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POSSIBLE SOURCES OF COAL FOR THE PUBLIC WORKS HEATING SYSTEM IN OTTAWA

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POSSIBLE SOURCES OF COAL FOR THE PUBLIC WORKS HEATING SYSTEM IN OTTAWA

by

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INTRODUCTION

The Department of Public Works, in fulfilling its responsibilities to provide heating and cooling for federal buildings in the national capital region, is faced with the need for rapid expansion of its heat generation and distribution systems. In order to accomplish this as rationally as possible, the Division of Mechanical Engineering set up the Ottawa Master Plan Study to investigate the economic, aesthetic, environmental and energy efficiency aspects of all practical means, including heat-recovery incineration of garbage, for meeting the future heating requirements. The study is being carried out by an interdepartmental task force led by DPW. The immediate objective of the task force is to prepare a brief of firm recommendations to Cabinet by the end of June 1975.

At the request of A. E. Toole, Chairman of the Ottawa Master Plan Study, the author joined the task force as an EMR representative, mainly to advise on fuel selection and on the design of suitable combustion equipment. Subsequently he was given the specific task of investigating the availability, possible sources and probable cost of coal as a potential fuel. This report summarizes possible sources, examines transportation costs under various conditions and estimates the pithead cost at which the various coals would be competitive with residual oil at $2.00, $3.00 and $4.00 per million Btu.

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ESTIMATE OF COAL REQUIREMENTS

For purposes of determining possible sources and availability, a rough estimate of coal requirements is sufficient, and this has been calculated making the following assumptions for two cases.

Assumed from DPW estimates of heat requirements, a combined plant burning coal and garbage, with a net production of one billion Btu/hr.

Assumed from the NCC incinerator study, Graph 2-2, for 1982, that the garbage-burning portion of the plant produces 265 million Btu/hr on a year-round basis.

Assumed that coal having a higher heating value of 12,000 Btu/lb is burned with a boiler efficiency of 90%.

Case 1

Assumed from DPW records that the equivalent full-load factor is 2800 hr/yr for heating, and 850 hr/yr for cooling (total = 3650 hr/yr).

Then the heat production from the combined plant = 3650×10^9 Btu/yr and the heat production from the garbage-burning portion of the plant = $8760 \times 265 \times 10^6 = 2321 \times 10^9$ Btu/yr.

Therefore the heat production from coal = 1329×10^9 Btu/yr

and the coal requirement $= \dfrac{1329 \times 10^9}{0.90 \times 12000 \times 2000} = \underline{61{,}500 \text{ tons/yr}}$

Case 2

Assumed that the existing plants at Cliff Street and the Printing Bureau are relegated to peaking duty to the extent that the new plant has an annual load factor of 60%.

Then the heat production from the combined plant

$= 0.60 \times 8760 \times 10^9 = 5256 \times 10^9$ Btu/yr

As in Case 1, heat production from the garbage-burning portion of the plant = 2321×10^9 Btu/hr

Therefore the heat production from coal = 2935×10^9 Btu/yr

and the coal requirement $= \dfrac{2935 \times 10^9}{0.90 \times 12000 \times 2000} = \underline{136{,}000 \text{ tons/yr}}$

From the foregoing calculations it appears that the fuel requirement of the proposed new plant will lie between 60,000 and 135,000 tons/yr of coal having a higher heating value of 12,000 Btu/lb.

ESTIMATES OF CANADIAN COAL RESOURCES

A quick review of the literature on Canadian coal resources is apt to be confusing, because various authorities offer rather diverse estimates, depending on the criteria used for defining an economic resource. It is perhaps significant that studies over the past half century have generally offered successively smaller estimates of our total resources.

A useful starting point is the estimate by Latour and Chrismas* of western Canadian coal resources. Their breakdown by rank and province is given in Table 1. Their definitions of the three resource classifications are as follows:

"Measured or Proven Resources

Measured resources are those for which tonnage is computed from dimensions revealed in outcrops, trenches, mine workings and drillholes. The points of observation and measurement are so closely spaced, and the thickness and extent of the coal are so well defined, that the computed tonnage is judged to be accurate within 20 per cent of the true tonnage. Although the spacing of the points of observation necessary to demonstrate continuity of coal differs from region to region according to the character of the coal beds, the points of observation are, in general, about half a mile apart."

