuel, or gasoline, situation, since this is national in scope and does not involve any peculiar sectional problem. Indirectly, however, it has an important bearing on the fuel-oil situation, since petroleum refining practices have greatly extended the flexibility of possible yields of products per barrel of crude oil. The motor-fuel situation has therefore been considered carefully as it pertains to this aspect of the major problem.

In gathering pertinent data for this survey the Battelle Institute staff have relied on their own broad knowledge and experience, supplemented by published information, and by interviews with a great many authoritative officials in industry and government - in the East and West. Space precludes mentioning at this point all those consulted, but a list is given in the Appendix of those contacted on the specific subject of this survey. It is a pleasure to acknowledge the generous time and help given by these contributors, who in every case have been most cordial and cooperative in supplying the information.

In a report of this scope contributions have been made by a large number of staff members of Battelle Institute, their identity being shown by noting the authorship of various chapters and sections of the report. Many others from Battelle's staff have contributed importantly in various ways to the preparation of the report.

Except where noted especially, all tonnage figures in the report refer to net tons of 2,000 pounds, and barrels are 42 gallons. There is some doubt in many cases, as to whether freight rates are given on a net or gross ton basis, but as a general rule coal rate structures are figured on the basis of net tons of 2000 pounds.

II. SUMMARY AND CONCLUSIONS

GENERAL

It should be stated at the outset that this is not an engineering report to determine definitely the type of fuel or fuels best suited to the various needs of consumers in Washington. The investigation was undertaken to determine whether Washington is faced with a serious fuel problem during the foreseeable future of 15 to 20 years.

The answer is "no". Supplies of coal, oil, wood, and electricity - the most important fuels used in the state - are adequate to meet present needs, and it appears to all those contributing to this report that this relationship will continue for the foreseeable future.

However, it is true that some of these fuels, coal especially, are more costly to the consumer in Washington than in certain other industrial areas in the United States. It would appear that this situation will likewise continue, since there does not seem to be any chance of obtaining relief from the high cost of coal in that area. Washington will have to pay slightly more for its oil than other states closer to producing fields, but this differential is not great.

On the other hand, Washington has the great advantage over most other states of enjoying probably the cheapest electric power anywhere in the United States, with vast reserves of hydropower not yet developed.

Present fuel requirements of Washington are estimated of the general order of magnitude of 250 trillion Btu, not including additional large amounts contributed in the past by wood in rural and small urban areas and in plants consuming their own waste wood for heat and power.

These requirements were met in 1944 by about 19 million barrels of fuel oil, 3.4 million tons of coal, 9.5 billion kilowatt hours of hydroelectricity, plus vast amounts of wood over and above the measured sales of 1.3 million cords or units. In terms common to all these fuels - heat units - oil was most important in measured consumption, supplying about 116 trillion Btu; coal was second with about 81 trillion Btu; hydroelectricity was third with about 32 trillion Btu; and measured wood sales were last with around 20 trillion Btu. Actually, the vast unmeasured usage of wood might bring it up toward the top - possibly ahead of oil.

These figures, at best, are only rough approximations, and they cover all uses - oil for vessels, railroads, and military; coal for railroads; and electricity for electrothermal and electrometallurgical uses. All of these uses, however, are a part of Washington's fuel problem.

Discussion of the use characteristics of the various fuels is not amenable to brief summarization, and the reader is referred directly to Chapter III. Suffice to say that a variety of characteristics are important in determining which particular fuel is best for any particular use.

In spite of her costly coal, Washington's fuel bill was lower, on the average, than many other industrialized parts of the country in years preceding 1946. This was brought about largely by the cheapness of her fuel oil supplies and her electric power.

For many years prior to World War II California tended to produce more oil than the market really required, the result being the availability of fuel oil in the Northwest consuming area at prices low enough to displace coal in ever growing amounts. Absence of state control over California oil production contributed to this situation, as did the lag of petroleum refiners in California in installing catalytic cracking facilities. Severe competition among petroleum producers for petroleum product markets resulted at times in abnormally low price levels. During World War II prices were frozen at these low levels by O.P.A. It was this abnormally low price situation which finally forced two of the major fuel oil suppliers in the Northwest to cancel contracts with their outlets and withdraw from the market a little over a year ago.

