YUKON THERMAL POWER GENERATING STUDY

FOR

PAN OCEAN OIL LIMITED

061806

This report has been examined; declared acceptable as Representation Work under Section 32 and Schedule B of the Canada Mining Regulations and valued in part of the amount of $ 173,851.00

Chief, J M Patterson

Date Feb. 7, 1979.

Prepared By

MONENCO CONSULTANTS LIMITED
Calgary, Alberta, Canada

December 1978

monenco consultants limited

900 ONE PALLISER SQUARE, 125 - 9th AVENUE S.E.
CALGARY, ALBERTA, CANADA T2G 0P6

Telephone: (403) 263-1680 Telex: 038-22636

15 December 1978

Mr.J.S. McKinney
Supervisor Coal Exploration
Pan Ocean Oil Limited
1050 Three Calgary Place
Calgary, Alberta T2P 0J1

Yukon Thermal Power
Generating Study
<u>File: P00 6888-2</u>

Gentlemen;

We have pleasure in submitting our revised report on the preliminary study for a thermal plant located in the Bonnet Plume area of the Yukon Territory.

This report presents the "Order of magnitude" capital costs for a 3 x 75 MW mine mouth coal fired generating plant with an assessment of operating and maintenance costs. The costs of power delivered at Carmacks and at the plant bus bar are also given.

It has not been possible to draw a direct comparison of the cost of power between the proposed hydro scheme in the Yukon and the thermal plant as the report on the hydro station is still considered confidential.

We suggest that in any further negotiations with Northern Canada Power Commission or Yukon Electric, it may be more realistic to make comparisons of cost at the plant bar bus rather than at Carmacks. While the transmission line costing has been done on the same basis as that of the hydro plant, the dedicated thermal plant line is penalized when compared with the multi-purpose use of the line from the hydro development. In addition, the thermal plant is more central to the ultimate load centre.

...2

For study purposes, we have assumed that the cost of coal at the plant inlet conveyor is $30. per ton which you have indicated to us.

When you have had an opportunity to study this report, we shall be pleased to review it with you and to provide any additional information you may require.

Yours very truly,

Z. Kolisnyk, P. Eng.
Vice President Thermal

ZK:CA

1.0 INTRODUCTION

This study provides an order of magnitude cost estimate of generated power associated with a proposed thermal plant in the Bonnet Plume area north of Mayo in the Yukon Territory.

The capital, operating and maintenance costs are estimated for a mine mouth 3 x 70 MW (net) coal fired generating station including two possible routes and two transmission line voltages to transmit power from the site to Carmacks. The cost of fuel, mine, coal preparation plant, site access, land and land rights have not been included in the scope of this study.

No detail design has been undertaken on any part of the study. Conditions such as permafrost, extreme temperatures, freight, construction problems, etc. have been assumed. Further investigations and studies would be required to produce a more accurate estimate at this site.

2.0 SUMMARY

The levelized cost of power at the power plant has been estimated to be in the range from 35 to 37 mills/kWh.

Due to transmission line costs and power losses, the cost of power at Carmacks would be in the range of 45 to 54 mills/kWh.

Since the cost of fuel has not been a part of this evaluation, we have allowed $30 per ton of coal at the plant conveyor. The components of power cost in mills/kWh are approximately as follows (alternative 2B assumed):

Capital cost	16.6 mills/kWh
Operating and maintenance cost	2.1 mills/kWh
Fuel cost	17.9 mills/kWh
Transmission line cost	12.2 mills/kWh

3.0 PLANT DESCRIPTION

3.1 LOCATION AND ACCESS

The site selection has been limited by the detail available on 1:250,000 scale topographical mapping.

Road access and an air strip have not been included within the scope of this report.

3.2 BRIEF DESCRIPTION

The 3 x 70 MW (net) thermal plant would comprise a powerhouse, precipitators, stack, coal handling, ash handling, water treatment, circulating water system, make-up and blowdown systems, waste and sewage disposal, and various auxiliary facilities.

The steam generating plant would be of the pulverized coal fired, non-reheat type, which would supply steam to the steam turbo-generator units. The steam turbo-generators, nominally rated at 75 MW, would exhaust into water cooled surface condensers, and would be equipped with regenerative feed heating. Emergency generators would be provided for emergency power generation and/or plant start-up.

Coal from the mine processing plant would be stored and transported to the powerhouse bunkers. Natural gas or light oil is assumed to be available for heating, boiler light-up, flame stabilization and emergency power generation.

Each steam generator would be equipped with an electrostatic precipitator to remove the fly ash from the flue gas stream before the gases are discharged into a common steel lined concrete stack.