"Indicated or Probable Resources

Indicated resources are those for which tonnage is computed partly from specific measurements and partly from projection of visible data from a reasonable distance on the basis of geologic evidence. In general, the points of observation are about 1 mile apart, but they may be as much as $1\frac{1}{2}$ miles apart for beds of known continuity."

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*Latour, B. A., and Chrismas, L.P. "Preliminary Estimate of Measured Coal Resources Including Reassessment of Indicated and Inferred Resources in Western Canada", Paper 70-58, Geological Survey of Canada, Dept of Energy, Mines and Resources. 1970, Reprinted 1973

"Inferred or Possible Resources

Inferred resources are those for which quantitative estimates are based largely on broad knowledge of the geologic character of the bed or region and for which few measurements of bed thickness are available. The estimates are based primarily on an assumed continuity in areas remote from outcrops of beds, which in areas near outcrops were used to calculate tonnage classed as measured or indicated. In general, inferred coal lies more than 2 miles from the outcrop or from points for which mining or drilling information is available".

TABLE 1

Coal Resources of Western Canada
By Rank and Province
(thousands of short tons)

Province	Measured	Indicated	Inferred	Total
		Low and Medium Volatile Bituminous		
Alberta				
Inner Foothills Luscar Formation	542,000	7,526,500	3,535,400	11,503,900
Inner Foothills Kootenay Formation	440,100	12,193,700	3,831,100	16,464,900
Alberta Total	982,100	19,620,200	7,366,500	27,968,800
British Columbia	6,943,000	10,775,000	40,480,100	58,198,100
Rank Total	7,925,100	30,395,200	47,846,600	86,166,900
		High Volatile Bituminous		
Alberta				
Outer Foothills		6,278,600	3,043,700	9,322,300
British Columbia	45,600	100,400	172,900	318,900
Rank Total	45,600	6,379,000	3,216,600	9,641,200
		Subbituminous		
Alberta	1,221,800	6,197,300	2,530,000	9,949,100
		Lignite		
British Columbia	340,000	300,000	300,000	940,000
Saskatchewan	291,500	7,024,000	4,698,400	12,013,900
Rank Total	631,500	7,324,000	4,998,400	12,953,900
Grand Total	9,824,000	50,295,500	58,591,600	118,711,100

Some additional comments concerning these resources can be made as follows:

1. A more recent evaluation of the lignite deposits in southern Saskatchewan[1] places the economically recoverable resources at 5.7 billion tons, rather than 12 billion tons.

2. 1972 estimates of Alberta sub-bituminous coal resources, published by the Energy Resources Conservation Board of Alberta[2] are as follows:

Ultimate recoverable reserves:	50 billion tons
Surface-mineable ultimate recoverable reserves:	5.6 billion tons
Proved remaining recoverable surface-mineable reserves:	4.3 billion tons
Proved remaining recoverable underground-mineable reserves:	1.04 billion tons

The figure of 9.9 billion tons of sub-bituminous coal given in Table 1 was based on surface-mineable coal only. Thus, the more recent Energy Resources Conservation Board figures show a reduced estimate for surface-mineable coal.

3. No attempt was made to apply a recovery percentage to any of the resource estimates in Table 1. Typical recovery percentages for current mining technology are 80% for strip mining and 57% for underground mining.

4. Many areas in Alberta wherein coal measures are known to occur have not been readily accessible. Thus future exploration will undoubtedly add to Albertas resources of bituminous coal.

With respect to the coal resources of the Maritime provinces, the following information is extracted from "An Energy Policy for Canada"[3]

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[1] Broughton, P. L., Irvine, J.A., and Whitaker, S. H. "Lignite Coal Resources of Southern Saskatchewan".