As a result of this situation, the readjustment in fuel oil prices in Washington has been unusually severe - from its position of enjoying probably the lowest average fuel oil prices of any states other than some of the major oil producing states, Washington was suddenly skyrocketed up near the top of the list. This major price readjustment has now brought fuel oil prices into reasonably close balance with present motor fuel prices. The two major fuel oil suppliers who withdrew from the market are, according to reports, back in the area seeking new outlets.

COAL

On the other hand, Washington's per ton coal bill is higher than in most other large consuming districts in the United States. This results from (1) the higher cost of mining her own better quality coal, because the characteristically steeply dipping, faulted nature of the coal seams precludes mechanizing the mines to the degree necessary to effect real cost savings, (2) the lower heating value and poor storing characteristics of the subbituminous coal susceptible of cheaper mining, and (3) the long, costly rail haul for coal brought in from Utah, Wyoming, and Montana.

The future does not appear to offer any hope for relief from this situation.

Washington's better quality coal will be costlier to mine in the future - most of the better seams above "water level" have already been mined, and the thinner, dirtier seams, plus deeper zones of the better seams, will entail more labor and lengthier hauls to extract. In short, coal operators have naturally taken the most easily produced coal first, and much of this has been none too good because of high ash content.

The greater ease of mining the subbituminous coal of southwest Washington is not sufficient to outweigh the lower heat value and poor storing characteristics to attract consumers. Although it sells at

a much cheaper price, it is not sufficiently cheaper to penetrate markets any appreciable distance from its source. There appears to be a little hope of drying this coal efficiently, and thus making its use more attractive, but this possibility would have to be studied with care, and extensive tests made, before a definite answer on this can be made.

The chances of gasifying this coal at large central plants near the mines, and piping the gas to consuming centers do not appear attractive in competition with oil at present price levels. A careful review of gasification processes indicates the likelihood that the high-pressure Lurgi method offers the best promise of gasifying this type of coal, with the chance that 450 Btu gas could be produced at around 40 cents per thousand cubic feet and piped 100 miles to Seattle or Portland for around 1 cent per 1000 cubic feet in quantities of around 50 million cubic feet per day. It is believed that oil gas costs at present only around 30 cents per thousand cubic feet of 500 Btu gas; thus, the Lurgi gas is probably not yet competitive. Cost of a Lurgi plant to produce 50 million cubic feet per day would probably be in the general neighborhood of \$6,000,000 to \$8,000,000 - an appreciable sum of money to gamble at this stage of petroleum exploration where there is still a reasonable chance that, overnight, a major oil field may be discovered in California, or even Washington, to assure continuation of oil supplies at present or even lower price levels for many more years in the future. There is the additional chance of discovering commercial quantities of natural gas in Washington. It should be emphasized that the cost estimates just cited are only rough approximations made by experts who have gone over carefully the German experiences with gasification plants and converted costs as best they could to American standards.

Low-temperature carbonization of Washington's subbituminous coal, likewise, does not appear to offer attractive possibilities of yielding an improved fuel at prices competitive with those of other fuels at present. It is estimated that a char or semi-coke from such a process might be produced and marketed in Seattle, for instance, at a price of around \$15.00 per ton. Such a product would have a calorific value of about 12,000 Btu per pound, but it would be high in ash - around 18 per cent - and it would be a weak, friable product with a high percentage of fines. Briquetting, to make the product more attractive for domestic use, would probably raise the Seattle price to around \$16.00 per ton. It would have good burning characteristics, however. The product would not be very attractive for use as industrial carbon. These estimates, again, are only the best approximations that could be made with limited data available. A major factor in this cost picture is the necessity of processing about two tons of subbituminous coal to obtain one ton of semi-coke or char.

Chances of any substantial reduction in the delivered price of Rocky Mountain coal are poor. Present prices f.o.b. mine are reasonable for such highly mechanized operations as are characteristic of coal mines in those states, and the freight rate for the long haul appears to be in line with long hauls in other parts of the country, running in the general neighborhood of 0.5 cent per ton mile. Reserves of easily-mined coal of high quality in the Rocky Mountain area are huge. The possibility of lowering coal prices in Washington by developing supplies from other areas of potential production, such as British Columbia and Alaska, does not appear

promising. Large areas of excellent coal lie undeveloped in parts of British Columbia and Alberta, but new costly rail facilities are needed, and the haul from such potential areas would be longer than from districts now producing. Production from the Bering River or Matanuska districts in Alaska and transportation to Washington appears to involve heavier costs than competition with other fuels now permits.

