SOME ASPECTS OF THE POWER RESOURCES OF CANADA
WITH SPECIAL REFERENCE TO COAL

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URBANA, ILLINOIS
The Modern World’s Dependence Upon Minerals:

National progress in the modern world as a rule is largely contingent upon the possession and exploitation of natural resources. This statement might be made even more definite. No modern nation has ever reached a point of great ascendency without a reserve of minerals large enough to give her a moderate degree of stability. A large proportion of the international disputes of recent years has been the result of an effort to acquire mineral holdings. No doubt the present unrest in western and central Europe has for a part of its foundation the struggle for possession of some block of mineral wealth. A map of the “danger spots” of the world shows striking similarity to one showing the distribution of valuable mineral deposits.

A nation binds itself together with steel rails, copper wires and transportation units, builds its structures with steel and aluminum, pays for its purchases with gold and silver, and last but not least, it moves its goods and warms itself with coal, oil and gas. Water power, transformed into electrical energy, is playing an increasingly important role as a driver of the machinery and lighter of the lamps of the nations. Minerals and power constitute the international waterword!
Relation of Man Power to Fuel:

Fuel from the mines or wells or from the forests gives us heat and energy to turn the wheels of industry. Man and animal power are still vital factors in some parts of the world, but where notable advancement is being made, man is the director rather than the energizer.

Value of World Power Resources:

It will be interesting to note at this point the relation of man power to coal as measured by the amount of work each can do. The amount of work that 27.8 pounds of coal will do per day is equivalent to one horsepower.1

Furthermore, it requires about 20 men to do the work of one horse per day.2 Thus the Canadian coal reserve exclusive of lignite contains the potential energy of 1,137,814,338,129 H. P. or 22,756,286,480 M. Power per day. Converted into more understandable terms this is the equivalent of 379.3 man power per capita per day.

Old industries thrive and make new growth where power is cheap. Population is attracted by the native resources and culture follows. Western Europe and eastern United States are monumental examples of the progress that comes with the utilization of power resources. New and vital industrial units are constantly being developed coordinate with the increased use of power. Southeastern

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Fig. 1.

World Coal Resources 1924

Source: Dowling, D. B. Coal Fields and Coal Resources of Canada; Ottawa 1915.
Australia, western United States and now the U.S.S.R. each has recently shown the rapid rate of advancement that may result from the use of available power. Whether or not the Soviet States will make any real economic contribution remains to be seen. Suffice it to say that the energy assets of the Donetz Basin are finally contributing very potently to the industrialization of the Ukraine.

**Canada as a Land of Opportunity:**

Canada has fuel, she has water power, she has a vast area of undeveloped land and a sparse population. What is to follow industrially is a problem of the future. She is a nation of far-sighted people. Her opportunities are limited only by the geographic and economic bounds that have restricted her thus far.

**Canada, a Leading Coal Possessor:**

First in importance among the fuel resources of the Dominion is coal. Few countries in the world are as well supplied with carbonized material as is Canada. In Alberta, the largest single area with coal bearing strata, there are 56,000 square miles underlain with fuel. This closely approximates the area of Illinois or Wisconsin. In all, Canada has 12% of the world's coal reserves (Fig. 1). The United States alone has a greater proportion of the world's reserve.

The distribution of this fuel is in very widely separate areas, there being nearly 3,000 miles between the submarine deposits of Cape Breton Island and the Vancouver Island coal mines.
Fig. 2.

Location of Canadian Coal Reserves by Provinces.

Source: Dowling, D. B. Coal Fields and Coal Resources of Canada. Dept. of Mines, Ottawa, 1915
Explanation of Figure 3.

Graph of Distribution of Canadian Coal by Grade.

The small inner circle shows the Canadian coals by grade to be composed of lignite 92.8%, bituminous 6.9%, and anthracite 0.3%. The larger outside circle shows the distribution of this same coal by provinces. Alberta has 98% of the lignite and the rest of Canada has 2%. British Columbia has 81% of the bituminous and the rest of Canada 19%. All of the anthracite is found in Alberta and British Columbia.
Graph Showing Distribution of Canadian Coal by Grade.

at Nanimo. The provinces of British Columbia, Alberta, Saskatchewan, New Brunswick and Nova Scotia are all supplied with some coal. In the Northwest Territory and the Arctic islands there is nearly 3% of the Canadian coal reserve. Only Quebec has no coal and the 0.01% that Ontario possesses is so very small it can hardly be called a "reserve". The chart (Fig. 2) shows the distribution by provinces of the Canadian coal reserves.¹

Extent and Character of Coal Deposits:

A brief description of the extent and nature of the coals is necessary for an understanding of the power status. Fig. 3 illustrates the distribution of Canadian coal by grade.

Province of Alberta:

Since Alberta contains 36.9% of the reserve of Canadian coal, it is appropriate to discuss that province first. Three-eighths of the total land area of the province is underlain by carbonaceous fuel. Of this, 382,500,000,000 metric tons are subbituminous and lignitic in character; 3,892,800,000 metric tons, or 1.1%, are of the high carbon class, that is anthracite.

