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A Preliminary Analysis of Modal Selection For the Movement of Western Canadian Coal To Ontario

by Christopher J. Boon[*]

1. INTRODUCTION

THIS PAPER presents the results of a research project carried out under the supervision of Dr. R. W. Lake as part of the author's MBA program at Queen's University at Kingston. Ontario. Support was provided by a Transport Canada Research and Development Centre Research Fellowship, and by the Canadian Institute of Guided Ground Transport. The full project report is available as CIGGT Report No. 78-6.

The problem of selecting an appropriate mode, or combination of modes, for the movement of Western Canadian coal to Ontario markets has taken on a sense of immediacy in the past year and a half. Ontario Hydro has now finalized agreements for the movement of bituminous thermal coal from the Coal Valley area of Alberta and the Crow's Nest field in British Columbia via rail and lakeboat through a new transshipment facility at Thunder Bay. In 1975, the Steel Company of Canada Limited took an equity position in a metallurgical coal property in the Upper Elk River Valley, and is now involved in a new feasibility study on the property. Dominion Foundaries and Steel Limited has also acquired equity in a Western Canadian metallurgical coal property.

Although the initial eastward movement of coal will be by rail and lakeboat, consideration of longer-run alternatives is likely to become an issue of growing importance, to judge by the current political and legal battles being waged in the United States by proponents of coal-slurry pipelines as alternatives to the existing rail networks. Some work has been done on coal-slurry systems in Canada, notably a study prepared for Ontario Hydro by Shelpac Research and Development Ltd, and released in March 1975. However, these studies have either neglected to include the costs for all system components, or else have been more concerned with technical rather than economic feasibility. In particular, the gathering system required by a high-volume system, the provision of adequate supplies of water for slurry preparation, and the dewatering and water treatment facilities have been omitted or glossed over in most existing reports.

The results of these disparate approaches have been predictable. When attempts are made to compare costs of service, or tariff schedules, the uncertainties surrounding just what costs are included are frequently too great to allow any meaningful conclusions to be drawn.

If the provision of an efficient transportation network is to be realized as a national policy objective, then it is necessary that accurate and comparable cost data be available to the decision-makers. While a prefeasibility study such as this cannot pretend to offer definitive accuracy, the application of a consistent costing methodology does allow the development of comparable systems costs, and thus, in this instance, of comparable (if not complete) "tariff" schedules.

2. SYSTEMS ANALYSIS

2.1 Some General Comments

While examining the literature in preparation for this study, one particular observation kept recurring. Almost without exception, such studies as were reported exhibited a strong bias towards one mode and against all alternatives. The range of costs attributed to a given mode was quite spectacular, even allowing for inflation and cost escalation. Further, there was a tendency on the part of some authors to cost portions of the relevant system, rather than all components, then compare these partial costs to the full costs of other modes.

In analyzing the four systems initially selected for study—unit train/lakeboat, slurry pipeline/lakeboat, high-voltage direct-current (HVDC) transmission, and coal gasification—an attempt was made to follow a middle course amongst high and low estimates. This did not always prove possible.

For example, two sources of cost data were available for the HVDC system, and both apparently overstate the costs. The figures developed by Canadian Arc-

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[*] *Canadian Institute of Guided Ground Transport, Queen's University at Kingston, Ontario.*

tic Gas Study Limited (CAGSL) were derived to justify the position that there was no preferable alternative to a Mackenzie Valley gas pipeline. On the other hand, the costs developed by Ontario Hydro lack this intentional bias, but given the environment prevailing in such conservation organizations, there is a strong incentive not to underestimate costs, especially in the preliminary stages of project costing. It is much more acceptable to "save" money during the detailed design and construction phases than to risk a cost overrun.

Although it had been anticipated that the HVDC and coal gasification alternatives would not be cost-competitive, the magnitude of the difference, as shown in Figure 1, was surprisingly large—about three times that expected.

2.1.1 The Analytical Model

Since the transportation decision for bulk commodities such as coal is typically a long-term one, the use of a single "tariff" rate generated using conventional discounted cash-flow methodology is really inadequate to assess the available alternatives. The author was fortunate to have access to the DCF resource transportation "tariff" computer model, MRAIL, which offers a significant improvement over the conventional DCF approach. MRAIL assumes that the transportation tariff will not be fixed over the long term, but rather will vary so that the carrier will cover the costs of operating the system, and receive a fair rate of return on equity investment.