Dependence of Washington consumers on coal "imported" from the Rocky Mountain area puts them at the mercy of the railroads to provide enough cars to move the coal. In times of car shortages, such as exists at present, this situation might lead to serious repercussions. Aggravating this is the general practice of coal retailers to stock relatively small quantities of coal. This, however, could be corrected by increasing the size of dealers' yards and encouraging heavier stocking of coal - both, however, at increased costs to the dealers which are already abnormally high, as reflected by the size of dealers' margins.

Dealers' margins on coal in Washington appear to be excessively high, although no comprehensive study of this was possible within the scope of this survey. Retail margins between \$2.50 and \$5.00 per ton are easily the highest in the entire country. Relatively small, seasonal business volume; long, hilly hauls; high labor costs - these are pointed to by dealers in justification of the high margins. It appears, however, that there is room for increased efficiencies whereby these excessively high margins might be reduced, to the benefit of the Washington consumer and to the benefit of coal in competing with oil.

PETROLEUM

Even at the higher oil prices now prevailing, oil is actually cheaper on the basis of calorific value than is coal. Comparing Utah slack delivered at \$10.54 per ton with PS 400 oil at \$1.905 per barrel, delivered, gives a cost to the consumer of 42 cents per million B.t.u. for coal, and of 30 cents per million B.t.u. for oil.

As one Washington fuels authority put it, "The Washington coal industry has existed throughout the last few decades only by reason of the repeated recurrence of oil scares". There is no denying the truth of this statement. Oil is the crux of Washington's fuel problem, and the subject of future petroleum supplies is analyzed rather comprehensively in this report.

Despite the heaviest withdrawals of petroleum in the history of the industry to fuel World War II, coming largely from our domestic fields, our proved reserves are comfortable - being not far from the largest in the history of the industry. True, postwar consumption is likewise the largest in the industry's history, and estimates indicate continued growth. But measured against this heavy consumption the ratio of proved reserves to annual production is around 12 to 1 for the entire United States. The ratio for California is a little lower, around 10 to 1. Very seldom has this ratio been this high or higher.

The petroleum discovery ratio for the United States has been disappointing for almost a decade, and the rate for California has been even less encouraging than that of the United States. There is no denying, however, that vast oil deposits remain to be discovered in the United States, including California, but it will cost more and take much longer to find these than the deposits already discovered from which we are now producing our oil.

Nevertheless, even if one were to view the future of petroleum discoveries through the eyes of a pessimist, there still remain the vast proved reserves in foreign countries, together with larger quantities yet to be found there. Cheap production in these areas, such as the Near East, plus cheap transportation by tanker, literally brings deposits situated halfway around the world to our back door. Indeed, it has been averred by authorities that Persian Gulf oil can be laid down at California ports as cheaply as or cheaper than oil taken from California wells. Large proved reserves, plus probable ones not yet discovered, also are situated in the South American fields, largely Venezuela and Columbia.

Prior to and during World War II the vast oil potential of the Near East was scarcely scratched, but plans are now under way to expand greatly production from this area. It will take time - possibly a couple of years - to add the new wells, refineries, and pipe lines already planned, but once this is done the output from that region is expected to supply European and African requirements, with perhaps additional amounts to spare, and moving to the Far East, possibly to the Americas.

South American oil has in the past largely gone to Europe. With this market supplied by the Near East oil, South American oil, in excess of South American requirements, may (1) be pinched in to serve as a future reserve, or (2) invade United States markets. There would appear to be some question whether the producing countries concerned would be willing to see their petroleum revenues reduced severely through large production cuts. Under either of these alternatives, however, South American oil will be available for a long time to supplement any dwindling United States production, and will certainly act as a "governor" to prevent any runaway prices on the West Coast.

The future tariff policy of the United States will be important in this connection. At present, there is an excise tax levied on imported crude oil to the extent of 10.5 cents per barrel on a quota of 5 per cent of total crude oil run to stills in the United States during the preceding year. Imports over this quota are taxed at 21 cents per barrel - the long-time rate that applied until the Venezuela Trade Agreement set up the 50 per cent reduction on the quota basis late in 1939. Up to 1946 imports had never exceeded or even approached closely the quota entering at the lower tax rate.

There will be a stiff fight waged by independent petroleum producers against heavy importation of oil, but there does not appear to be much doubt that the United States government will establish a policy which will permit entry of oil in sufficient quantities to allow production from our own fields at rates no higher than the maximum efficient rate of production.

