CHAPTER 3
COAL DELIVERY OPTIONS AND COSTS

To date, as shown in Chapter 2, inadequate reserves of coal have been identified to support a 50 MW power station. Therefore, we are unable to provide a cost estimate based upon a coal reserve such that a reasonable level of confidence can be placed in the feasibility study for a 50 MW power station. Inadequate information exists to support the economic analysis of a coal-fired power station fuelled by domestic coal reserves. The reserves to support this power station simply are nowhere near the quantities required such that even a reliable conceptual cost estimate of coal mining and delivery can be determined.

Nonetheless, given the information available an estimate of the range of costs for a power station can be estimated. The potential for importing coal from known suppliers within the region to provide a more reliable imported coal cost estimate can also be determined.

3.1 COST ESTIMATE FOR DOMESTIC COAL

Armenia has low quality coal occurring in thin coal seams under geologically complex conditions. The coal deposits investigated so far by Armenian and U.S.G.S. professionals show small deposits with coal resources that hold little promise to develop mineable economic reserves. The coal seams tend to be thin and erratic in nature. These conditions generally preclude underground mining methods. The use of underground mining methods is also restricted because the complex structural conditions that exist include intense faulting and folding. For deposits that have been explored adequately enough to assess the resources from a mining perspective, it is expected that surface mining along coal outcrop areas would be a satisfactory method. Because seams explored so far are thin and the coal dips down rather quickly in these deposits, surface mining would generally be restricted to surface contour-haulback methods.

Surface contour-haulback methods open up a narrow strip of coal along the outcrop of the coal so coal seams can be mined for market. Often the widths of the pits to mine coal such as that found in Armenia are narrow and range from 30 to 90 meters in width, depending on the seam thickness, quality of the coal, overburden thickness, ground slope, and mining economics. Of the conditions observed so far in the coal resource areas, the ground slope increases upward in the area of coal outcrop such that the width of the mining pit around the outcrop is even more limited. If conditions are found to exist wherein the ground slope approximates the dip of the coal so that a relatively thin overburden thickness exists over a broad area, then significant resources of coal could be a candidate for reserves to support a coal-fired power station. Unfortunately, these conditions have not yet been found to exist in the hilly conditions of Armenia.

Therefore, it will be necessary to find an extensive outcrop length and/or thicker coal seams to develop the needed reserves. Consequently, a reasonable assumption for the likelihood of low-cost reserves for a coal-fired power station in Armenia is a contour-haulback type of surface mine. Because reserves of this type of mine are dependent upon a fairly narrow pit width that is influenced by maximum economic stripping ratios, the cost of coal produced at a typical mine site can be roughly estimated.

In the U.S.G.S. evaluation of the Antaramut coal deposit, a mining engineer was commissioned to develop a pre-feasibility study for one million tonnes of coal. This study[1] concluded that a contour-haulback surface mining method would be feasible and developed a cost estimate based on local mining equipment, resources, and labor. Local assistance in developing costs for this study was provided by the Republic of Armenia State Committee on Reserves. In Hagler Bailly's opinion, this work is the most reasonable estimate for planning purposes. The costs estimated by the U.S.G.S. are summarized in Table 3-1.

Table 3-1
Theoretical Minimum Delivered Domestic Coal Costs Per Tonne (1)

Total Mining Cost	$15.11
Proposed Profit	$3.77
Total Mine Cost Delivered on Rail	$18.88

Note:
(1): Source: p. 33 U.S.G.S report referenced in footnote.

These costs represent a small mining operation wherein production is expected from contour-haulback and auger mining operations producing a total of about 40,000 tonnes per year. Larger mining operations would have lower fixed and unit variable costs and as such could be more economic. However, with the need to increase reserves it is likely that stripping ratios would increase and mining costs would subsequently increase as well. Given that a better geologic model upon which to develop a theoretical mining cost is not available, this is the best assessment for the lower mining cost estimate, for the time being.