The program requires, as input, schedules of estimated operating costs and capital expenditures, estimates of the proceeds from the disposal of assets, and the projected annual traffic volume. As well, values must be specified for a number of model parameters, as summarized in Table 1. The values given therein are for the "base case" used for comparison of the "tariff" schedules generated by the program.

Given these parameter values, and the input data, the MRAIL program, in essence, solves the standard discounted cash flow equation, with the present value set equal to zero and the discount rate at the designated parameter value, to yield a tariff schedule which will generate adequate annual revenue over the relevant time period.

2.1.2 The Costing Methodology

To develop "tariff" schedules that are truly comparable, it is necessary to employ a consistent costing methodology. The approach selected, after some consideration, was to identify the minimum incremental capital and operating costs associated with the movement of the projected coal traffic on each system, and to use these cost estimates as the input data for MRAIL. The impact of this approach on the slurry pipeline costs is relatively small, since the bulk of this investment is purely incremental; however, the unit train alternative represents incremental traffic on what is essentially an existing infrastructure, with all the problems of joint costs and benefits that this entails. By restricting the costs to those which could not, under any reasonable set of assumptions, be assigned to other traffic, it has been possible to obtain consistent minimum incremental capital and operating costs for both alternatives. Since the lakeboat and Thunder Bay transshipment components are common to both systems, these have also been eliminated from further study, allowing the analysis to focus on the unit train versus slurry pipeline decision.

The following cost-allocation rationale was developed to handle the problem of allocating the costs of upgrading the relevant portions of the existing rail system between the projected coal traffic and other traffic moving over the same lines:

(1) Projects for other traffic were prepared.
(2) An estimate of capacity for relevant rail links was obtained.[1]
(3) Coal traffic (in trains per day in each direction) required to move the projected annual demand was allocated to each rail system.
(4) Links with capacity restrictions, inadequate siding lengths, and other limitations were identified.
(5) The CP rail-weight standards[2] for upgrading based on annual gross tonnages were adopted as a guide to the weight of rail each link should contain, based on current (1976) traffic levels.
(6) Links which would require upgrading only with the addition of coal traffic were thus identified, and these costs charged against this traffic.

The application of this rationale identified three critical links, and the upgrading costs for these were allocated to the coal traffic.

In addition, the costs of upgrading sidings and signal systems as required to handle unit train consists, and the costs of upgrading the Foothills Subdivision branch line into the Coal Valley region of Alberta, were assigned to the movement of coal. Finally, the incremental cost of upgrading the relevant CN links