Patton² describes the Alberta coals as belonging to three separate horizons—the Kootenay, Belly River and Edmonton. Of these, the first is of the highest quality, it being in the more mountainous district where deformation and metamorphism have had their effects. The Edmonton coals are in the main brown or lignite.

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They vary considerably and grade up to fair bituminous that will stand coking. The Edmonton seams are found in the main in the basin of a large synclinal trough. There is no great dip in most of the seams and as a result they can be worked rather economically. The beds vary in thickness from slightly less than 5 feet to as much as 25 feet. Their depth averages 1400 feet.

The Belly River coals are all bituminous, grading from sub-anthracite to low bituminous. This series occupies about 16,000 square miles of eastern Alberta. Again, as in the Edmonton coal, as the seam approaches the mountains to the west the quality of the coal is considerably improved. The fixed carbon content increases from 41 to 56%. Bowling describes these measures as lying at various depths. From a seam near Medicine Hat that outcrops in the bank of a stream, he goes to a 4 foot seam 2,300 feet under the surface. He also describes a few outcrops in the Peace River district.

**British Columbia Coal Deposits:**

British Columbia has 6.2% of the Dominion's coal reserve. The quality of the Rocky Mountain coals is high, only 10% of it being subbituminous. The mountainous nature of the region with its numerous valleys and eroded areas explains also the widespread distribution of the rather isolated patches of coal. Here again Patton provides a convenient division of three important

units for the area, as follows: Vancouver Island, Nicola-Similkameen, and Crownest Pass.

It is estimated that the first is underlain by 868,939,000 tons of coal, most of which is of fair quality. Some of it has been coked. The second area produces the smallest output of the province and the coals vary from lignite to sub-anthracite. Crownest Pass has the best quality coals in Canada. Almost any of it can be coked and the fixed carbon content is very high. The seams are thick and the geologic faulting is slight, making this district exceptional from the standpoint of economy of production and value of the product.

The following chart illustrates the depth and thickness of various beds in the British Columbia area.1

<table>
<thead>
<tr>
<th>Location</th>
<th>Aggregate Thickness</th>
<th>Average Depth in Feet</th>
</tr>
</thead>
<tbody>
<tr>
<td>Morrissey</td>
<td>316 ft.</td>
<td>3,500</td>
</tr>
<tr>
<td>Fernie</td>
<td>172 ft.</td>
<td>2,250</td>
</tr>
<tr>
<td>Spanwood</td>
<td>216 ft.</td>
<td>2,030</td>
</tr>
<tr>
<td>Princeton</td>
<td>28 ft.</td>
<td>50</td>
</tr>
<tr>
<td>Nicola</td>
<td>9 ft.</td>
<td>250</td>
</tr>
<tr>
<td>Bear River</td>
<td>21 ft.</td>
<td>Valley outcrop</td>
</tr>
<tr>
<td>Bulkley River</td>
<td>20 ft.</td>
<td>&quot;</td>
</tr>
<tr>
<td>Northern B. C.</td>
<td>60 ft.</td>
<td>&quot;</td>
</tr>
</tbody>
</table>

The quality of the British Columbian coals is in general much higher than in the Prairie Provinces. Due to a greater de-

formation in the mountainous areas these coals have been pressed
and metamorphosed into bituminous coking coal over a large portion
of the area. Some faulting in the coal areas have made mining
operations difficult, but the value of the product offsets this
handicap.

Saskatchewan Coal Deposits:

Saskatchewan has 4.8% of the coal reserves of Canada and
all of this is brown coal of a very mediocre grade. The area under­
lain by this lignite is estimated at 13,000 square miles and con­
taining 59 billion tons.¹ It is all located in the southern por­
tion of the province and continues across the international bound­
ary, forming the Dakota lignite fields. The lower horizon coal­
bearing rocks are between 196 and 300 feet deep. These have an
aggregate thickness of 35 feet.

Coals of Eastern Canada:

The Maritime provinces, Nova Scotia and New Brunswick,
possess a little less than 1% (0.8%) of the Dominion’s coal reserve,
New Brunswick’s share being so slight as to be insignificant. The
coals of this area, however, are of good character and fall into
the bituminous group. The total resources are estimated to be
151 million tons for New Brunswick and for Nova Scotia, 7½ billion.
The total land area underlain by these reserves is 398 square miles.
The area may be conveniently sub-divided into three groups accord­

¹ Dowling, D. B.: Coal Fields and Coal Resources of Canada:
Dept. of Mines, Ottawa, 1915.
ling to the geographical location as follows: Cape Breton Island, Grand Lake and Cumberland-Picton.