These costs were calculated in the fall of 1999 and converted to U.S. dollars at a rate of 540 drams per U.S. dollar and can be assumed to be appropriate for a constant dollar analysis. Given the likely mining conditions found to date and potential for new coal deposits in Armenia it is reasonable to estimate this cost represents the lower boundary for the range of costs that could be expected for Armenian coal production. Because adequate coal reserves to support a 50MW power station have not been identified, only a FOB-rail price range of $18 to $50 per tonne can be employed to predict the likely cost of fuel for the power station. A positive economic rate of return for the power station can be expected to lie within the lower portion of this range of costs.

[1] Potential Mineability and Economic Viability of the Antaramut-Kurtan-Dzoragukh Coal Field, North-Central Armenia: A Prefeasibility Study, Douglas W. Huber and Brenda Pierce.

In order to evaluate delivered coal prices, it is assumed that coal would be delivered from a location such as the Antaramut area that has local rail access. We can then project the rail transportation cost components can then be projected. The rail haulage cost per tonne-kilometer, for bulk materials, were quoted by Armenian transportation officials as equivalent to $0.024, assuming a 540 dram exchange rate.

It is assumed that the power station would be located in Hrazdan because this location provides significant reductions ($20 million) in the construction of the power station at this site. The Hrazdan power station complex provides pre-investment from other facilities that can be used by a coal-fired fluidized bed power station. Economic analysis shows that the initial capital investment of the power station is the single most important variable in the economic viability for the project; thus, the reduction of capital for the power station guides the site selection.

The rail haulage distance from the Antaramut project to the Hrazdan power project is estimated to be about 300 kilometers. With the $0.024 per tonne-kilometer unit haulage cost assumption, the transportation cost to Hrazdan from the Antaramut project is $7.20 per tonne. By assuming the FOB $18.00 to $50.00 per tonne cost to produce coal as a reasonable cost of coal in Armenia, the Hrazdan delivered theoretical cost of coal is $25 or $57 per metric tonne. Given the available information about the coal deposits, this range of figures cannot, at present, be narrowed further.

To estimate coal quality, information from the Antaramut coal deposit was used. The reserve quality shown in Table 2-3 was used and equal thickness of both seams was assumed. During mining, it is assumed that two inches of non-coal material is added to both the seam top and bottom such that the ash content of the coal is increased. This is a normal occurrence in mining operations and is dependent upon the characteristics of the geologic contact between coal and non-coal materials as well as the skill of the mining workers.

Considering these resources and the effects of mining dilution on thin seams, we recommend a coal with the characteristics shown in Table 3-2 is employed as a typical domestic coal product specification delivered to a coal-fired power station (until more specific information becomes available). It must be understood that this is a theoretical coal quality and represents the best available information to approximate typical deliveries, if they were economic. The coal is delivered in the run-of-mine, or raw, state and that it has not been beneficiated in any way.

Table 3-2
Recommended Assumptions for the
Quality of Domestic Coal Delivered to an Armenian Power Station

Quality Characteristic	Units	Value
Calorific Value – As Received Basis	Kcal/kg	4,100
Ash Content – As Received Basis	%	50
Moisture Content – As Received Basis	%	5.1
Sulfur Content – As Received Basis	%	3.0
Volatile Matter – Dry Ash Free Basis	%	25.5

3.2 COST ESTIMATE FOR IMPORTED COAL

The efforts to date to find a domestic coal reserve base in Armenia have not identified a reliable resource. As the domestic coal potential dwindles, an alternative that appears reasonable is the development of a foreign coal source or a foreign power source supplied by foreign coal. One source within the region is the Georgian coal mine, Tkibuli, near the city of Kutaisi in western Georgia.

The Tkibuli mine is actually a complex including the Imereti, Mindeli, and Western 2 underground mines. There are older mines on the property that have been in production for several decades. Between the years 1960 and 1985, production ranged from 1.2 to 1.4 million tonnes per year but decreased to 700,000 tonnes by 1991. The three mines referenced have A, B, and C1 coal reserves of about 90 million tonnes while there are future resources of about 230 million tonnes, some of which may be mineable and economical.