ANNUAL SYSTEMS TARIFFS, PER TON OF COAL OR THE EQUIVALENT IN COAL-DERIVED ENERGY, DELIVERED TO ONTARIO FOR USE

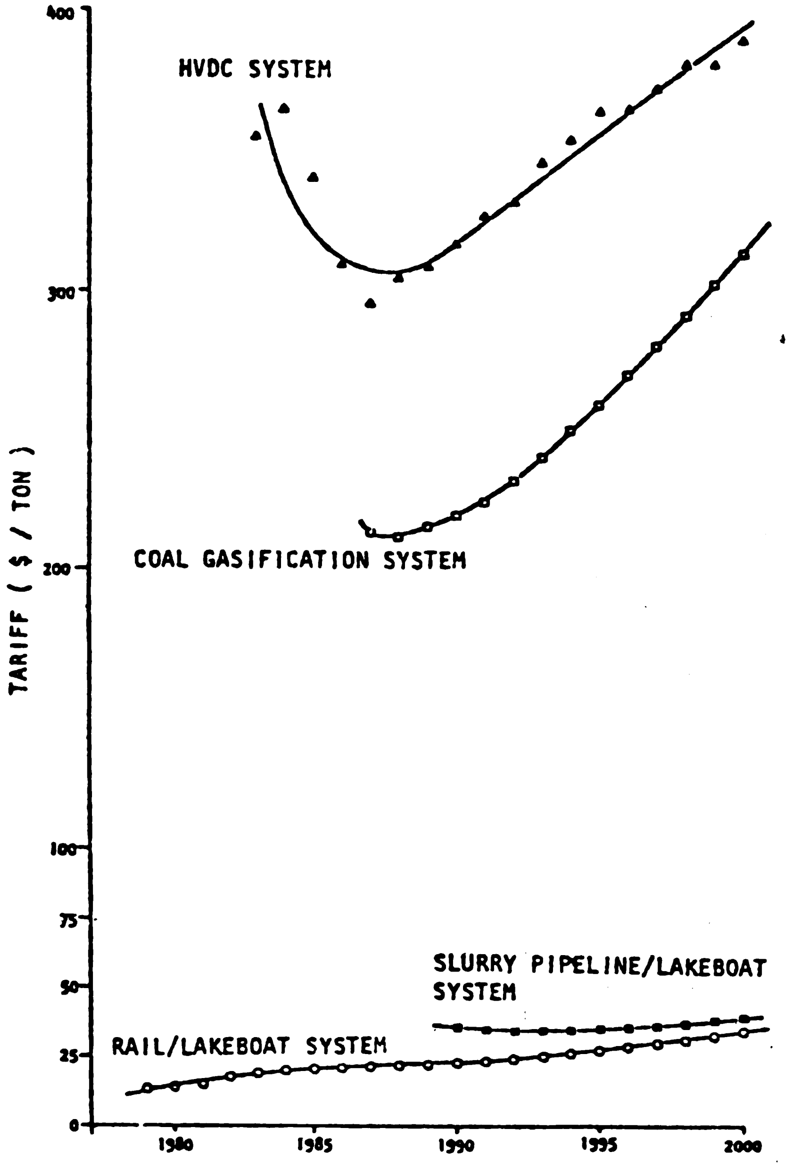

FIGURE 1

with 136-lb RE CWR, which offers a superior section and hence improved performance with lower maintenance costs under unit-train traffic, should be charged against the coal traffic, together with allowances for work on other track structures and on curves and gradient sections.

TABLE 1

BASE CASE VALUES FOR MRAIL PARAMETERS

Return on Equity:	11½%
Bond Interest Rate:	11%
Delay in Development:	0 years
Escalation Rate:	5%
Debt: Equity Proportion in Capital Structure:	75:25
Term of Debt:	30 years
Life of Capital Goods:	30 years

Capital costs for rolling stock and motive power were based on the acquisition of 100 per cent new equipment, plus spares, as required for a 145-hour cycle for CN and a 130-hour cycle for CP Rail services,[3] and no improvement in trainset productivity over the period of the study was assumed. Operating costs were developed on a purely incremental basis; incremental demand was taken to occur at the start of each year, and the additional trainsets required were assumed to be in operation for the full year.

2.2 Unit Train Costs

Table 2 summarizes the capital expenditures for roadbed and track structures, and motive power and rolling stock, for each railway, and presents the schedule of capital outlays used as input for the MRAIL program.

The operating costs for the unit train movement of coal to Thunder Bay include track maintenance costs over and above the level required by non-coal traffic, plus the actual costs of train operation, plus interference costs which were assessed at 15 per cent of total operating costs. These costs are summarized in Table 3.

2.3 Slurry Pipeline Costs

The slurry pipeline alternative is based on the system studied by Shelpac

TABLE 2

CAPITAL OUTLAYS FOR THE UNIT TRAIN MOVEMENT OF COAL TO THUNDER BAY ($1977 10^6)

	Canadian National	CP Rail	Total
Track & Structures	40.26	41.70	81.96
Rolling Stock & Motive Power	186.22	200.88	387.10
Total	226.48	242.58	469.06

Schedule of Expenditures

Year	1978	1979	1980	1981	1982	1983	1984	1985	1986	1987	1988	1989
Outlay	78.44	30.37	36.86	8.2	15.37	31.77	9.37	2.20	22.65	22.54	14.45	15.37
Year	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	
Outlay	7.17	7.20	22.54	7.17	14.34	23.60	7.17	15.37	22.57	22.54	31.76	

TABLE 3

RAIL SYSTEM OPERATING "EXPENDITURES," INCLUDING INTERFERENCE
(\$1977 10^6)

	Canadian National	CP Rail	Total
Maintenance	86 43	52.59	139.02
Operating Costs	1,115.47	1,012.96	2,128.43
Interference	180.29	159.83	340.12
	1,382.19	1,225.38	2,607.57

TOTAL OPERATING COST SCHEDULE

Year	Total Cost	Year	Total Cost	Year	Total Cost
1978	29.11	1986	82.95	1994	147.50
1979	38.04	1987	95.69	1995	164.74
1980	47.51	1988	104.14	1996	169.43
1981	47.94	1989	113.05	1997	178.43
1982	52.24	1990	117.51	1998	191.49
1983	65.35	1991	122.06	1999	203.29
1984	69.67	1992	134.75	2000	222.31
1985	70.09	1993	139.20		