[2] "The Adequacy of Alberta's Reserves of Surface-Mineable Sub-bituminous Coal to Meet Market Requirements" Energy Resources Conservation Board, Calgary, Alberta. April 1974

[3] "An Energy Policy for Canada, Phase 1, Volume I - Analysis" Energy, Mines and Resources, Ottawa, Canada 1973

"The Maritime coal reserves have been extensively mined over the past 170 years and most of the readily accessible coal has been extracted. In New Brunswick, operations are now limited to a single, very thin coal seam with recoverable reserves in the order of 3 million tons. It is of local value only to nearby electrical utility stations. In Nova Scotia, virtually all of the coal mining is being conducted in the sub-sea collieries of Cape Breton Island. These old and extensive mines are not economic but some possibilities exist elswwhere in this Sydney coal field for opening new and more efficient collieries. The field contains approximately 100 million to 150 million tons of coal reserves. Some of these coals are of marketable quality and may be economically recovered through new openings at the coast line but could not support the present labour force. One new colliery, the Lingan mine, has recently been opened".

Exploration programs are under way in both New Brunswick and Nova Scotia, sponsored jointly by EMR and provincial authorities. In the meantime, production in the Sydney coal field is being expanded, and is expected to reach 3.5 million tons per year by 1976. This is high-volatile bituminous coal, mostly of metallurgical quality.

An exploratory drilling program is presently under way in Cumberland County, near Springhill, Nova Scotia. The existence of coal in the area is well known, but it remains to be seen whether there is a seam of sufficient thickness and continuity to support an economical medium sized mine.

POSSIBLE COAL SOURCES

Nova Scotia

1. Cape Breton Development Corporation

Although Devco is not presently in a position to supply additional markets, it seems likely that by 1980 increased demand for coal to generate thermal power in Nova Scotia will justify the opening of a new mine having sufficient surplus capacity to supply DPW requirements. This would be bituminous coal of about 12500 Btu/lb, probably at a price competitive with the present cost of residual oil.

2. Cumberland Mining Associates

Whether Cumberland County will be a possible source of supply depends on the outcome of the drilling program presently under way. If sufficient reserves are found, it will still be necessary to develop a mine. The coal would likely be

bituminous of about 12,000 Btu/lb. Although this is a very tentative source, it is mentioned here because it is closer to Ottawa than any other known deposit of Canadian coal, and presumably development will be undertaken only if the coal can be mined at a price competitive with residual oil.

New Brunswick

At present New Brunswick does not seem to be a likely source of coal unless the exploration program presently under way makes a significant discovery. The coal mined in New Brunswick in the past has all been from the Minto area, and has an unusually high sulphur content.

Saskatchewan

1. Manitoba and Saskatchewan Coal Company Ltd

This company operates the M & S strip mine at Bienfait and the Boundary Dam mine at Estevan but the latter operation only supplies the Boundary Dam generating station. It appears that the company has sufficient reserves under lease at Bienfait to supply the DPW requirements. The coal, of course, is lignite with a higher heating value of about 7000 to 7500 Btu/lb*.

2. Manalta Coal Ltd

This company operates the Klimax mine, which is a fairly large strip mine in Estevan, and appears to have sufficient reserves under lease to supply DPW requirements. Estevan lignite is similar in analysis and heating value to Bienfait lignite.

3. Saskatchewan Power Corporation

A majority of the lignite deposits in Saskatchewan are under lease to the Saskatchewan Power Corporation, which generally hires a private operator to do the mining. From a recent conversation with an official of SPC, it appears that the SPC does not have sufficient reserves in its leases near Estevan to permit the sale of lignite to DPW. However, a new generating station and a new mine are now planned for Poplar River, approximately 125 miles west of Estevan. Here reserves under lease are sufficient that SPC might be willing to sell some of the lignite that will be mined for the generating station. The Poplar River lignite deposits have a higher heating value of about 6000 Btu/lb.

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*The higher heating values given for western Canadian coals are quoted from Tibbetts, T.E., and Montgomery, W.J. "Evaluation of Canadian Commercial Coals: 1972 Saskatchewan, Alberta and British Columbia. Information Circular IC 305 Canada Centre for Mineral and Energy Technology (former Mines Branch) Department of Energy, Mines and Resources, Ottawa, Canada April 1973

Alberta

The prospects of obtaining Alberta coal are complicated by the fact that the province has declared a moratorium on further coal exploration and development until it has completed an assessment of its resources and its own future needs. However, if it is assumed that by 1980 the assessment will have been completed, and will have concluded that Alberta indeed has sufficient coal to permit sales outside the province, three areas may be considered.

