COST ANALYSIS OF FOUR ALTERNATIVES FOR HAULING COAL FROM THE PROPOSED OTHELLO MINE

For the Jackson Mining Company
Grand Forks, British Columbia

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EXECUTIVE SUMMARY

The proposed Othello mine has an expected annual production of 5 million tons. The mine requires a cost-effective method of transporting the coal from the mine site to the mainline railroad.

Four suggested alternatives were analyzed, considering various interest rates and study periods:

1. Diesel trucks
2. Diesel trains
3. Electric trains
4. Electric fleets

Capital costs and annual operating costs were determined for each alternative, and combined to form an Equivalent Uniform Annual Cost. Figure 1 shows the results for the preferred interest rate of 6%.

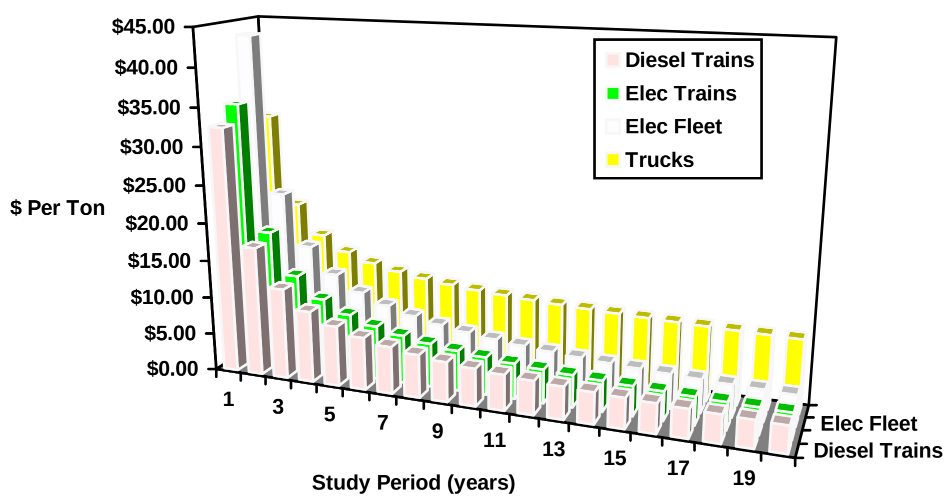

Figure 1. EUAC for alternatives at 6%

Diesel trains and electric trains were the two preferred alternatives. The EUAC calculations revealed that the cost curves for diesel trains and electric trains cross at different points, depending on the interest rate. At an interest rate of 6%, the curves cross at 12 years. Therefore, from 1 to 12 years, diesel trains are preferred, and after 12 years, electric trains are preferred. This crossover year increases with increasing interest rates.

Therefore, if both the study period and the interest rate are known to the investors, the preferred alternative can be chosen from the calculations provided in this report. Other factors may affect the investors' choice of transportation for Othello mine coal, but these factors are outside the scope of this report.

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1.0 INTRODUCTION

1.1 The Situation

The Jackson Mining Company has discovered a high-grade coal deposit in the mountains about 95 kilometers due north of Grand Forks, British Columbia. The company expects the market for this grade of coal to increase dramatically in the near future, and thus anticipates developing the deposit if development costs and transportation costs are acceptable. Jackson Mining has tentatively named its proposed mine site the Othello Mine. MMT Consulting has been authorized to determine the most cost-effective method(s) of transporting the coal from that mine site to the mainline railroad, a distance of approximately 80 kilometers (Jackson Mining, 1999, p.16).

Four transport alternatives will be considered in the following analysis:

1. Diesel trucks
2. Diesel trains
3. Electric trains
4. Electric fleets.

The criterion used to evaluate each option is the Equivalent Uniform Annual Cost (the EUAC).EUAC is a cost measure that considers startup (capital) costs as well as annual operating and maintenance costs. The EUAC discussed in this report is in dollars per ton, or how much it costs to haul one ton of coal from the mine site to the railhead.