The depth and thickness of the coals of the Maritime provinces can readily be determined from the following chart compiled from Gray: 1

<table>
<thead>
<tr>
<th>Location</th>
<th>Aggregate Thickness</th>
<th>Depth in Feet</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sydney Area</td>
<td></td>
<td></td>
</tr>
<tr>
<td>(a) horizon</td>
<td>22' 5&quot;</td>
<td>176-394</td>
</tr>
<tr>
<td>(b) &quot;</td>
<td>19' 1&quot;</td>
<td>1154-1483</td>
</tr>
<tr>
<td>(c) &quot;</td>
<td>6'</td>
<td>2489</td>
</tr>
<tr>
<td>Cunakiland Area</td>
<td>49'</td>
<td>Slope Mines</td>
</tr>
<tr>
<td>Picton Area</td>
<td>183' 9&quot;</td>
<td>Surface to 1440</td>
</tr>
<tr>
<td>Grand Lake Area</td>
<td>3' 4&quot;</td>
<td>Surface to 40</td>
</tr>
</tbody>
</table>

These coals vary in quality but in general they are of good grade bituminous. The poorer lignites have been briquetted with success and coke has been made of the local coals by the British Empire Steel Company in Sydney. The lower grade coals of this area are of considerable importance on account of the briquetting plants already established in the region.

Coal In Central Canada:

Manitoba, Ontario and Quebec are practically coalless.

Ontario, in the Moose River Basin, has a small portion

of lignite estimated by Dowling\(^1\) at 25 million tons. Quebec is sterile, containing no carbon fuel, save wood. Manitoba is fortunate in having a small quantity of brown coal in the vicinity of Turtle Mountain. The quantity is estimated at about 150 million tons and is extended over an area that is not in excess of 45 square miles.

**Arctic Canada**

Little is known relative to the Arctic coals, either as to extent or quality. Patton\(^2\) gives the areal extent of the Arctic and Northwest Territories' coal deposits as 9,000 square miles. The tonnage is estimated by the same authority at approximately 15 billion tons. The geographical position, in high and inaccessible latitudes, precludes the possibility of this latter area being of any economic value for many years.

**PEAT**

Peat is a carbonaceous material representing the first stage in coal formation. It usually occurs in bogs or swamps when a great amount of water is present. The water excludes large quantities of oxygen and decay does not set in at a rapid rate. Most dried peat contains about \(\frac{3}{5}\) carbon and so can be utilized as fuel when the moisture content is reduced.

Ireland has for many years utilized its peat for cheap fuel. More recently Germany has made concerted efforts to use her peat resources and with success.

Canada has approximately 37,000 square miles of peat and her total tonnage has been estimated at 199 million.

Haanel describes the conditions that make a peat bog suitable for fuel production under these headings:

1. Location: convenient to shipping point and accessible to market.
2. Extent: sufficient to justify erection of a plant.
3. Depth: over 5 feet.

It is fortunate that over 90% of the peat of the Dominion is buried in Ontario and Quebec, those provinces so barren of coal. The character of these peat deposits is good. Irish peat is said to have a calorific value of nearly 11,000 B.T.U. per pound.

According to Haanel, "in some of the bogs examined in the province of Quebec, a heating value of over 10,000 B.T.U. per pound has been found", or almost equal to the Irish peat. The calorific value of most Canadian peat does not run this high. It ranges from 7,100 to 10,500 B.T.U. per pound. The possibility of developing these resources will be discussed later.

2. Ibid.
3. Ibid.
Fig. 4
Forest Resources of Canada.

Source: Zon and Scharnow

- Rocky Mt. Pines and Firs.
- Northeastern Hardwoods...
- Western Spruce Forests...
- Arctic Forest...
- Eastern Hardwood.
- Douglas Fir....
- Western Larch..
- Eastern Pine...
Fig. 5.

Comparative Timber Areas in Three Selected Regions

WOOD PRODUCTS

Vast Forest Areas:

The Dominion has a vast wealth in her forest reserves. Of her 3,667,700 square miles, 35% is in timber. In the area of soft woods Canada has slightly less than the total for Europe and almost double that of the United States. In addition to her excellent timber resources which are available for building purposes, there is a vast area of scrub forests to the north. (Fig. 4). This region extends beyond the 60th parallel north latitude. The future of this scrub timber is limited to two or three possible uses. It may be used locally for fuel, it may be used in the pulp and paper industries or it may be used for the match industry. In the utilization of this northern section the experience of Sweden is suggestive. There this same wood type has been used chiefly in the manufacture of wood pulp and matches.

The relative timber situations in Canada, Europe and the United States is shown in Fig. 5 below.

Distribution by Provinces:

Provincial distribution of forests is of some significance. There is an excellent supply of wood, all of which could be used for fuel, in the two provinces where coal is lacking, namely Ontario and Quebec. The chief forest area by leading provinces is shown in the following figures.1

Fig. 6.

Distribution of Canadian Timber by Area.