Producing our wells at higher rates will reduce the amounts of oil that can ultimately be recovered by current production methods.

Reliance on imported oil even from sources as close as Venezuela, involves the considerable risk of being cut off during any future major war. This possibility provided the principal incentive behind the expanded research program to develop the best methods, with cost estimates, of manufacturing synthetic liquid fuels by gas synthesis, coal hydrogenation, or oil shale distillation - programs presently being actively pushed by the Bureau of Mines and the petroleum companies.

This is a program of national concern, and one that should be supported on a national basis. The State of Washington, however, has a stake in the program, and should watch it closely for any developments that might have an effect on the use of her low-rank coal deposits.

Changes in petroleum refining techniques in recent years, involving principally the use of catalytic cracking methods, have resulted in making refining practices all the more elastic. Within broad limits, the yield of refined products can now be tailored to fit the market demands. Catalytic cracking stands as a potential threat to light fuel oil and diesel oil supplies, since these oils are used as charging stock for this process. However, if the prices of these distillate oils are in balance with that of gasoline, there is no question but that sufficient quantities will be produced to meet demands.

A radically new technique recently developed - production of motor fuel and diesel oil by a modified Fischer-Tropsch method of gas synthesis from natural gas - if proved successful commercially - may tend to relieve the light fuel oil situation by supplying both motor fuel and diesel oil from the vast reserves of natural gas. Thus, the pressure to cut more deeply into distillate oils as catalytic cracking stock for producing motor fuel might be materially lessened.

The petroleum industry fully realizes the responsibility it owes to its customers - customers it has been instrumental in promoting in the past. In this respect, the industry, by and large, feels that the customer is the boss, and that, within reason, his needs must be served. Unfortunately, Washington recently experienced a situation which represented a slight departure from this policy. Incidentally, a much better public relations job could and should have been done by the petroleum industry in connection with their action in cutting off fuel oil supplies to their distributing outlets in Washington a year ago.

Lessened supplies of fuel oil, if such were to materialize in Washington, would not have serious repercussions. Perhaps the first pinch might come in heavy residual oil, forcing industrial and commercial users to revert back to coal or possibly to electricity if it is available for heating and power applications. Railroads using residual oil for fueling steam locomotives might convert to diesel fuel, if supplies and prices are right, to coal, or to electricity. Vessels will continue using heavy oil for bunkering, and it might mean higher costs for bunkering in the United States, or possibly bunkering in foreign ports where supplies may be available at lower prices.

Oil gas may cost more, under these conditions, with some consumers possibly converting to electricity for cooking and water heating, for instance.

Shortages of distillate oils, if such were to develop, would involve conversion to coal for house heating, or possibly to electricity for users willing to pay the higher prices. Railroads would be faced with the alternative of paying higher prices for lesser supplies, converting to coal, or electricity, if other radical energy conversion techniques haven't been developed by then.

By and large, Washington is in a better position than most other sections of the country, in such an eventuality, because of the abundant potential supplies of cheap hydroelectricity that are scheduled for development over the next decade or so.

ELECTRICITY

Although electricity at present is in tight supply in Washington, the effectuation of the advance program of Bonneville Power Administration over the next decade will provide large additional supplies needed by her growing commerce, industries, and population. With average prices of from 2 to 3 mills per kwhr for large industrial users, and of less than 1 cent per kwhr for average residential users, Washington power consumers enjoy the lowest electricity rates of any place in the country. As a result, the amount used per residence is higher than elsewhere, and it is still going up.

The inherent possibilities of space heating with electricity constitutes a moot point at the present time, with BPA attempting to promote its use against the opposition of electricity distributing organizations - private utilities, municipal-owned utilities, and Public Utility Districts. Additional supplies needed for such use are not available now, nor will they be available until additional generating units are installed at Grand Coulee; distributing facilities would have to be altered materially at great expense to meet the greatly increased load requirements; and the nature of the load, coming on top of present peak loads in the winter, with no compensating load in the summer, makes such low load-factor uses expensive. All utilities are pointing out these facts to the public, and indicating the likelihood that rates for space heating will have to be increased above the general all-purpose rate. In BPA's now proposed rate schedules, now before the Federal Power Commission for action, provision is made to guarantee power for resale for space heating at 4.5 mills per kwhr.