The alternatives will be studied over study periods ranging from one to twenty years, and at interest rates varying from 6% to 10%. A short evaluation of each alternative's capacity to handle an increase in production is also provided.

1.2 Limitations

All calculations and recommendations are based on the assumption that fuel and electricity costs will remain constant or comparable throughout the study period.

1.3 Background

The Othello mine under study has anticipated coal sales of 5 million tons annually (Jackson Mining, 1999. p. 6). Each of the following transportation alternatives would have to handle this volume. Also, the ability to expand in the future would be an asset.

1.3.1. Diesel trucks

The CAT 777B truck was chosen for this study because of its load capacity of 95 tons and its power output of 920 horsepower. These trucks would be running 24 hours a day.

1.3.2. Diesel trains

Each train would be running with 6 diesel engines and 98 coal cars. It takes 11.2 hours to complete a round trip, and the time it takes to produce the amount of coal the train hauls is 17.2 hours. Thus, the train would haul a complete load and then idle for about 6 hours until the next load was ready.

1.3.3. Electric trains

Each train would run 4 electric engines and 98 coal cars. The haul times are the same as quoted for the diesel train.

1.3.4. Electric fleets

Each fleet would consist of three of the above electric trains. The first train is loaded and sent off. While it is en route, the second train is loading, and this load-and-go process is repeated for the third train. The departures would be timed so that the second train leaves just as the first train crests the highest point of the pass through which the rail line runs. This would also be repeated for the third train. In this way, the electricity generated by the first and second trains on their downgrades could be conserved and used to assist in powering the second and third trains on their upgrades.

Four sidings would need to be constructed in order to allow the outgoing and returning trains to pass each other. However, these sidings are proposed for options 2 and 3 as well.

Complete specifications for all four alternatives can be found in Appendix G.

2.0 COST ANALYSIS

Data has been collected for the capital costs and for the annual operating costs for all alternatives. Much of this data is available in Merrill Lynch's industrial guides (Jacobs, 1994, pp.140-175 and Ringness, 1998, pp. 242–63).

2.1 Annual Costs

The annual costs involve three main components:

1. fuel
2. labour, and
3. maintenance.

2.1.1 Fuel consumption

Fuel consumption is a major factor because of the large amounts of energy required to transport 5 million tons coal annually. Calculating fuel requirements is complicated—Appendix A contains the full breakdown of fuel calculations for the alternative hauling methods. Such calculations are based on the total resistance faced by a particular method of hauling the coal. For an example of how total resistance is calculated, see Table 1, which calculates the resistance for diesel trucks on the proposed road.

Table 1. Tractive and Grade Resistances for Diesel Trucks

Section	**Grade** (%)	**Truck Wt** (ton)	**Load Wt**	**Total Wt**	**Rt** (lb)	**Rg**	**Tr**
G	2.0	66.3	95.0	161.3	16125.0	6450.0	22575.0
F	1.8	66.3	95.0	161.3	16125.0	5805.0	21930.0
E	2.0	66.3	95.0	161.3	16125.0	6450.0	22575.0
D	2.1	66.3	95.0	161.3	16125.0	6772.5	22897.5

The first column in Table 1 lists the sections into which the road has been divided for analytical purposes. These sections of road have varying grades. Grade resistance (Rg) and tractive resistance (Tr) are found for each section. (Sample calculations for these are given in Appendix E.) The calculated total resistance (Tr) is then used in the next table.