Research and Development Ltd, with the addition of a gathering component to collect the coal at a central slurry preparation site near Drumheller, Alberta.[4] To maintain comparability, it has been assumed that the pipeline will be designed to handle thermal and metallurgical coal movements to Thunder Bay through the end of the century. The design would be able to accommodate a maximum annual throughput of some 30 million tons. This would require an approximately 44-inch diameter pipeline.[5]

Although such a pipeline could be constructed in as little as three years, this time assumes that all needed preparatory work has been completed, the right-of-way acquired, and the design finalized.[6] Shelpac's study is much less optimistic on this matter. The development plan proposed by that group would require eleven years from design inception through start-up. This would make the earliest start-up date sometime in 1988. Four components must be costed: the gathering network, the central slurry preparation facility, the pipeline itself, and the dewatering and water purification facility at Thunder Bay.

The capital costs associated with the gathering component include the upgrading of 402 miles of track to mainline standards, as discussed in Section 2. This will include extensive siding construction as well as improvements to the track and roadbed. It has been assumed that existing trainsets will be switched over as required, since these will be consumer-owned rather than railway-owned. Under this assumption, no new trainsets would be required before 2000.

The capital cost of a slurry preparation facility is uncertain, but historical data for similar facilities suggest costs of the order of \$0.70 to \$1.25 per annual ton of throughput. However, recent discussions have indicated that capital costs in the neighbourhood of \$4.50 per annual ton would now be more realistic.[7]

No costing or design study was available for an 1100-mile, 44-inch slurry pipeline. However, the available data indicated that a capital cost of the order of one billion dollars would be appropriate. Considering that the 1048-mile, 36-inch line proposed for the U.S. was estimated to cost \$750 million in 1975. this is probably not unreasonable.

The provision of adequate facilities to separate the coal from the water, dry it to an acceptable level of surface moisture, and decontaminate the water used in transporting the coal is crucial to the viability of a slurry pipeline system. Estimates from within the industry indicate that the cost of the dewatering facilities will be on the order of \$3.50 per annual ton, with up to an additional

$5.50 per annual ton required to provide treatment facilities for the very acidic, highly contaminated water.

Table 4 summarizes the proposed schedule of capital expenditures, while Table 5 summarizes the operating costs for the slurry pipeline alternative.

3. "TARIFF" SCHEDULES AND ANALYSIS

The cost schedules reported in Section 2 were used as the primary data input for MRAIL, together with the "base case" financial parameter defined above. Further, 30-year-old equipment was assumed to be salvageable at 5 per cent of initial cost, with the salvage value prorated over the life span of the equipment. Capital cost allowance was assumed to flow through to other corporate operations, and it was assumed that debt would be issued for all capital expenditures up to the specified proportion. Each system was assumed to operate for 30 years, with annual operating costs held constant after 2000 (in terms of current dollars). Each system was then evaluated on the basis of the "tariff" schedule through 2000. The derived tariff schedules are shown in Table 6.

Although the unit train alternative is clearly preferable through 2000, the advantage it enjoys is steadily decreasing. Further, the development of the systems "tariff" has been based on the **minimum incremental** capital and operating costs, and this approach does not consider allocated costs that would, or **could,** be charged against the service. Since the bulk of the pipeline expenditures are purely incremental, the impact of these

TABLE 4

ANNUAL CAPITAL EXPENDITURES — SLURRY PIPELINE ALTERNATIVE ($1977 10^6)

Project Year	1978	1979	1980	1981	1982	1983	1984	1985	1986	1987	1988
Annual Expenditure	11.00	16.21	24.91	41.28	55.02	76.36	69.98	98.26	279.22	508.25	302.73
Cumulative Expenditure	11.00	27.21	52.12	93.40	148.42	224.78	294.76	393.02	672.24	1180.49	1483.22

TABLE 5

TOTAL ANNUAL SLURRY PIPELINE OPERATING COSTS ($1977 10^6)