A Plains Area

The coal deposits in the Alberta plains are all of sub-bituminous rank, ranging from 8000 to 9500 Btu/lb. Coal is mined in several localities over a wide area, but the operations with a present production capable of meeting DPW requirements are as follows:

1. Manalta Coal Ltd

This company operates the Vesta mine near Halkirk, and the Whitewood Mine and Highvale Mine near Wabamun. All three are strip mines; the last two supply mine-mouth generating stations operated by Calgary Power Ltd. The higher heating value of the coal ranges from 8000 to 8500 Btu/lb.

2. Forestburg Collieries Ltd

This company operates the Diplomat Mine near Forestburg. It is a strip mine, producing upwards of 500,000 tons per year, and expansion of capacity is planned. The higher heating value of the coal ranges from 8400 to 8800 Btu/lb.

3. Century Coals Ltd

This company operates the Atlas Mine, which is an underground mine near Drumheller. Although it is a small operation (production in 1973 was only 38000 tons) it is mentioned here because the 1974 Coal Operators List* comments that "the company is investigating new markets for its coal". Furthermore, it is possible that the Province of Alberta will decide to make only the more expensive coal from underground mines available for use outside the province. The higher heating value ranges from 9100 to 9650 Btu/lb.

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*Operators List 4, Coal Mines in Canada, Published by Energy, Mines and Resources, Ottawa, Canada January 1974

B Outer Foothills Belt

As can be seen in Table 1, the outer foothills belt of Alberta, immediately west of Calgary and Lethbridge, and extending northward, is believed to contain about ten billion tons of high-volatile bituminous coal. Mining was carried out in this area to supply the railways while steam locomotives were in use, but no mines are operating now because the coal is not suitable for metallurgical use, and until recently the demand for thermal coal could be more readily met from the sub-bituminous strip mines in the plains area. Ontario Hydro has investigated the outer foothills belt extensively, but development is presently blocked by the provincial moratorium. Furthermore, since most of the deposits lie in environmentally sensitive and recreational areas, there is some doubt that mining will ever be permitted.

Despite this unpromising outlook, the potential of the outer foothills belt should not be overlooked. Should a mining development be permitted for a large-scale user such as Ontario Hydro, the same mine might be able to supply DPW with high-quality bituminous coal having a higher heating value of about 12000 Btu/lb.

C Inner Foothills Belt

The inner foothills belt overlaps the southern part of the Alberta-BC border, then runs northwest parallel to the border on the Alberta side, and projects into BC where the border swings north. The coal is generally low and medium-volatile bituminous, with a higher heating value of about 10,000 to 12,000 Btu/lb as mined, and 13,000 to 14,000 Btu/lb when cleaned. The cleaned coal is of good metallurgical quality, and the present extensive mining operations export almost exclusively to the Japanese steel industry. DPW requirements could probably be met by any of the following companies operating in the area, but at the current price for metallurgical coal, which is presently about $40/ton at the mine. Uncleaned coal might be available at a somewhat lower price.

1. Coleman Collieries Ltd

This company operates an underground mine at Vicary Creek, and a surface mine at Tent Mountain, both in the Crowsnest area. Combined output is over one million tons per year, all of which is exported to Japan.

2. Canmore Mines Ltd

This company produces about 230,000 tons/year, of semi-anthracite and low volatile bituminous coal, mostly from an underground mine at Canmore. The coal is exported to Europe as well as Japan, and in the past Canmore semi-anthracite found widespread acceptance for small stokers in the Ottawa area. Semi-anthracite, however, is not suitable fuel for pulverized-fired boilers.

3. Cardinal River Coals Ltd

The Cardinal River Mine at Luscar is a strip mine which produces about 1.5 million tons/year for export to Japan.

4. McIntyre Porcupine Mines Ltd

This company operates the Smoky River Mines at Grande Cache. One is a surface mine producing about 1.5 million tons/year, the other is an underground mine producing not quite one million tons/year. The coal from both is exported to Japan.