The ash would be slurried and transported to the mine tailings pond (it is assumed that this pond is available for ash disposal), if possible. The water from the tailings pond would be recycled to the ash plant.

The circulating system would consist of a cooling tower, pump-house, condenser, make-up and blowdown systems and a make-up storage reservoir.

The water treatment plant would be sized for a maximum make-up rate of 4% of the steam generator output.

The water treatment plant and other liquid waste effluents would be treated and discharged to a waste disposal pond and after treatment to the make-up reservoir.

The plant would be started and operated from a central control room.

3.3 LIST OF ALTERNATIVES

Alternative 1

- 140 MW net generated power at plant terminals for 8760 hours annually
- transmission line 240 kV and 280 miles long

Alternative 2

- 140 MW net generated power at plant terminals for 8760 hours annually
- transmission line 240 kV and 400 miles long

Alternative 3

- 210 MW net generated power at plant terminals for 7000 hours annually
- transmission line 240 kV and 280 miles long

Alternative 4

- 210 MW net generated power at plant terminals for 7000 hours annually
- transmission line 345 kV and 400 miles long

3.4 ITEMS EXCLUDED FROM SCOPE OF STUDY

The list of items not included in the scope of the study are:

- land and land rights;
- mine;
- coal preparation plant;
- coal transportation to the plant coal handling system;
- auxiliary fuel pipeline;
- access road and air strip;

- ash lagoon (assumed that tailings pond is available for ash discharge);
- fuel costs;
- any other fuel gas cleaning systems other than precipitators;
- interest during construction;
- supply of power to intermediate points between the thermal plant and Carmacks.

3.5 ASSUMPTIONS

3.5.1 Structures and Foundations

The main buildings would consist of structural steel frames clad with double skin insulated wall panels and built up roofing on a metal deck.

In the absence of detailed geotechnical information, it has been assumed that the foundations for the powerhouse, stack and main coal handling structures would be reinforced concrete slabs on forced air ventilated pad foundations. The foundations for the other structures would be drilled steel piles with an air gap between the underside of the structure and the ground.

The working area around the power plant and the coal handling system, and the access roads for the cooling water system would consist of insulated granular fill to prevent extensive thawing of the permafrost.

The granular materials required for the ventilated pad foundations, site preparation, access roads and concrete were assumed to be available in the vicinity of the site.

3.5.2 Circulating Water System

A cooling tower system has been selected for the cost estimate for the following reasons:

1. Unknown difficulties involved in using cooling pond in permafrost areas (thawing of the permafrost).

2. Available site information is not sufficient to locate a cooling pond and to determine its costs.

3. Cooling towers are economically competitive with cooling ponds and their construction can be adapted to permafrost areas more easily.

Make-up would be taken from Illtud Creek for two months of the year, and discharged to the make-up storage pond. The make-up storage pond would supply the circulating water system annual requirements. A blowdown line would transport water from the circulating water system to the make-up storage pond and to the river. The make-up and blowdown lines would be in a gravel roadway with an assumed length of 12,000 feet.

3.5.3 Precipitators

It has been assumed that high efficiency electrostatic precipitators will be required for flue gas clean-up.

3.5.4 Operating Schedule

Two alternatives of power plant utilization have been evaluated.

Alternative 1 assumes that one unit serves as a standby. The power plant output would be 140 MW (net) for 8760 hours per year.

Alternative 2 assumes typical power plant utilization; 7000 hours per year on MCR (maximum continuous rating of 210 MW).

3.5.5 Electrical Systems and Equipment

The plant electrical system is based on the unit principle which affords the greatest availability at least cost, and thus appears most appropriate to this application. Power for station services and systems, and for boiler/turbine auxiliaries during unit start-up would be supplied by the station service system. Following unit start-up, the boiler/turbine auxiliaries would be supplied from the associated unit service transformer.

At the unit rating of 75 MW, the generator voltage would be 13.8 kV, and transformed up to the transmission voltage by individual generator transformers.

Except for the larger motor drives, which would be supplied from the 4000 volt system, utilization voltage throughout the plant would be either 600 volts or 208/115 volts AC. Emergency generators would be connected to the station service 4000 volt switchgear.

The boiler/turbine/generator units, emergency generators and auxiliary power systems would be controlled from a common central control room. The coal plant would be controlled from a local control room while the ash handling and precipitators would be controlled from the boilerhouse. Wherever practicable, systems and processes would be controlled automatically, and would normally require minimal operator involvement.

3.5.6 Transmission to Carmacks

A point to point 138 kV transmission system is assumed for delivery of power from the thermal plant to Carmacks. In view of the high cost of transmission facilities, only a single circuit line is provided, i.e. the supply is not firm. To provide a firm supply, duplicate circuits with similar capabilities would be required.