This mine appears to have at least 60 million tonnes of coal reserve that could be sold on the open market. They currently are facing an extremely lackluster market due to the regional economic problems. The mine is working a rather thick section of coal on the flank of a synclinal (bowl-shaped) coal deposit. Future production capacity of the mine has been estimated to be between 500,000 and 1,000,000 tonnes per year but currently is selling less than 50,000 tonnes per year. The total coal seam thickness being mined is approximately 15 to 30 meters thick and is separated by up to five non-coal intervals which range from one to 3.5 meters thick.

Current mine plans call for the production of coal necessary to support a 125 MW coal-fired power station. Station construction is visualized such that commercial operations could commence in year 2003. The mine employs a modified caving method with continued mining operations down-dip from mined-out operations. They are said to require about $20 million in capital in order to restart the mine at levels to support the 125 MW power station. The capital required includes equipment for operations such as conveying, ventilation, rail haulage, drilling, electrical, and hoisting.

The produced coal has a lower-calorific value of 4,000 - 4,500 kcal/kg, a sulfur content of 1.0 – 1.5%, and an average ash content of 30 - 35%, on an as-received basis. It might be reasonable to expect this coal could be sold FOB at the mine for a price of roughly $30 to $35 per tonne.

The cost of delivered Tkibuli coal to the Hrazdan site can be estimated because the coal can be delivered by rail from Tkibuli to Hrazdan. The exact condition of the rail along the route is not known but it is operable and used, for the most part. There are sections where the rail bed requires improvement. The rail distance from Tkibuli to the Armenian border near Sadakhlo, Georgia is estimated at 260 kilometers and the distance from that point to Hrazdan is estimated to be 360 kilometers. The Georgian bulk cargo rate is $0.017 per metric ton-kilometer and the Armenian rate is $0.024 per metric tonne-kilometer. The Georgian component of rail transport would be $4.42 and the Armenian component would be $8.64 for a total estimated freight cost of $13.06 per tonne. No international taxes or custom fees are included in this estimate.

The likely cost of purchasing coal from the Georgian Tkibuli mines is $30 to $35 and the rail freight is $13 for a total delivered cost FOB Hrazdan of $43 to $48 per tonne. If one assumes the lower figure of $43 per tonne and the calorific value of 4,300 kcal/kg, this coal, on a delivered energy basis at the plant would cost $10.00 per million kilocalories or $2.44 per million British Thermal Units. This coal could be considered as somewhat expensive due to the lower quality of coal involved but still represents a reasonable alternative to respond, in some part, to the energy security issue.

The quality of coal from the Tkibuli mine is similar to the quality of coal that might be achievable from Armenian mines. It is possible that the coal could be beneficiated at Tkibuli but beneficiation tests as well as mine investment are necessary to produce coal from this complex. Given the potential to produce coal from Tkibuli for an Armenian coal-fired power station, as part of an alternative energy source, or strategic back-up for local coal, assuming one million tonnes of production per year is possible, the Georgian plant has the potential to support a 150 MW power station. If this alternative appears to be a reasonable way to diversify energy sources to enhance energy security, power costs might be cheaper if a power station were constructed at the Tkibuli mine site and power were shipped by wire rather than resorting to the higher costs of coal transport.

The possibility of using Tkibuli coal in a Georgian power station could also realize improved economics if a power station site near rail at the border near Sadakhlo was deemed to be feasible. The cost of coal (lower range) at that location could be significantly reduced to the $35 per tonne level, rather than the $43 per tonne level. This option is obviously worth considering but requires suitability for the power station siting.

The Tkibuli mine in Georgia should be considered as a source of coal for an Armenian coal-fired power station; thus, it is recommended a pre-feasibility study be developed to analyze this option in more detail. Furthermore, the option of placing the power station at the mine site in Georgia and transmitting the power to Armenia should also be reviewed in an attempt to improve the economics of the facility.