Table 2. Speed, Power, and Fuel Consumption for Diesel Trucks

Section	**Grade** (%)	**Tr** (lb)	**Power** (hp)	**Speed** (mph)	**Dist** (mi)	**Time** (hr)	**BTU** (x1000)	**Fuel** (gal)	**Total**
G	2.0	22575	920.0	12.55	8.4	0.67	1572.5	11.34	42.62
F	1.8	21930	920.0	12.92	7.2	0.56	1309.3	9.44	35.49
E	2.0	22575	920.0	12.55	5.4	0.43	1010.9	7.29	27.40
D	2.1	22897.5	920.0	12.38	4.8	0.39	911.4	6.57	24.70

As in Table 2, the speed for each section is calculated, given the maximum power output of the alternative, to a maximum of 50 kph. The distance and time are then calculated and used to find total BTU per section of road. Finally, the total fuel consumed per section is determined; this depends on the fuel efficiency of that transportation alternative. All the calculated values for the various sections of road are added together to find the fuel consumed per trip. Then, given the cost of fuel, a total cost per trip is found.

2.1.2 Labour

The next component of annual cost is labour. The method used to calculate labour differs from the trucks to the trains. Since the trucks are assumed to run 24 hours a day, the total hours per year is multiplied by the number of drivers and further by their hourly wage rate. In the other approach, the time per trip for the trains was calculated. That figure was multiplied by the number of engine staff and train persons needed, and further by their hourly rate. The results of these calculations can be found in Appendix B.

2.1.3 Maintenance

This third component of annual operating costs can be further divided into unit maintenance and road maintenance. Road or rail maintenance is given as a cost per kilometer, and then multiplied by the total distance covered. The results of these calculations appear in Appendix B.

2.2 Capital Costs

Capital costs for each of the four alternatives consist of:

1. cost of the transportation units
2. cost of construction, and
3. cost of communication systems.

2.2.1 Transportation units

The number of required units was found by taking the annual output of the mine and calculating the number of units that would haul the coal with the maximum efficiency. It was found that 30 diesel trucks and trains of 98 cars were needed. Seven extra trucks would be purchased, to allow for expansion and also to allow trucks to be taken off the road for maintenance.

2.2.2 Construction costs

Construction costs can be determined by examining three main factors:

1. road and rail construction
2. the maintenance building, and
3. electrical installations (where applicable).

Road and rail construction were found by multiplying the cost per kilometer by the total distance covered. For the rail alternatives, the costs of switches, loops, and sidings must be added. Overall, then, the railroad construction costs outweigh road construction costs by more than $45 million. In the case of the maintenance building costs, the truck maintenance facility would be $1.6 million more than the building required for the train options.

The two electric train options involve an additional expense—they require an electric installation, at a cos

2.2.3 Communication systems

This is the third main component of the capital costs for this project. Such a system is necessary to control the movements of any of the four alternative transportation methods, so the same figure has been used for all four alternatives. A Global Positioning System, on-board computers and two-way radios make up the complete system.

2.3 Cost Comparisons

The costs for the four alternatives are provided in Table 3, below.

Table 3. Capital and Operating Costs

Option	Capital Costs	Annual Operating Costs
Diesel Trucks	$115,539,000	$38,027,700
Diesel Trains	$149,083,000	$4,574,400
Electric Trains	$161,783,000	$3,061,000
Electric Fleets	$201,463,000	$2,766,600

Table 3 makes it clear that there is a direct correlation between the two cost parameters: the more expensive the system is to purchase and install, the less it will cost to operate. However, the investors must also consider the cost of borrowing the required capital funds. This expense, which can be considerable, is factored into a comprehensive comparative tool called the Equivalent Uniform Annual Costs; this measure is discussed next.

2.4 Equivalent Uniform Annual Costs

Once the capital and annual costs are found, they can be combined with varying interest rates and study periods to calculate tables of Equivalent Uniform Annual Costs (EUAC). The purpose of converting all costs into an EUAC is to provide a common means of comparing all the alternatives. The capital costs are spread over the length of the study period, and added to the annual costs. Thus, a comparison of EUACs will yield a qualitative assessment of the alternatives to go with the quantitative assessment suggested by Table 3 (Winters, October 7, 1999).