Year	Gathering	Slurry Preparation	Pipeline	Dewatering	Total	Total Tonnage (in tons 10^6)	Average Cost/Ton
1989	28.38	13.34	30.00	21.63	93.36	14.32	$6.519
1990	28.38	15.51	30.00	23.26	97.15	15.50	$6.268
1991	31.00	16.55	30.00	24.73	102.27	16.59	$6.165
1992	31.00	17.44	30.00	25.98	104.42	17.54	$5.953
1993	33.56	18.71	30.00	27.94	110.21	18.92	$5.825
1994	36.18	19.83	30.00	29.26	115.27	20.12	$5.729
1995	38.60	21.00	30.00	30.86	120.45	21.38	$5.634
1996	41.22	22.38	30.00	32.74	126.33	22.88	$5.521
1997	43.78	23.91	30.00	34.81	132.50	24.56	$5.395
1998	46.40	25.52	30.00	36.98	138.90	26.32	$5.277
1999	46.40	27.37	30.00	39.52	146.10	28.32	$5,159
2000	49.02	28.78	30.00	41.48	149.28	29.78	$5.013
Total					1,436.24		

TABLE 6

TARIFF SCHEDULES FOR MOVEMENT OF COAL TO THUNDER BAY ($/ton)

Year	Unit Train	Slurry Pipeline	Difference
1978	9.162	---	---
1980	11.700	---	---
1982	12.964	---	---
1984	13.914	---	---
1986	14.743	---	---
1988	16.172	---	---
1989	16.837	31.368	14.531
1990	17.531	30.389	12.858
1992	18.994	29.464	10.470
1994	20.797	29.140	8.343
1996	22.851	29.554	6.703
1998	24.969	30.510	5.541
2000	27.514	32.101	4.587

allocations on the competitiveness of the unit train alternative is the central issue.

In this context, the answer is relatively clear. The incremental analysis developed a basic "tariff" rate which provides for the recovery of all direct capital and operating costs, plus a reasonable rate of return on the marginal investment. However, in pricing the service to the shipper, the railways would set the highest rates that would capture the traffic and satisfy regulatory considerations, with the additional revenue providing a contribution to system fixed costs (overhead) and possibly a margin of real economic profit.

To ascertain the sensitivity of the above results to the various study assumptions, analyses with different parameter values and cost estimates were undertaken. The range over which each input was varied is summarized in Table 7.

The transportation decision proved to be relatively insensitive to variations in the base case financial parameters. However, since it is entirely conceivable that both capital and operating costs were overstated or understated, the sensitivity of the decision to total cost was examined. Figure 2 shows the sensitivity of the tariff schedules to this simultaneous variation in total costs. If the total costs

TABLE 7

SUMMARY OF BASE CASE AND SENSITIVITY PARAMETER VALUES

Parameter	Base Case Value	Sensitivity Value(s)
Debt/Equity Ratio	3.00	1.50, 0.00
Bond Interest Rate	11%	8%, 9%, 10%, 12%, 13%
Return on Equity	11½%	0.00,7½%,8½%,9½%,10½%,12½%,13½%,14½%,20%
Delay in Construction	0	4 yrs
CCA Flowthrough	yes	no
Salvage Included	yes	no
Cost Escalation	5%	10%
Capital Costs	100%	125%, 75%
Operating Costs	100%	125%, 75%
Total Costs	100%	125%, 75%