3.3 POWER PLANT SITING OPTIONS

Power station siting options within Armenia to date include the Hrazdan and Vanadzor sites. The site at Vanadzor has been discounted because the site does not meet space requirements, does not have well developed support infrastructure and has no need for electricity/heat demand in that area. In addition, this site has since been sold to a private Russian entity. No other options have been considered for the siting of the 50 MW power station.

One technique often used to enhance the competitiveness of a power station is to site the power station near the mine in order to reduce the transportation cost component of the delivered fuel price. This technique is even more desirable as the ash and moisture content of the coal increase. Because much of the coal evaluated in Armenia appears to be of high ash, it is possible that a mine-mouth power station may make economic sense. The difficulty at this point in the investigation of coal resources is that adequate reserves have not been found to justify the siting of a power station in a mine-mouth fashion.

In order to provide some level of guidance on this issue, a site such as Antaramut could provide an acceptable quantity of coal upon which a mine-mouth power station could be justified. The economic alternatives for the price of delivered coal, comparing truck haulage to a mine-mouth power station versus rail haulage to an off-site power station is shown in Table 3-3. A coal heat content of about 4,100 kcal/kg is assumed a rail haulage distance of 300 kilometers, and a coal freight transportation price of US$0.024 per tonne kilometer for this analysis.

As can be seen in Table 3-3, the preliminary derived differential cost of delivered coal is estimated at US $7.20 per tonne with a delivery volume of 308,000 tonnes per year.

Table 3-3
Mine-Mouth Power Station
Economic Analysis Differential
Delivered Coal Cost Comparison

Parameter	Hrazdan Site	Antaramut Mine Mouth Site
Capital Cost Saving Due to Plant Siting	$20,000,000	$0
Tonnes Delivered Per Year	308,000	308,000
Rail Transportation Costs/Tonne	$7.20	$0
Rail Transportation Cost/Year	$2,220,000	$0
Haulage Savings over a 35-Year Life	$0	$77,700,000
Capital Cost Savings	$20,000,000	$0
Total Savings	$20,000,000	$77,700,000
Net Present Value of Savings (a)	$20,000,000	$21,400,000
Net Present Value Differential		+ $1,400,000

Note:
(a) Assumes a 10% discount rate.

Table 3-3 shows the net present value break-even haulage distance, under these conditions at current rail bulk haulage rates, is about 300 kilometers. Considering the capital cost increase to site the power station at a new virgin location is at least the $20 million estimated by Burns and Roe, the break-even haulage distance is 281 kilometers for this quality of coal. A 3,500 and a 5,500-kcal/kg coal would have a NPV saving of $5.0 million and -$4.0 million at a 10% discount rate, and break even haul distances of 240 and 377 kilometers, respectively. This information can be used as a rough guide to determine the likely impact of alternate plant siting options for differing grades of coal in Armenia. There are other siting related issues such as proximity to the existing electricity transmission lines, supply of water, transportation access, environmental impact, etc. that must be considered in order to properly analyze siting options. It will be necessary to evaluate each opportunity on a case by case basis as the analysis will depend upon any potential future solid fuel supply source.

In order to analyze, from an economic perspective, raw fuel deposits that appear to have higher price levels, it will be necessary to determine to what extent subsidization will support the mine and/or the power station. It will be necessary to analyze power station economics with a range of delivered coal prices so that the range of economically acceptable delivered coal prices can be determined. Acceptability must be determined based on the outlook for the potential to attract either development or private bank funding for both the mining and the power generation complexes. This analysis will provide the limits of acceptability for mine development based on likely mining costs for the coal deposit being considered. Any projects considered that have likely mining costs above the bank acceptability economic limits will have to be based upon subsidization concepts, which, as discussed in chapter 4 of this report, require conceptual definition and acceptance by Armenian authorities and development aid agencies.