Specialists in BPA studying electric space heating are now thinking in terms of a saturated condition when 3 per cent of the 1,000,000 homes in Washington and Oregon are thus heated by 1950, according to their estimates.

By and large, therefore, electric space heating should probably be placed in the luxury class for some time, with the probability that it will comprise only a minor element in the domestic heating field.

The aluminum reduction industry is now taking more than half of Bonneville Power Administration's firm energy sales, and applications have been placed for large additional power blocks which are not now available. It is probable that the present full-capacity activity of aluminum reduction plants in the Pacific Northwest will continue so long as business in general is good. The future of aluminum is strong, and the cheap power and equable climate - both permitting relatively steady, full-year operations - are attractive for aluminum reduction in the Northwest. There is, thus, little likelihood of relief from the present power shortage through lessened activities in the aluminum industry in Washington.

In general, it is believed that cheap hydroelectricity has been a detrimental factor to Washington's coal mining industry, with prospects that this will continue so in the future.

Adverse effects revolve around the competition of cheap hydroelectricity for generation of power and light. Whereas power generation comprises one of coal's principal markets in many other sections of the country, this is only a minor use in Washington, and even this is dwindling. In the long term future, when oil supplies dwindle, with resulting price increases, cheap and abundant electricity will always stand as an important and attractive alternative to coal as a source of heat and power.

Beneficial effects to the coal industry, present and potential, comprise the following: (1) cheap electricity would lower coal mining costs - if and when increased usage justifies mechanizing the mines in the subbituminous district of southwest Washington; (2) cheap electricity will result in increased demand for coal for domestic and industrial use, to some extent, through the attraction of new industries and population to Washington because of the cheap, abundant hydroelectricity; (3) possible use of cheap electricity for drying the subbituminous coal of southwest Washington, thus yielding a product with more attractive use and storing characteristics; and (4) possible use of cheap, abundant electricity for use in making oxygen in connection with the Lurgi process for gasifying Washington's subbituminous coal, if and when the competitive fuel situation justifies such action.

WOOD

Wood is perhaps the most important of all fuels for residential heating in Washington, taking rural areas and supplementary use in fire-places into account, judging from Bureau of Census figures on types of fuel used in home-heating equipment. Consumption statistics for more than portions of large urban areas are not available, however, so that the picture regarding wood must necessarily remain somewhat of a question.

There is no doubt, however, that in large cities such as Seattle the use of wood for residential space heating is diminishing. Costs have gone up and strikes in sawmills have raised serious question concerning the reliability of supplies. The bulky characteristics of wood - whether millwood, hogged fuel, or sawdust - prevent extensive storing, and even retail dealers store only relatively small quantities. This makes all the more serious any

stoppage of supplies from the source - whatever the cause may be.

Illustrative of the shift away from wood is the ceramics industry in Washington, which in the past decade or so has changed over almost entirely from wood to oil.

Nevertheless, many commercial heating installations and the laundry industry continue to favor wood, but maintain standby equipment for use in case of a supply stoppage.

In spite of a trend to produce less wood waste through improved techniques together with a desire to up-grade the use of such waste, the forest products industries, including paper manufacture, will probably continue indefinitely to use large amounts of wood waste as a fuel for heating and power. Quantities produced will fall off with the anticipated reduction of lumbering to a sustained yield basis.

INDUSTRIAL CARBON

Industrial carbon in Washington is, and will be, relatively costly. Requirements for electrodes in the aluminum reduction industry will be met by increased production of petroleum coke in the Pacific coast area, largely in California, but possibly also from new plant facilities contemplated in Spokane. Transportation to coastal points by water from Los Angeles will lessen costly rail hauls used during war years, and if Spokane facilities for petroleum coke manufacture materialize the costly rail freight to the inland aluminum reduction plant at Spokane would be avoided. Petroleum for making coke there must come by rail, however, from Rocky Mountain producing fields.

Foundry coke will have to be brought into the area from outside points - Canada, Rocky Mountain States, the Midwest, or possibly from Birmingham, Alabama, or from foreign sources by all-water transportation. Coke from Curran-Knowles ovens, such as those at the government Tacoma plant, does not have the strength needed in a good foundry coke.