TARIFF SENSITIVITY TO CHANGES IN TOTAL SYSTEMS COSTS

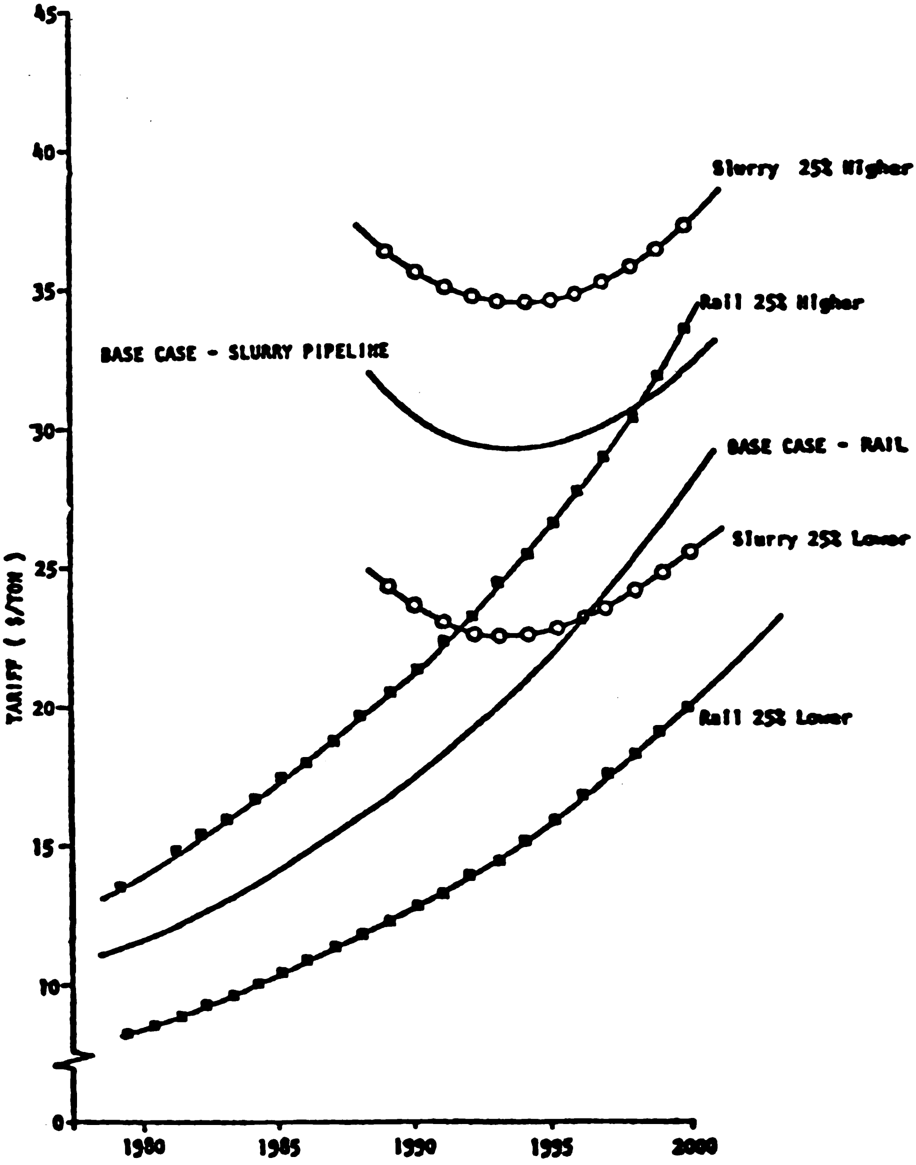

FIGURE 2

for rail were to increase by 25 per cent, while the total costs for the slurry system were to decrease by 25 per cent, then the decision would be reversed. This is certainly not the only combination of changes that would result in a decision reversal, but it is typical.

4. CONCLUSIONS

The objectives of the current National Transportation Policy, as set forth in Section 3 of the National Transportation Act (NTA), might be summarized as "the maximization of net economic benefits to the nation, without particular regard for the distribution of these benefits."

In this context, the preceding analysis indicates that the railway system is preferable. In the existing regulatory environment, however, pricing considerations may well prompt shippers and consumers to opt for the slurry pipeline alternative. It could be user-owned and controlled, and would offer substantial shelter from the impact of operating cost escalation.

A central issue must be addressed at the policy level. How can the economic benefits accruing to the nation from the adoption of the unit-train system best be captured, without penalizing shippers or consumers, on the one hand, or further interfering with the operation of a free enterprise railway system, on the other?

FOOTNOTES

[1] As given by J. Jardine, Chief Engineer, Maintenance, CP Rail, 18 October 1976, to Princeton University Track Course.

[2] "A Conceptual Basis for Estimating Rail Line Productivity and Capacity," J. A. Macdonald, C. Schwier and E. R. Petersen, unpublished CIGGT report No. 76-4, May 1976.

[3] "Coal Power for Electric Utilities," L. F. Kirkpatrick, President, Nova Scotia Power Corporation, in Proceedings of the 28th Canadian Conference on Coal, 26-28 September, 1976, p. 78.

[4] "A Coal Pipeline System, Western Canada to Ontario," prepared by Shelpac Research and Development Ltd., March 1975.

[5] "Economics of Slurry Pipeline Systems," T. C. Aude, T. C. Thompson and E. J. Wasp, Proceedings of the 15th Annual Meeting, Transportation Research Forum, 1974.

[6] "Economic Comparison of Rail and Slurry Pipeline for the Domestic Movement of Western Canadian Coal to Central Canadian Markets," G. M. McLaughlin, Bulk Freight Division, Canadian Transport Commission, Report No. 128, 1974.

[7] F. W. Pemel, P. Eng., personal communication, March 1977.