Most of the aforementioned mines have some sort of cleaning process to upgrade the coal to meet metallurgical requirements. Thus, there is the possibility of meeting DPW requirements with washery middlings or oxidized coal at a substantially lower price than the metallurgical coal commands. A rather detailed investigation would be required to properly assess this alternative.

British Columbia

British Columbia has the largest coal resources of all the provinces. Most of the deposits are located in the southeastern area adjacent to the Crowsnest coal field of Alberta. These contain low-volatile bituminous coal of metallurgical quality which is presently being mined for export to Japan. There are also small deposits at various locations elsewhere in the province, for example the lignite deposits at Hat Creek, but these appear to be too small or too remote to merit consideration for supplying the DPW requirements.

The following companies operate in the southeastern area:

1. Kaiser Resources Ltd

This company extracts nearly eight million tons/year from the Michel underground colliery and the Balmer strip mine, both near Natal. The cleaned coal has a higher heating value of about 13,000 Btu/lb, and is exported to Japan.

2. Fording Coal Ltd

The Fording Mine at Fording Valley is a surface mine producing about four million tons/year for export to Japan. The clean coal product has a higher value of about 13,800 Btu/lb.

As with the Alberta mines producing metallurgical coal, the above companies have middlings and oxidized coal which presently constitute something of a disposal problem.

TRANSPORTATION METHODS AND COSTS

Transportation Rates

The possible methods for long-distance transport of coal are limited to rail and water. Rail furthermore offers two alternatives:

1. Unit trains, which are esentially freight trains hauling coal cars only, rather than mixed freight. These are commonly employed for moving quantities of less than one million tons/year.
2. Integral trains, which consist of cars and locomotives permanently coupled together, shuttling continuously between the pick-up and delivery points. These are frequently employed for moving quantities in excess of one million tons/year between two points. Sophisticated means for rapid loading and unloading are provided.

The following figures were offered as current freight rates for fairly long hauls*, together with the comment that rail rates are likely to increase at 1.5 times the inflation rate.

Rail Transport:	Unit Trains	2.5 to 3.0¢/ton mile
	Integral Trains	1.1 to 1.5¢/ton mile
Water Transport:		0.3 to 0.4¢/ton mile
+ charge for use of Welland Canal		50¢/ton

*Telephone conversations with P. J. Read, Marketing Transportation Division, Energy Development Sector-Coal, Department of Energy, Mines and Resources, Ottawa, Canada

The higher values are used in the calculations which follow.

With respect to water transport, both Prescott and Cornwall have seaway-depth ports capable of accepting vessels with 27 ft draft. The former would be suitable for unloading coal from western Canada, the latter for coal from eastern Canada. In either case, however, some capital expenditure would probably be required for handling and storage facilities at the dock.

Western Canadian Coal

Three sources of coal are considered here, as follows:

1. Lignite from Estevan or Bienfait in Saskatchewan.
2. Sub-bituminous coal from the area encompassing Drumheller and Forestburg in Alberta.
3. Bituminous coal from the Inner Foothills Belt on the Alberta-BC border.

The possibility of obtaining bituminous coal from the Outer Foothills Belt of Alberta is not considered here. Transportation costs for this coal, if it became available, would be much the same as from the Inner Foothills Belt.

For western Canadian coal three transportation scenarios seem worthy of discussion; these are treated in the following sections.

Scenario 1: Unit Train From the Mine to Ottawa

This appears to be the only method of transportation presently available, since the DPW coal requirements are too small to justify an integral train. The approximate transportation costs are:

1. Lignite, Estevan to Ottawa (1650 mi. at 3¢/ton mi) $49.50/ton
2. Sub-bituminous, Halkirk to Ottawa (2130 mi. at 3¢/ton mi) $63.90/ton
3. Bituminous, Michel to Ottawa (2190 mi. at 3¢/ton mi) $65.70/ton

Scenario 2: Integral Train From the Mine to Thunder Bay
Unit Train From Thunderbay to Ottawa

This scenario depends on DPW tying into some larger-scale movement of coal eastward to Thunder Bay, such as might occur if Ontario Hydro contracts with a western mine to supply the Thunder Bay generating station. Integral train transport from the mine to Thunder Bay might then be feasible. The approximate transportation costs would then be:

1. Lignite,	Estevan to Thunder Bay	(720 mi at 1.5¢/ton.mi)	$10.80
	Thunder Bay to Ottawa	(940 mi at 3¢/ton.mi)	$28.20
		Total	$39.00/ton
2. Sub-bituminous,	Halkirk to Thunder Bay	(1190 mi at 1.5¢/ton.mi)	$17.85
	Thunder Bay to Ottawa	(940 mi at 3¢/ton.mi)	$28.20
		Total	$46.05/ton
3. Bituminous,	Michel to Thunder Bay	(1250 mi at 1.5¢/ton.mi)	$18.75
	Thunder Bay to Ottawa	(940 mi at 3¢/ton mi)	$28.20
		Total	$46.95/ton

Scenario 3. Integral Train from the Mine to Thunder Bay
Lake Freighter from Thunder Bay to Prescott
Unit Train from Prescott to Ottawa

This scenario envisions the movement of western coal to central Canada in quantities large enough to justify the proposed coal dock at Thunder Bay. This would likely happen if, for example, Ontario Hydro secured a supply of western coal for some of its large generating stations such as Nanticoke. By tying into such a system, DPW could reap the benefits of integral train transport from the mine to Thunder Bay and water transport from Thunder Bay to Prescott on the St. Lawrence. The approximate transportation costs would then be:

1. Lignite,	Estevan to Thunder Bay (as in Sc. 2)	$10.80
	Thunder Bay to Prescott (1200 mi at 0.4¢/ton mi)	$ 4.80
	Prescott to Ottawa (50 mi at 3¢/ton.mi)	$ 1.50
	Welland Canal Fee	0.50
	Total	$17.60/ton
2. Sub-bituminous,	Halkirk to Thunder Bay (as in Sc. 2)	$17.85
	Thunder Bay to Prescott (1200 mi at 0.4¢/ton mi)	$ 4.80
	Prescott to Ottawa (50 mi at 3¢/ton.mi)	$ 1.50
	Welland Canal Fee	$ 0.50
	Total	$24.65/ton
3. Bituminous,	Michel to Thunder Bay (as in Sc. 2)	$18.75
	Thunder Bay to Prescott (1200 mi at 0.4¢/ton.mi)	$ 4.80
	Prescott to Ottawa (50 mi at 3¢/ton.mi)	$ 1.50
	Welland Canal Fee	$ 0.50
	Total	$25.55/ton

The approximate nature of the foregoing figures must be stressed. In addition to the assumptions on freight rates and the rounding off on distances, no allowance was made in Scenario 2 for the cost of unloading coal from integral trains and reloading on unit trains. Similarly, in Scenario 3, nothing was allowed for the cost of transferring the coal from rail to ship and back to rail. Furthermore, 3¢/ton mile may be an unrealistically low estimate for the short haul from Prescott to Ottawa.

Eastern Canadian Coal

Here bituminous coal from Cape Breton is the only source considered, and it is assumed that it moves by water to Cornwall, thence by unit train to Ottawa. The approximate transportation costs are as follows:

Sydney to Cornwall (930 mi at 0.4¢/ton.mi)		$3.75
Cornwall to Ottawa (60 mi at 3¢/ton.mi)		1.80
	Total	$5.55/ton

If coal becomes available from the Cumberland field, transportation costs should be about the same.

Transportation Costs per Million Btu

Since the coals under consideration vary substantially in heating value, the transportation costs per ton must be corrected to arrive at transportation costs per unit of energy delivered. Costs per million Btu are summarized in Table 2, calculated for the typical range of higher heating values of each coal source and each transportation scenario.