<table>
<thead>
<tr>
<th>Province</th>
<th>Total Area</th>
<th>Forest Area</th>
<th>Percent of Total Area in Forest</th>
</tr>
</thead>
<tbody>
<tr>
<td>New Brunswick</td>
<td>24,854</td>
<td>17,576</td>
<td>70</td>
</tr>
<tr>
<td>Quebec</td>
<td>649,667</td>
<td>515,626</td>
<td>74</td>
</tr>
<tr>
<td>Ontario</td>
<td>365,880</td>
<td>240,000</td>
<td>66</td>
</tr>
<tr>
<td>British Columbia</td>
<td>353,000</td>
<td>149,300</td>
<td>42.3</td>
</tr>
</tbody>
</table>

In as much as the stand varies so much from place to place the actual amount of wood rather than the area covered would seem to be a better basis for comparison. It has been estimated by Zon and Sparhawk\(^1\) that Canada has a grand total of 1,093,000 millions board feet now standing. \(\text{Fig. 3}\) illustrates the distribution of this timber by three major areas of the Dominion, namely Eastern, Prairie, and British Columbia.

Duly\(^2\) has estimated, according to the following figures, that fuel wood is about 66\% of the total production:

<table>
<thead>
<tr>
<th>Product</th>
<th>Thousands of Cubic Feet</th>
</tr>
</thead>
<tbody>
<tr>
<td>Fuel wood</td>
<td>779,100</td>
</tr>
<tr>
<td>Lumber</td>
<td>359,967</td>
</tr>
<tr>
<td>Lath</td>
<td>10,545</td>
</tr>
<tr>
<td>Shingles</td>
<td>23,789</td>
</tr>
<tr>
<td>Squared timbers</td>
<td>3,793</td>
</tr>
<tr>
<td>Logs exported</td>
<td>5,459</td>
</tr>
<tr>
<td>Ties</td>
<td>50,535</td>
</tr>
<tr>
<td>Posts</td>
<td>21,204</td>
</tr>
<tr>
<td>Poles</td>
<td>5,711</td>
</tr>
</tbody>
</table>

\(^1\) Zon & Sparhawk: *Forest Resources of the World*, 1923: 37497.  
Canada uses most of her fire wood in the homes of her rural population. In addition to this domestic consumption, the mills that develop their own power for sawing depend to a considerable extent upon wood refuse for steam raising.

Professor Henry Louis has estimated the wood waste sent to refuse burners as 3,200,000 cords, or about 6,000,000 tons annually. This approximates 30% of the total wood fuel consumption of the Dominion.

**Canada versus United States Wood Fuel:**

The Dominion Fuel Board and Department of Interior have estimated the average yearly cordage of fuel for a period from 1922-1926 to be 9,078,432. This amounts to 817,058,980 cubic feet. Her population is 10,354,000. Thus Canada has a wood fuel consumption per capita of about .87 cords. In the United States, Brown has estimated that 100,000,000 cords of fire wood are consumed annually. This slightly less than one (.89) cord per capita.

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3. 1 cord of cut wood equals 90 cubic feet.
or about the same as for Canada.

**Heat Value of Wood:**

The average heating value of wood is somewhat greater than peat and a bit less than the average lignite. Brown\(^1\) estimates the average B.T.U. for dry wood to be 8,028 per pound. Standard peat fuel has a heating value of about 6,750 B.T.U. while lignites vary from 8,500 to 10,000 B.T.U. per pound.

It is interesting to note that Canada is a small exporter of fuel wood, the average for the 1922-1926 period being, 15,923 cords.\(^2\) During the same time she imported 7,192 cords. This interchange of wood fuel was entirely with the United States and was of a very local nature. In a country with so large a wood fuel reserve and a population widely separated from the coal areas, it is safe to presume that wood fuel will continue to be of considerable importance as a power resource for some time to come.

**Conservation:**

It will be necessary, however, for a considerable amount of conservation to be carried on within the Dominion in order to lessen the chances of depletion of the wood fuel supply. There are so many destructive agents such as wind, fire, insects and fungus diseases that are limiting new growths, that it becomes more and more essential to be judicious in the lumbering of Canada's timber resources. Forest fires alone destroy timber each year in

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1. Ibid.
the provinces that is equal to the total fuel wood consumption. Insects destroy almost double the amount that fire consumes, according to the report of the Committee for Investigation of the Resources of the Empire. The same committee further states that "The annual drain on the soft woods of the Dominion is not less than 4 billion cubic feet. At this rate the accessible stands of virgin soft wood will last 25 years."

**Value of Fuel Wood Decreases:**

Of course, the importance of wood as an essential fuel is constantly diminishing. Nevertheless, in a country where the forest areas are near the population centers and the coal deposits are thousands of miles away, it would be wise to be thrifty of the timber resources and to replenish the supply by reforestation.

Wood charcoal was a primary necessity for the steel industry half a century ago. In some places charcoal is used in limited quantities even today for metallurgical processes.

Sweden used a vast amount of charcoal for the smelting of her iron ore many years ago. Today the Swedes have found their wood to be much more valuable as wood pulp and for the manufacture of matches. The result has been a complete swing away from the less profitable carbonizing industry to the highly profitable pulp and match industries.

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Hydrogenation of Coal

Perhaps no recent development has been of more significance to the power problem of Canada than the discovery of a practical process of producing crude oil by hydrogenating coal. Hydrogenation of many substances has been possible for a great many years. The organic chemists have been able to reconstruct the molecular plan of the hydrocarbons and in so doing produce many synthetic substances.