Figure 1 on the following page gives a graphic representation of EUAC for the four alternatives, with study periods ranging from one to twenty years, and at an interest rate of 6%. The format of the graph makes it easy to compare the four alternatives at this interest rate. For example, at an interest rate of 6% diesel trains provide the most cost-effective method of transporting coal from the mine for study periods from two to twelve years.

The sharp decline in EUAC after the early study periods reflects the fact that the capital costs are being spread over longer and longer study periods. For shorter study periods, the capital costs play a larger role in determining EUAC, while for longer periods the annual operating cost is the more significant determinant. A full summary of EUAC for interest rates of 6%, 7%, 8%, 9%, and 10% appears in Appendix D.

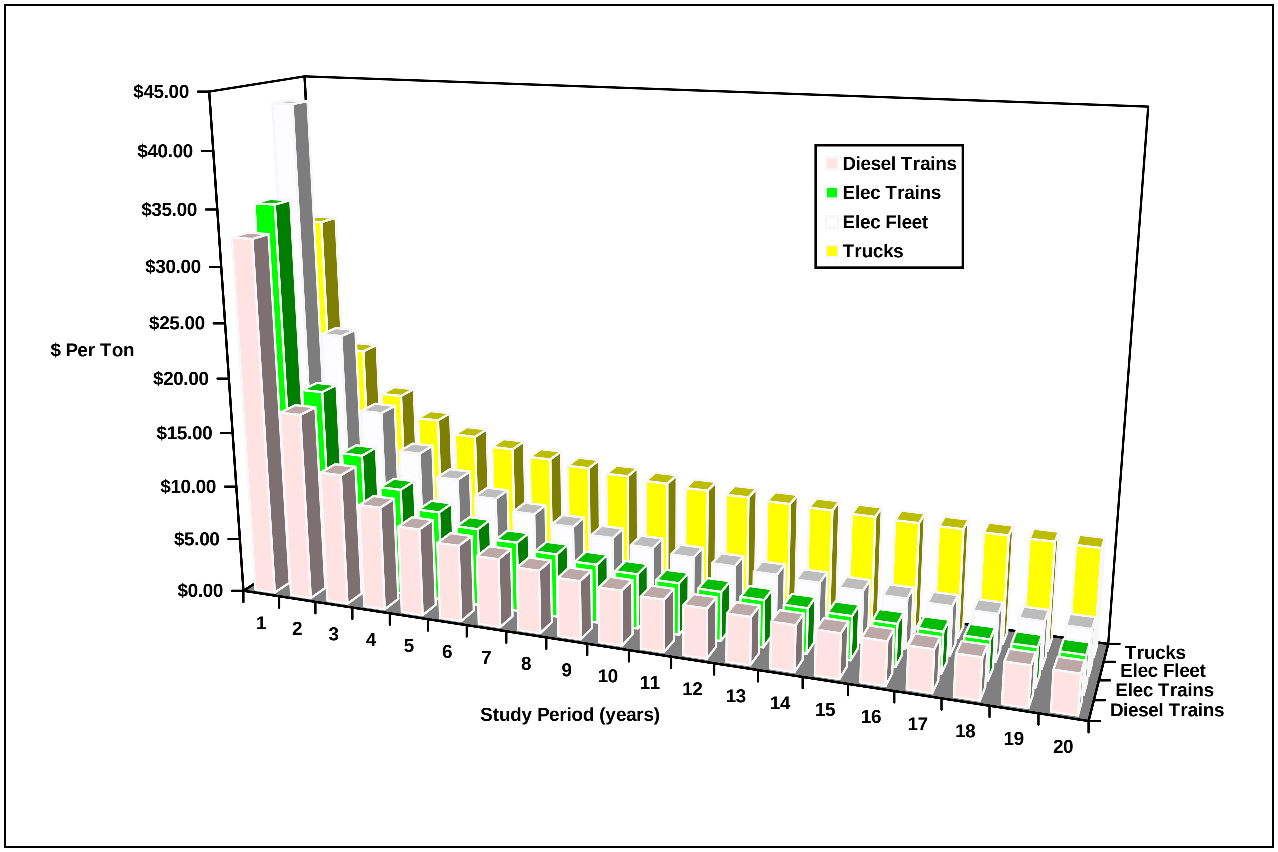

Figure 1. EUAC for four alternatives at 6%

3.0 POTENTIAL FOR EXPANSION

Market conditions or additional discoveries of coal seams may result in mine expansion. If this proves to be the case, it would require an increase in the transportation of coal. Thus, it is prudent to examine each transport alternative's potential for expansion.

3.1 Diesel Trucks

In order to protect against breakdowns, 37 diesel trucks would be purchased, although only 30 are needed to effectively haul the coal from the mine site at a time. This leaves seven trucks for immediate expansion. In other words, an immediate increase of 23.3% could be achieved. Also, it is very easy for a trucking system to grow with the mine, because one or two additional units can readily be purchased as needed.

3.2 Diesel and Electric Trains

It takes both the diesel and electric trains 11.2 hours to complete a round trip, while it takes the mine 17.2 hours to produce enough coal for a full load. Therefore, six hours are spent idle, waiting for the next load. This leaves room for a 53.5% increase in production. Increases past this amount would result in either adding more cars and engines to the trains, or switching to fleets of trains. Both of these are expensive capital options.

3.3 Electric Fleets

It takes the electric fleets 22.4 hours to complete a round trip, while it takes the mine 51.6 hours to produce enough coal to for a full load. Therefore, 29.2 hours are spent idle, waiting for the next load. This leaves room for a 130% increase in production. Increases past this amount would result in either adding more cars and engines to the trains, or adding more fleets. Again, this involves expensive capital options.