PITHEAD COST OF COAL

Estimating the cost of coal at the mine five to six years from now is a risky undertaking at best. When attempted for mines which in some cases are not yet opened, it becomes rather meaningless. The following figures are offered with the qualification that they are probably correct within limits of + 100%, -50%:

Saskatchewan Lignite	$5.00/ton
Alberta Sub-bituminous	$7.00/ton
Albert and BC Bituminous	$40.00/ton
Nova Scotia Bituminous	$35.00/ton

TABLE 2

Transportation Costs for Coal per Million Btu

Coal Source and Higher Heating Value	Transportation Cost, $/10^{6}Btu		
Cape Breton Bituminous			
12,000 Btu/lb		0.23	
14,000 Btu/lb		0.20	
	Scenario 1	Scenario 2	Scenario 3
Saskatchewan Lignite			
6,500 Btu/lb	3.81	3.00	1.35
7,500 Btu/lb	3.30	2.60	1.17
Alberta Sub-bituminous			
8,000 Btu/lb	3.99	2.88	1.54
9,500 Btu/lb	3.36	2.42	1.30
Alberta or BC Bituminous			
10,000 Btu/lb	3.29	2.35	1.28
12,000 Btu/lb	2.74	1.96	1.06
14,000 Btu/lb	2.35	1.68	0.91

For the present purposes, it is probably more useful to attempt to establish the maximum pithead cost at which coal is competitive with residual oil. On a Btu input basis, this can be done simply by subtracting the transportation cost given in Table 2 from the established or projected Btu-basis price for oil. However, it is the price of fuel on a Btu output basis that is of real concern, since boiler efficiency will vary with the different fuels, mainly because of their different moisture and hydrogen contents. Lignite, for example, suffers an efficiency penalty bacause of its high moisture content, therefore it will require a higher Btu input than bituminous coal for the same boiler operating conditions.

Table 3 summarizes estimated boiler efficiencies for lignite, sub-bituminous coal, bituminous coal and residual oil. These efficiencies have been used to calculate maximum competitive pithead costs for the coals and transportation costs given in Table 2, and for residual fuel oil costs of $2.00, $3.00 and $4.00 per million Btu. The pithead coal costs thus calculated are given in Tables 4, 5 and 6. Where negative numbers appear, their magnitude indicates the extent to which the coal is rendered uncompetitive by transportation costs.

TABLE 3

Estimated Boiler Efficiency With Various Coals and Residual Oil

Fuel:	Sask Lignite	Alta Sub-bit	NS Bit	Resid Oil
Handbook Code*	S 2-2	ABC 9-2	NS 3-6	9720
Assumed Combustion Conditions				
Moisture as fired, %:	35	20	5	0
O_2 in flue gas, %	3	3	3	2
Stack Temp., °F	300	300	300	300
Combustion air temp., °F	80	80	80	80
Combustible in ash, %	5	5	5	0
CO in Flue Gas, %	0.05	0.05	0.05	0.05
Boiler rating, Btu/hr	300×10^6	300×10^6	300×10^6	300×10^6
Boiler load, %	100	100	100	100
Heat Losses				
Dry flue gas loss, %	4.95	4.80	4.80	4.35
Hydrogen loss, %	3.82	3.96	3.74	6.25
Combustible in ash, %	0.75	0.75	0.45	nil
Moisture loss, %	5.52	2.48	0.44	nil
CO loss, %	0.15	0.17	0.16	0.15
Radiation loss, %	0.34	0.34	0.34	0.34
Unaccounted for, % (assumed)	0.50	0.50	0.50	0.25
Total Losses;%	16.03	13.00	10.43	11.34
Efficiency, %	83.97	87.00	89.57	88.64

*Friedrich, F. D., and Hayden, A.C.S. "A Combustion Handbook for Canadian Fuels" Vol. 1, Fuel Oil and Vol. 3, Coal. Mines Branch Monograph 877, 1969 and 882, 1974 resp. Department of Energy, Mines and Resources, Ottawa, Canada. The code numbers identify the fuels and corresponding heat loss charts which were used to calculate the boiler efficiencies.