Over twenty years ago a German chemist, Friedrich Bergius, devised a method of producing petroleum from coal. Since then the industrial chemists of many nations have sought to make the process more practical. The efforts have been successful and last year Germany produced 300,000 tons of motor fuel by coal-hydrogenation. Observers estimate that there will be a 60% increase this year. In England an Hydrogenation plant has just been completed that has an output capacity of 150,000 tons annually.

The hydrogenation process in its present state of development is described in the magazine Time as follows:

"Finely powdered coal is made into a paste by mixing with tar or a tar derivative, the mixture fed into a heavy steel cylinder. At 840 degrees F, hydrogen gas is brought in under 3,700 lb. per sq. in. pressure. The hydrogen combines with the carbon or carbon compounds in the coal. Then light-molecule carbons like gasoline can be distilled off, as in the somewhat similar process of "cracking" petroleum."

1. Men and Molecules, Time, Vol. 28, no. 12, p. 50. Sept. 21, 1936
Canada has been experimenting with the possibility of producing fuel oil by this method. The limited supply of petroleum in the Dominion will make the hydrogenation of coal an important industrial factor. The vast beds of low grade bituminous and lignite in the Prairie Provinces will supply an abundance of raw material. Canadian industry can certainly look toward hydrogenation as an immediate method of supplying motor fuel. The vast and uncurtailed production of American petroleum will for a time undersell synthetic oil. Any country which lacks petroleum and has such an excellent supply of carbonaceous material such as is found in Canada has an extremely bright motor fuel future.
Petroleum

Little Petroleum or Gas Available:

With all its vast area the Dominion of Canada has only one tiny spot where petroleum is found in large enough quantity to be of commercial significance. That area is the southwestern section of Ontario. The following table represents the production in Ontario for the eight-year period prior to 1931:

<table>
<thead>
<tr>
<th>Year</th>
<th>Production (bbls.)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1924</td>
<td>154,317</td>
</tr>
<tr>
<td>1925</td>
<td>145,136</td>
</tr>
<tr>
<td>1926</td>
<td>136,971</td>
</tr>
<tr>
<td>1927</td>
<td>139,636</td>
</tr>
<tr>
<td>1928</td>
<td>134,164</td>
</tr>
<tr>
<td>1929</td>
<td>121,129</td>
</tr>
<tr>
<td>1930</td>
<td>117,302</td>
</tr>
<tr>
<td>1931</td>
<td>122,364</td>
</tr>
<tr>
<td>Total</td>
<td>1,074,086 bbls.</td>
</tr>
</tbody>
</table>

Compare this with the total produced in the United States in order to appreciate the insignificance of the output. The smallest figure that is available for United States annual production from 1890 to the present is 45,833,672 bbls. and in 1923 the States produced over 500,000,000 bbls.

Provincial Production:

Alberta and New Brunswick are two other areas that contain small quantities of crude oil. Not a great many years ago petroleum was found in the Mackenzie River basin near Fort Norman but this is inaccessible and is therefore of not great value at present. Oil is known to be present in British Columbia, Saskatchewan, Manitoba, Nova Scotia and there are oil shales in New
Brunswick and Nova Scotia that promise something for the future.
In Ontario, the two leading fields are the Petrolia and the Bothwell, the former producing in the neighborhood of 60,000 bbls. per year and the latter about 22,000.

**Petroleum Uses in Canada:**

The chief use of the petroleum produced in Canada is indicated by the following figures showing Ontario's refining operations: (figures below include imported crude oils)

<table>
<thead>
<tr>
<th>Products</th>
<th>1929</th>
<th>1931</th>
</tr>
</thead>
<tbody>
<tr>
<td>Canadian Crude Oil</td>
<td>4,239,363</td>
<td>4,272,303</td>
</tr>
<tr>
<td>Gasoline</td>
<td>101,276,701</td>
<td>95,954,920</td>
</tr>
<tr>
<td>Gas &amp; Fuel Oil</td>
<td>99,035,616</td>
<td>101,379,304</td>
</tr>
<tr>
<td>Illuminating Oil</td>
<td>19,136,614</td>
<td>14,656,833</td>
</tr>
</tbody>
</table>

**Further Prospects:**

In the Prairie Provinces the prospects for further development of petroleum fields are far from promising. Warren, describing the drilling for oil in a section of central Saskatchewan, lists seven separate explorations for oil in a region near the Turner Valley gas fields. In no case was there a more optimistic remark favoring oil or gas possibilities than: "A little gas and showings of oil were reported", and this in only one location.