Two alternative line capability requirements have been considered, namely:

1. 140 MW - corresponding to plant firm output (2 units), and

2. 210 MW - corresponding to plant maximum output (3 units).

For each of the above, two alternative line routes have also been considered, namely:

a) direct route south from plant to Mayo (over Selwyn Mountains) then follow highway to Carmacks (260 - 300 miles, 280 miles assumed), and

b) highway route west from the plant to Dempster Highway (along future plant access road) then follow highway and pipeline to Carmacks (400 miles assumed).

The first of these routes is shorter by 100 - 150 miles; however access through the mountains would be difficult, and may be neither practical nor economical from a construction and future maintenance viewpoint. The second route is the more likely particularly as the line would probably be tapped at various intermediate points along the pipeline to supply a number of compressor stations. Variations in transmission costs corresponding to alternative line capabilities and routes are based on the following assumptions.

A 240 kV transmission line is capable transmitting approximately 200 MW over 300 miles (route A), or approximately 160 MW over 400 miles (route B). Thus, 240 kV would appear to be appropriate for Alternatives 1A, 1B and 2A. To transmit 210 MW over 400 miles however (Alternative 2B) would require a voltage higher than 240 kV. The next standard voltage is 345 kV which would have a capability of approximately 320 MW over 400 miles. The line design has not been optimized at this stage.

It is appreciated that in the ultimate scheme, if a substantial part of the plant output is tapped off along the pipeline route, it may be possible to cater for full plant output of 210 MW, and still transmit at 240 kV. This would require a detailed system study at the conceptual design stage.

The cost estimates include for high voltage substations (single bus) at the thermal plant and Carmacks with one intermediate substation. Shunt reactive compensation has been assumed as 50% for route A and 75% for route B. Optimization of shunt reactor size and location, and the possible use of series compensation has not been considered at this stage, and will require further study at the conceptual design stage. Transformation from 240 kV or 345 kV to the 138 kV system is provided by two 150 MVA transformers at Carmacks (150 MVA firm).

3.6 TECHNICAL DATA

Coal

Assumed proximate coal analyses as fired:

	% by weight
Moisture	7.0
Volatiles	33.0
Fixed carbon	45.0
Ash	15.0
	100.0%
Higher heating value	9,500 BTU/lb

Heat Rates

Turbine gross heat rate (assumed)	8,900 BTU/kWh
Plant gross heat rate	10,230 BTU/kWh
Plant net heat rate	10,888 BTU/kWh

Steam Turbo-Generators (Design Data)

Steam flow per unit	620,000 lb/hr
Steam temperature	950°F
Steam pressure	1,250 psig
Turbine back pressure	2" Hga
Number of extractions	five

Steam Generators

Efficiency	87%
Feedwater inlet temperature	420°F

Mass Balance Data

	2 Units at MCR	3 Units at MCR
	(10^3 lb/h)	
Coal consumption (including rejects)	162	243
Ash rate (including rejects)	26	39
Mill rejects	2	3
Air	1,400	2,100
Flue gases	1,536	2,304

Stack and Precipitators

Height	235 ft
Flue diameter (each)	8 ft
Flue gas exit velocity	100 ft/s
Precipitator efficiency	99.5%

Circulating Water System

Heat rejected to condenser per unit	400 x 10^6 BTU/h
Circulating water flow per unit	40,000 USgpm
Temperature range	20°F
Circulating water inlet temperature (design)	70°F
Make-up rate per station (max.)	3,600 USgpm
Blowdown rate per station (max.)	1,800 USgpm

4.0 COST ESTIMATES

4.1 CAPITAL COST ESTIMATES

4.1.1 Power Plant

Table 4-1 shows a summary of the estimated capital costs of the power plant in 1978 Canadian dollars. The $213.3 million total is sub-divided into system components with a split into supply and installation elements for each system.

The accuracy range for the order of magnitude estimate is calculated to the range +30% to -10%. Thus, a contingency of +30% should be added to arrive at the maximum probable cost.

4.1.2 Basis of Estimate and Assumptions Made

The estimates for the civil and hydraulics portions of the work (mainly Divisions 1 and 2) were based on quantities derived from the information supplied and the size and location of the plant in question. Allowances were made in the estimates for both the costs of transportation of finished materials to the site and also the lower productivity of labour relative to the Edmonton area by virtue of the site location, climatic conditions and shift system likely to be employed. It was assumed that granular fill and concreting aggregates were locally available, but that site processing (e.g. washing, crushing, concrete batching) would be necessary.