TABLE 4

Maximum Competitive Pithead Cost for Coal
When Residual Oil Costs $2.00 per Million Btu
(36¢/Imp gal, 180,000 Btu/imp gal)

Coal Source and Higher Heating Value	Maximum Competitive Pithead Cost, $/ton		
Cape Breton Bituminous			
12,000 Btu/lb		42.96	
14,000 Btu/lb		50.97	
Transportation Scenario	1	2	3
Saskatchewan Lignite			
6,500 Btu/lb	-24.91	-14.38	7.07
7,500 Btu/lb	-21.09	-10.59	10.86
Alberta Sub-Bituminous			
8,000 Btu/lb	-32.45	-14.69	6.75
9,500 Btu/lb	-26.57	- 8.70	12.57
Alberta or BC Bituminous			
10,000 Btu/lb	-25.39	- 6.59	14.80
12,000 Btu/lb	-17.27	1.44	23.05
14,000 Btu/lb	- 9.23	9.53	31.09

TABLE 5

Maximum Competitive Pithead Cost for Coal
When Residual Oil Costs $3.00 per Million Btu
(54¢/Imp gal, 180,000 Btu/Imp gal)

Coal Source and Higher Heating Value	Maximum Competitive Pithead Cost $/ton		
Cape Breton Bituminous			
12,000 Btu/lb		67.21	
14,000 Btu/lb		79.25	
Transportation Scenario	1	2	3
Saskatchewan Lignite			
6,500 Btu/lb	-12.60	- 2.07	19.38
7,500 Btu/lb	- 6.88	3.62	25.07
Alberta Sub-Bituminous			
8,000 Btu/lb	-16.76	1.00	22.44
9,500 Btu/lb	- 7.93	9.93	31.21
Alberta or BC Bituminous			
10,000 Btu/lb	- 5.19	13.61	35.01
12,000 Btu/lb	6.97	25.69	47.29
14,000 Btu/lb	19.05	37.81	59.37

TABLE 6

Maximum Competitive Pithead Cost for Coal
When Residual Oil Costs $4.00 per Million Btu
(72¢ per Imp gal, 180,000 Btu/Imp gal)

Coal Source and Higher Heating Value	Maximum Competitive Pithead Cost $/ton		
Cape Breton Bituminous			
12,000 Btu/lb		91.45	
14,000 Btu/lb		107.53	
Transportation Scenario	1	2	3
Saskatchewan Lignite			
6,500 Btu/lb	- 0.29	10.24	31.70
7,500 Btu/lb	7.32	17.82	39.27
Alberta Sub-Bituminous			
8,000 Btu/lb	- 1.07	16.69	38.13
9,500 Btu/lb	10.70	28.56	49.84
Alberta or BC Bituminous			
10,000 Btu/lb	15.01	33.81	55.21
12,000 Btu/lb	31.21	49.93	71.53
14,000 Btu/lb	47.34	66.10	87.66

SUMMARY

1. Possible Canadian sources of coal are

Nova Scotia:	bituminous coal
Saskatchewan:	lignite
Alberta:	bituminous and sub-bituminous coal
British Columbia:	bituminous coal

2. Suppliers of Nova Scotia coal cannot meet DPW requirements at present, but expect to be able to do so by 1980.

3. Alberta has declared a moratorium on further coal exploration and development while a study of its own requirements is in progress. Presumably the study will be completed by 1980, but it is possible that surface-mineable sub-bituminous coal will be reserved for use within the province.

4. At present, western coal can be moved to Ottawa only by rail, using unit trains. If some large-scale user of coal, such as Ontario Hydro, initiates movement of large tonnages of coal from western to central Canada, transportation costs could be substantially reduced by utilizing integral trains from the mine to Thunder Bay, and water transport from Thunder Bay eastward.

5. Nova Scotia coal enjoys a substantial advantage over western coal with respect to transportation costs in that it can be moved most of the way to Ottawa by water.

6. Prescott and Cornwall both have ports capable of handling Seaway-depth vessels. Prescott would be suitable for unloading western coal. Cornwall would be suitable for unloading coal from Nova Scotia. Both ports would probably require some investment in handling and storage facilities on the dock.

7. Compared to residual oil at $2.00/million Btu (36¢/Imp gal) western coal would be competitive only if it could move to Thunder Bay by integral train, and thence to Prescott by lake freighter.

8. If the price of residual oil were to reach $4.00/million Btu (72¢/Imp gal), western bituminous coal shipped to Ottawa by unit train might be competitive with oil.

9. Nova Scotia coal at a pithead price of $40 to $50/ton would be competitive with residual oil at $2.00/million Btu (36¢/Imp gal).