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1. (In part from Dept. of Mines, Ontario, after 41 annual Report, Vol. XLI, Part V, p. 56; 1932; Toronto.)
remainder carried remarks similar to the following: "No oil or gas was reported, and the well was abandoned." In the Turner Valley of the Sheep River district, a few miles southwest of Calgary, oil is being produced in commercial quantities. Since the area shows an anticlinal structure, it is reasonable to believe that oil and gas wells may have a limited future in this region. The facts are that two companies were organized to exploit the area as early as 1913. They were: McDougall Oil Company and the Calgary Petroleum Products, Ltd. In 1917, the total flow from this area was approximately 85 bbls. a day. The gas from the same region at that time had an estimated flow of somewhat over 5,000,000 cubic feet per day.

A large part of southeastern Alberta and southwestern Saskatchewan is underlain by a Cretaceous horizon that is gas bearing. Southeast of Calgary the Medicine Hat gas horizon underlies a vast area and contains considerable natural gas. In a variety of locations, both in the Prairie Provinces and in British Columbia, borings have been made for gas and oil. There have been no findings of enough importance to warrant any especial enthusiasm for the future, save for gas.

Oil Shales in Canada:

There is another element in Canadian petroleum geology

Fig. 7

Petroliferous Shales of Canada.


Cretaceous Shales

Eastern Oil Shales
that must not be overlooked. With the diminution of the petroleum
reserves of the world, we may look more and more to the possibility
of producing a distillate oil from carboniferous oil shales. Canada
has an abundant supply of such oil shales. In the Prairie Provinces
there is a giant obtuse triangle of cretaceous shales underlying
the area (Fig. 7). Of this series the shales from the Ashville up
the Vermilion River and Perrbina are said by Kirk\(^1\) to be petrolifer-
ous. He further states that yields of oil amounting to from 7 to
9 gallons per ton have been taken from these shales. Of course, at
the present time this is too small an output to be of commercial
importance.

If one will compare this yield of oil distillate with some
of the oil shales of the United States, some indication of their
possible usefulness will be gained. In the eastern district of
Nevada near Elko, the richest oil shales produce from 30 to 35
gallons per ton. The Utah shales will yield as much as 15 to 20
gallons per ton and in Wyoming there are shales that yield 15
gallons per ton. Colorado oil shales produce 15 gallons per ton;
California's average yield is about 20 gallons; Montana, Kentucky
and Indiana have shales that will produce from 10 to 16 gallons
per ton.

In the Eastern provinces of Canada some shales produce
as high as 40 gallons per ton. It is safe to presume, therefore,

\(^1\) Kirk, S. R.: *Cretaceous Stratigraphy of the Manitoba Escarpment*;
Dept. of Mines, Summary Report; Part 8, 1929.
that the oil shales of the Prairie Provinces have a long time to wait before they will receive any great exploitation. The significant part is that these shales are almost continuous from the edge of the Manitoba escarpment west of Winnipeg to the mountains of British Columbia.

**Maritime Oil Shales:**

In New Brunswick and Nova Scotia there are other oil shales of some importance. In Alberta, Westmorland and Kings Counties, New Brunswick, there are enormous beds of oil shales that are reported to have produced an average of 40 gallons of oil per ton. In Nova Scotia two counties, Picton and Antigonish, have large oil shale deposits that report 30 to 40 gallons of oil per ton, according to Gray.¹

He further remarks: "Previous to the discovery of petroleum wells in the United States about 1860, Picton oil shales were mined for exportation to the United States, where they were used to enrich illuminating gas and a start was made in retorting of New Brunswick shales for the extraction of oil."

Here, certainly, is an opportunity for future industrial development.

**Water Power Requisites:**

The Dominion of Canada has both of the major requisites

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for the development of water power—elevation and rainfall. In the Laurentian Uplands, in the Mountains of British Columbia and Western Alberta, in the hill country of the Maritime Provinces and in the Canadian Shield, there is ample relief to supply gradient to the many streams found there. Add to this the fact that the Pacific coast is drenched by rain from the moisture-laden Westerlies and that eastern Canada is in the path of the continental cyclones, and it can be readily seen Canada is well-equipped by nature to provide enormous amounts of water power. The fact that rainfall is not a constant factor must be considered when any water power problem is approached. Canada gets most of her rainfall in the spring and autumn. Couple the spring rainfall with the melting snow and ice in the higher latitudes and one can readily see that the maximum flow will come in the spring months or in the early summer. It follows then that in mid-summer and in the winter months the minimum flow occurs. In the winter months the cold freezes the streams and thus curtails the possibilities for power production. During these months, in spite of a heavy precipitation of snow, the curve of available water goes down.

Hydro-Electric Resources in Canada:

The advance of the Dominion in development of her hydro-electric resources has been unusually good. In the last twenty years Canada has increased her horse power production from developed water power projects over 2000 per cent. In 1904 a scant 350,000

Fig. 8A.

Water Power Available by Provinces 1934 (Potential)

Source: Dept. of Interior. Bulletin 1733
Water Power Resources of Canada.
Ottawa, 1934
h.p. were developed, in 1914 two million h.p. turbine installations were available, and today the minimum produced is 7,332,070 h.p. (Fig. 8). The distribution of potential and developed water power in Canada is shown in the table below. The first column indicates the minimum water power possibilities of the Dominion. The second indicates the capacity at minimum flow of the turbines now installed.