Coke made from Washington's coal in Pierce and Kittitas counties is generally too high in phosphorus for some industrial uses, such as manufacture of ferro-alloys and calcium carbide. Furthermore, the ash content is so high in Washington coking coals that coke made from them runs close to 18 to 20 per cent of ash. Opening up of a seam not yet developed at depth in the Wilkeson mine offers the probability of producing coke with a substantially lower ash and phosphorus content.

Production of coking coal from the Pierce county deposits is necessarily expensive because of the difficulty in mining it and the limited mechanization possible under the prevailing conditions.

Nevertheless, it appears from the interest in bidding for the government coking facilities - the washery and mine equipment at the Wilkeson mine and the coke plant at Tacoma - that operations at the mine

and coke plant will be resumed and that a market for the 75,000 tons of coke per year, the capacity of the plant, is assured.

Outside possibilities for supplementing Washington's present carbon supplies are (1) from the extensive anthracite deposits presently being developed near Chimbote, Peru, and (2) from the large anthracite deposits of good quality, mined by strip methods practically at tidewater, near Hongay, French Indo China. Present ocean freight rates are possibly too high to move the anthracite these long distances competitively, but expected reductions in the future might make this possible.

ATOMIC ENERGY

Because of the secrecy which still surrounds most of the work concerning atomic energy, any present appraisal of the economic potentialities of this radical new energy as a source of power for commercial use is necessarily of limited value. Furthermore, the international aspects of the entire matter are such that with one stroke of a pen the whole technical developments to date could be wiped out overnight.

Estimates which have been released on the cost of power from atomic energy are only guesses, but these are given in the report as an indication of what the general order of magnitude may be, rather than as actual facts. Indications point to higher capital costs for an atomic energy power plant compared with coal. The assumed credit of \$20.00 per gram for by-product plutonium, plus the problem of obtaining sufficient uranium for extensive commercial applications at the assumed cost of \$10.00 per pound are important "ifs".

In spite of the vast field of unknowns which still surround this matter, those who are concerned with the problem feel that the world may be on the threshold of developments in atomic power which might well prove as revolutionary as the discovery of the steam engine. If this proves true, the entire fuel-supply problem may change. Decades may be needed to bring this about. Washington, however, should be fully as well provided for in such event as other states, in view of the location of one fission plant within the state now.

RECOMMENDED TECHNICAL LITERATURE

During the course of this study the technical and economic literature pertaining to the various subjects included was reviewed. Many of these references are listed as footnotes in the report.

However, for the convenience of those wishing to delve more deeply into many of these details, the following references contain especially good source material:

- (1) Green, S. H., "Coal and Coal Mining in Washington", Dept. of Cons. and Dev., Report of Investigations, No. 4, 1943.

- (2) Yancey, H. F., Geer, M. R., and Daniels, Joseph, "Analyses of Washington Coals", Bureau of Mines, T. P. 618, 1941.
- (3) Fieldner, A. C., "Low Temperature Carbonization of Coal", Bureau of Mines, T. P. 396, 1926.
- (4) Yancey, H. F., Johnson, K. A., and Selvig, W. A., "Friability, Slacking Characteristics, Low-Temperature Carbonization Assay, and Agglutinating Values of Washington and Other Coals", Bureau of Mines, T. P. 512, 1932.
- (5) Lowry, H. H., Editor, "Chemistry of Coal Utilization," Two Vols., John Wiley & Sons, 1945.
- (6) "Low-Temperature Carbonization of Utah Coals", Utah Conservation and Research Foundation, Salt Lake City, Utah, 1939.
- (7) Gentry, F. M., "The Technology of Low-Temperature Carbonization," Williams and Wilkins, Baltimore, 1928.
- (8) Institute of Gas Technology, "Gas-Making Processes", American Gas Association, October, 1945.
- (9) Powell, A. R., "Future Possibilities in Methods of Gas Manufacture", Statement Before the Federal Power Commission in Natural Gas Investigation, 1946.
- (10) Weir, Horace M., "High Pressure Gasification of Coal in Germany", Ind. & Eng. Chem., Vol. 39, pp. 48-54, January, 1947.
- (11) Sherman, Ralph A., "Fuels of the Future", Battelle Memorial Institute, 1943.
- (12) "Investigation of Petroleum Resources", Hearings Before a Special Committee Investigating Petroleum Resources, United States Senate, 79th Congress, S. Res. 36, Six Vols., Government Printing Office, 1945.
- (13) Bonneville Power Administration, Advance Program of System Development, Fiscal Years 1948-1953, October, 1946.

APPENDIX

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