The mechanical, electrical and instrumentation equipment costs were based on budget quotations from suppliers, and allowance was made for the high cost of transportation from the manufacturer to site. A productivity factor was applied to installation manhours recorded in the Edmonton area, to allow for the project and labour conditions likely to be experienced in the northern Yukon.

The general undistributed section of the estimate (Division 8) includes allowances for the detailed engineering design, construction supervision and commissioning of the plant as well as other construction indirects such as insurance, licences, temporary utilities and warehousing. Interest during construction is not included. Specific calculated allowances were made in this section for the cost of overtime premiums, construction camp costs and monthly air transportation of construction labour, all of which are considerably higher than in a comparable Edmonton area location.

4.1.3 Transmission Line

Capital cost estimate is shown on Table 4-2 with description and assumptions shown in paragraph 3.5.6.

4.2 OPERATING AND MAINTENANCE COST ESTIMATE

4.2.1 Power Plant

The operating and maintenance estimate excluding cost for fuel is based upon actual cost for a station located in Alberta, factored to suit the proposed station in the Yukon Territory.

The associated annual cost in 1978 dollars is estimated to be 2.0 mills/kWh.

4.2.2 Transmission Line

Annual operating and maintenance costs have been estimated as a percentage of capital cost:

Transmission line	3%
Substation	1%

4.3 ANNUAL COSTS AND COST OF POWER

Annual cost and cost of power are shown on Table 4-3. Levelized annual fixed charges (11% p.a.) used in Table 4-3 include for return, depreciation, income tax, other taxes and interim replacement. An allowance for insurance and a contingency for a typical power plant are also included.

TABLE 4-1

CAPITAL COST ESTIMATE

(Thousands Canadian Dollars in 1978 Price Level)

	Supply	Erect	Total
Site and Improvements	940	650	1,590
Buildings and Structures	18,840	17,040	35,880
Boilers and Auxiliaries	30,320	23,270	53,590
Turbo-generators and Auxiliaries	35,010	9,980	44,990
Electrical Systems	6,050	4,960	11,010
Control and Instruments	6,820	1,980	8,800
Miscellaneous Plant Equipment	690	220	910
Sub-Total	98,670	58,100	156,770
General Undistributed			56,570
Total			213,340
Precipitators (included above)	3,000	3,500	6,500

TABLE 4-2

TRANSMISSION LINE COST ESTIMATES

(Thousand Dollars - 1978 Price Level)

Alternative	1A	1B	2A	2B
Length (Miles)	280	400	280	400
Voltage (kV)	240	240	240	345
Capital Cost				
Transmission Line	68,600	98,000	68,600	118,000
Substations	8,900	9,600	8,900	13,500
System Engineering Studies	200	200	200	200
Total	77,700	107,800	77,700	131,700
Annual Operating & Maintenance Costs				
Transmission Line (3%)*	2,060	2,940	2,060	3,540
Substations (1%)*	90	100	90	140
Total	2,150	3,040	2,150	3,680

Note: * Percentage of Capital Cost Estimate

TABLE 4-3

ANNUAL COST AND COST OF POWER

Alternative		1A	1B	2A	2B
Generated Power (Net)	MW	2 x 70	2 x 70	3 x 70	3 x 70
Annual Operating Hours at MCR	h/yr	8760	8760	7000	7000
Annual Generated Power at Plant (Net)	kWh/yr	1226.4×10^6	1226.4×10^6	1470×10^6	1470×10^6
Transmission Line: Length	miles	280	400	280	400
Voltage	kV	240	240	240	345
Power Loss (Max)	MW	7	10	15	10
Annual Power Delivered to Carmacks (Net)	kWh/yr	1165.1×10^6	1138.8×10^6	1380.8×10^6	1411.4×10^6
Power Plant - Annual Cost					
Capital Charges(1)	10^3\$	23,470	23,470	23,470	23,470
Operating and Maintenance Cost	10^3\$	2,450	2,450	2,940	2,940
Fuel(2)	10^3\$	21,080	21,080	25,270	25,270
Total	10^3\$	47,000	47,000	51,680	51,680
Transmission Line - Annual Cost					
Capital Charges(1)	10^3\$	8,550	11,860	8,550	14,490
Operating and Maintenance Cost	10^3\$	2,150	3,040	2,150	3,680
Total	10^3\$	10,700	14,900	10,700	18,170
Grand Total	10^3\$	57,700	61,900	62,380	69,850
Levelized Cost per kWh					
At Power Plant	mills/kWh	38	38	35	35
At Carmacks	mills/kWh	50	54	45	49

Notes: (1) Annual Capital Fixed charges assumed 11% on constant (1978) Dollars; 30 year plant life

(2) Assumed fuel cost \$30/short ton at plant conveyor