**Canadian Water Power Resources**

<table>
<thead>
<tr>
<th>Province</th>
<th>H.P.</th>
<th>H.P. Capacity of Turbines Now Installed at Average Minimum Flow</th>
</tr>
</thead>
<tbody>
<tr>
<td>Quebec</td>
<td>8,459,000</td>
<td>3,493,320</td>
</tr>
<tr>
<td>Ontario</td>
<td>5,330,000</td>
<td>2,355,105</td>
</tr>
<tr>
<td>Manitoba</td>
<td>3,309,000</td>
<td>1,390,925</td>
</tr>
<tr>
<td>British Columbia</td>
<td>1,961,000</td>
<td>1,333,681</td>
</tr>
<tr>
<td>Saskatchewan</td>
<td>542,000</td>
<td>42,035</td>
</tr>
<tr>
<td>Alberta</td>
<td>390,000</td>
<td>71,597</td>
</tr>
<tr>
<td>Yukon &amp; N.W.Territory</td>
<td>294,000</td>
<td>13,199</td>
</tr>
<tr>
<td>New Brunswick</td>
<td>68,600</td>
<td>133,681</td>
</tr>
<tr>
<td>Nova Scotia</td>
<td>20,800</td>
<td>112,167</td>
</tr>
<tr>
<td>Prince Edward Island</td>
<td>3,000</td>
<td>2,439</td>
</tr>
<tr>
<td><strong>Totals</strong></td>
<td>20,347,400</td>
<td><strong>7,332,070</strong></td>
</tr>
</tbody>
</table>

These potential resources are graphically illustrated by Fig. 9A. The figures above are based on falls and rapids where the drop has been measured and has been shown to be great enough to generate power. There are, no doubt, many locations where no survey has been made nor about which information is available. Power estimates

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have been calculated on the basis of 24 hour power at 80% efficiency for conditions of 'Ordinary Minimum Flow' and 'Ordinary Six Months Flow'. The 'Ordinary Minimum Flow' is based upon averages of the flows for the two lowest periods of seven consecutive days in each year, over the periods for which records are available. The 'Ordinary Six Months Flow' is based upon the continuous power indicated by the flow of the stream for six months in the year.

The Dominion Water Power and Hydrometric Bureau has further estimated the average machine installation of Canadian power plants is capable of carrying 30% more load than the ordinary six months power flow. Using this percent the Bureau has estimated that Canada can at maximum installation and operation produce 43,700,000 h.p. Further, "the total turbine installation of 7,332,070 h.p. represents the sum of the manufacturers' ratings of the different units under the heads at which they are installed. It is not correct to subtract this figure from the totals of available power, 20,347,400, to determine what power remains undeveloped because, as stated above, it has proven sound practice to allow a turbine installation averaging 30 per cent in excess of the ordinary six month flow power, i.e., the present turbine installation indicates the development of only a little less than 17% of the present recorded water power resources."  

2. Ibid.
Fig. 9.
Utilization of Water Power by Central Electric Stations and Pulp Mills. 1934.

Source: Dept. of Interior. Bulletin 1733
Water Power Resources of Canada
Ottawa, 1934.
Hydro-Electric Power Uses:

There are three major uses for the hydro-electric energy produced in Canada, namely, central electric stations, pulp and paper mills, and general industrial plants (Fig. 9). The first of these groups represents 87% of the total hydro-electric installation in Canada. The energy produced by these turbines provides 99% of the electrical energy sold in Canada. The general manufacturing industries purchase a large block of power from these central stations, the total aggregating 4,119,679 h.p. This is nearly 63% of their total production. Wood and pulp industries use the second largest block of electrical power in the Dominion.

Newspaper Utilization of Electrical Power:

Since Canada has led the world in the production of newsprint for many years, it is only logical to suspect that the major essentials of the industry power should be a leading factor. The Dominion Water and Hydrometric Bureau of Canada has estimated that each ton of newsprint requires about 100 h.p./ Fortunately, the available wood is found in the same areas with the water power resources. Bulletin 1733 of the above mentioned bureau has this to say relative to the pulp industry and its relation to water power:

"This industry, the largest individual consumer of industrial power, has a total hydraulic turbine installation of

1. Ibid.
Fig. 10.
Utilization of Canadian Water Power
February, 1934

Undeveloped 64.5%
Developed 35.5%

Minimum Available
20,347,400 h.p.

Source: Dept. of Interior. Bulletin 1733
Water Power Resources of Canada
Ottawa, 1934.
600,990 h.p. In addition to this primary power, hydro-electricity is purchased from central electric stations to operate a motor installation of more than 1,031,000 h.p. so that the hydraulic installation to supply motive power to the industry totals more than 1,632,000 h.p. This represents more than 89.5% of the total power equipment of the industry."

Other industries, among them mineral-reducing plants, electro-chemical, mine installations, saw mills, grinding mills, pumping plants, machine shops and railway operations, use about 5% of the energy produced by the turbines of the Dominion. It may be noted here that hundreds of small communities in Canada are supplied with hydro-electric needs from the small grinding and saw mills scattered throughout the country.