4.0 CONCLUSION

The tables in Appendix D (pages 31–41) contain the Equivalent Uniform Annual Cost values for the four options at varying interest rates. Using the EUAC method clearly shows that the diesel and electric train options give much better results than the diesel trucks and the electric train fleets.

However, it's not easy to choose between the diesel train and electric train options, as the following tables show. The diesel train option is the better alternative for the first 12 or so years, after which the electric train option becomes slightly better.

Table 4. Diesel Trains as Best Alternative

% Interest rate	Study period (yrs)
6	1 to 12
7	1 to 13
8	1 to 14.5
9	1 to 16
10	1 to 19

Table 5. Electric Trains as Best Alternative

% Interest rate	Study period (yrs)
6	1 to 12
7	over 13
8	over 14.5
9	over 16
10	over 17

Although Tables 4 and 5 show that the diesel train option has a slight overall edge in EUAC, the figures throughout the study periods are quite close. For more details of just how close these figures are, see the following appendices.

In any event, the choice between diesel and electric trains may depend on additional factors, not just transportation cost analysis. One prime consideration will be how long the investors plan to operate the mine. This in turn will depend on factors such as the continuing quality of the coal deposits, the market demand, and the market price of coal. Other criteria might include the availability of diesel fuel or electricity, expected fuel or wage increases, or environmental concerns.

These additional factors are beyond the scope of this report and must be decided by the investors.

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APPENDIX A: FUEL CONSUMPTION CALCULATIONS

Note: for purposes of this example, only page 11 has been included.

APPENDIX B: ANNUAL OPERATING COSTS

Note: for purposes of this example, only page 20 has been included.

APPENDIX C: CAPITAL COSTS

Note: for purposes of this example, only page 25 has been included.

APPENDIX D: EQUIVALENT UNIFORM ANNUAL COSTS

Note: for purposes of this example, only page 30 has been included.

Note: The following Appendices have **not** been included in this example:

- Appendix E: sample calculations re: the energy consumed by the four transportation alternatives
- Appendix F: mine site topographic maps
- Appendix G: unit specifications for the four transportation alternatives