**Future of Canadian Water Power**

That Canada has barely touched her water power possibilities goes without saying. Based on the minimum flow she is using only 33% of her available water power (Fig. 10). The industry is practically unlimited in the eastern and western provinces of the nation. In the Prairie Provinces where the abundant coal reserves are found there are relatively no water power resources. Fortunately this may aid in the trend toward reduction of competition between power producers. The Department of Interior has made a conservative estimate of the capital investment represented by these installations and place their figure at $1,675,000,000 in 1934.
CONCLUSIONS

Factors Controlling Resources:

The Canadian power resources are enormous in size and are widely distributed over the provinces. They are modified by various climatic and geographic factors. Chief among these is latitude. The distance that Canada has free for active power development ranges between the 43rd and 50th parallels north latitude. Of this, only that narrow strip south of the 50th parallel can be used over six months of the year. The intense cold freezes the streams and curtails water power possibilities; the ground freezes and eliminates the chance of using the peat deposits and most of the lignite in the Prairie Provinces. Oil and coal are not reduced in their production rates by the temperature factor to any appreciable extent.

Transportation:

Transportation is another factor that has a vital effect on the use and development of power assets. There are two well-developed railroad systems in the Dominion. The Canadian National and Canadian Pacific are the main lines; the Intercolonial Lines constitutes a third branch that is of minor significance. These railroads are handicapped by the climatic factors, such as snow and ice to such an extent that much of the coal must be carried during the open season. Water transportation offers another
possibility. The Great Lakes are closed to traffic from about October 1 to April 1, and no river except the St. Lawrence is available for carrier purposes. The Gulf of St. Lawrence is a valuable pathway for Nova Scotian coal being shipped to the Quebec and Montreal markets. In fact, most of the 2,931,234 tons of bituminous coal exported to other provinces from Nova Scotia in 1928 went by way of the St. Lawrence. The ocean bodies, Atlantic and Pacific, provide transportation routes for coals that are mined in Nova Scotia and British Columbia to be moved to nearby American cities. This is not a very large item. In 1931 Nova Scotia exported 4.0% of her total exports to other countries, chiefly the United States. In 1935 her greatest year for exports to other countries, the amount totalled 24%. British Columbia exported 807,715 tons of coal to other countries in 1931. Of this, 149,109 tons were sent to foreign ports other than the United States.

The movement of electrical energy is not so great a problem as some of the others and yet there is a very definite limit to which electricity can be practically distributed. Any distance over 300 miles from the source is near the limit. Fortunately the potential possibilities of this type of power are so widely scattered that the distribution of electricity will never be a serious problem. Here the consistent flow of water or a practical means of storage for electrical energy will be the dis-

turbine factor.

The Rocky Mountains in the west present a barrier of sufficient size to cause a transportation problem for power resources. Again the pleasing thing is that coal is widely distributed through this area and there is ample relief and an abundance of rainfall to supply water power.

The problem that Canada faces relative to her power resources is not so much one of amount and type but one of distribution.

**United States vs. Canada:**

The United States has long been a source of supply for the coal users of Ontario. The proximity of the coal fields of Pennsylvania and the adequate railway connections between Canada and the United States, coupled with the fact that most of Canada's people live in that narrow point of Ontario adjoining the United States, makes a fine coal market for the American producer. To indicate the dominance of American coal in Ontario, these figures will suffice:

<table>
<thead>
<tr>
<th>U. S. Coal Exports to Ontario</th>
<th>Anthracite Short tons</th>
<th>Bituminous</th>
</tr>
</thead>
<tbody>
<tr>
<td>1923</td>
<td>3,059,964</td>
<td>11,717,298</td>
</tr>
<tr>
<td>1924</td>
<td>2,591,710</td>
<td>8,933,935</td>
</tr>
<tr>
<td>1925</td>
<td>2,182,717</td>
<td>9,100,462</td>
</tr>
<tr>
<td>1926</td>
<td>2,444,290</td>
<td>10,551,095</td>
</tr>
<tr>
<td>1927</td>
<td>2,113,072</td>
<td>11,863,542</td>
</tr>
<tr>
<td>1928</td>
<td>2,159,657</td>
<td>10,643,022</td>
</tr>
<tr>
<td>1929</td>
<td>2,203,236</td>
<td>11,332,183</td>
</tr>
<tr>
<td>1930</td>
<td>2,080,681</td>
<td>10,492,151</td>
</tr>
<tr>
<td>1931</td>
<td>1,613,435</td>
<td>8,819,083</td>
</tr>
</tbody>
</table>
In every case the United States coal was about 50% of the total consumed. Some British coal was imported by Canada through the same years but the amount was so small that it was hardly noticeable.

If the Dominion can provide adequate, regular and inexpensive transportation for her fuel resources and will couple this with judicious use of water power, the Canadian people can be an independent nation from the power standpoint. Without these Canada will always depend upon her neighbors for fuel and power resources.
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