

Feasibility study of Gol-Gohar iron ore open cast mine operation of Iran

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ABSTRACT: Feasibility study of the mining operation is one of the most important parts of the total mineral exploitation process. The economic importance of this, increases with the size of the mineral reserves. Gol-Gohar is one of the largest iron ore mines in Iran with an annual output of some 11 million tons.

In this paper, the total costs associated with Gol-Gohar open cast mine have been calculated. These have been divided into capital cost, labor cost, energy and materials and supplies costs. Total revenues have also been estimated based on reliable forecasts for future.

The results have then been analyzed and in particular, the effects of the inflation of prices on costs and other variables have been fully demonstrated.

The paper calculates that the results obtained from feasibility studies of mining operations, can be affected seriously when uncertainties are present in the economy and when there are instabilities in the general price levels. It has also been concluded that fluctuations in the exchange rates can have a dramatic impact on the success of such long term activities.

1 INTRODUCTION

Mining enterprises are complex industrial organizations, and decision making has to involve shortcuts. Over time, shortcuts that prove reliable become embedded in the culture of the organization-continuing to be used even when the economic environment has changed. With the advance of computing technology and economic science, mining projects have been increasingly subjected to analytical scrutiny. Yet the value of mining companies remains strongly influenced by human factors not capable of analysis by even the most sophisticated tools. Costing and analysis of any mining development are necessarily based on a specific mine plan, which has to be prepared assuming certain ore body characteristics. However, ore bodies are seldom clearly defined, and the effort to find and delineate them is itself an economically significant task. The economics of mining will determine what parts are or are not included in the definition of ore. When mine economics change, the amount of material in the ground does not change, but the amount of economically viable ore does change. The amount of economically viable ore is also dependent on the assumptions used for its calculation and can change with a change in assumptions.

2 ECONOMICAL INVESTIGATION

The evaluation of a mining project from exploration through exploitation is a diffuse and complex process. Mine development activities for a capable project are begun when a deposit is discovered and continued through to start of construction. The technical feasibility and the economic viability of each project are determined during the phases of mine development, with more detailed engineering data required at each stage. There are three levels of engineering studies during development that are commonly declared by the mining industry, as follows:

Conceptual study; Pre feasibility study; Feasibility study and economic analysis.

2.1 Conceptual Study

The conceptual study, also generally referred to as a scoping study, is the first level study and the preliminary evaluation of mining project. The principal parameters for a conceptual study are mostly assumed and factored. Accordingly, the level of inaccuracy is as high as ± 50 percent.

Although the level of drilling and sampling must be sufficient to define a resource, flow sheet development, cost estimation and production scheduling are often based on limited data, scientific test work and engineering design. The results of a conceptual study typically identify:

Technical parameters requiring additional examination or test work; General features and parameters of the given project; Magnitude of capital and operating cost estimates; Level of effort for project development

A conceptual study is useful as a tool to determine if subsequent engineering studies are warranted. However, it is not valid for economic decision making nor is it sufficient for reserve reporting.

2.2 *Pre feasibility study*

The pre feasibility study describes an intermediate step in the engineering process to evaluate a mining project. The principle parameters for a pre feasibility study are based on some engineering basis.

The level of accuracy is higher than the scoping study at, say, ± 20 percent.

The engineering objectives of a pre feasibility study are to determine:

Resources and reserves; Mining and milling method; Capacity of production; Environment issues and permitting requirements; Development period and mine life; Product recovery rates; Product marketability; Capital cost and operating cost estimates; Economic analysis with sensitivity.

At the pre feasibility study stage adequate geology and mining has been conducted to define resource and a reserve. Sufficient test work has been completed to develop mining and processing parameter for equipment selection, flow sheet development and production and development scheduling. Capital and operating cost estimates are derived from preliminary test work, assumed factors. The economic analysis of a pre feasibility study is of sufficient accuracy to access various development options and overall project viability. However, these cost estimates and engineering parameters are typically not considered of sufficient accuracy for final decision making or bank financing. The study may or may not be sufficient for reserve reporting. Without a pre feasibility study, the more costly and time consuming final feasibility study may focus on a less optimum mine design or process plan.

2.3 *Feasibility study and final economical analysis*

2.3.1 *Feasibility study*

A feasibility study describes the last and most detailed step in the engineering process for evaluating a mining project for a go/no-go decision and financing plan. Principle parameters for a feasibility study are based on exact and complete engineering and test work. Accuracy is higher than the pre feasibility study and typically ± 10 percent.

Feasibility study aims are like pre feasibility study aims, but the level of detail and accuracy for each objective are more stringent. The level of detail is typically assigned by whether the project is to be financed by the company or a bank financed. Often the term 'bankable' is used in describing a feasibility study. This term simply defines that the level of detail of the study is sufficient for financing provided the results are positive. In some cases, if the project is to be company financed the level of detail is higher than in a typical 'bankable' feasibility study. Detailed geological and mine engineering work has been conducted to define a resource and reserve. Detailed test work has been completed to develop all mining and processing parameters for slope stability of pit, geotechnical, hydrology, flow sheet development, equipment selection and sizing, power consumption, production and development schedules, capital and operating cost estimates.

2.3.2 *Final economical analysis*

Final economic analysis is based on annual cash flow calculations for the mine life. Economic analysis is performed as the final step in the engineering study to provide a measure of the project's economic viability.

Economic analysis is performed using conventional pro forma cash flow analysis for the mining industry incorporating the following:

Leveraged or unleveraged financing; Project basis; Pre or after tax basis; Discounting period of project's annual cash flows.

Economic measures determined in the analysis typically contain:

Net present at selected discount rates; Discounted cash flow return of investment; Internal rate of return; Payback period.

Inputs to the cash flow derived from the various selections of the engineering study contain:

Ore production and grade schedules; Commodity recovery; Commodity production schedule; Capital costs (preproduction, sustaining and working); Operating costs.

In addition to the inputs from the engineering study, other parameters to the pro-forma cash flow contain: Royalties (private and governmental); Commodity price; Tax rates, depreciation, depletion, etc.

According to statement, the development of any level of study requires professionals with extensive mining experience in many different disciplines. Enhancing the capabilities of the study team will reduce the risk faced during the development of the property.

On the other hand, an experienced team can provide the knowledge base to optimize the project as much as possible or apply the best available proven technology during the pre feasibility and feasibility study stages.

Additionally, following the tradition progression of the studies from conceptual to pre feasibility to feasibility to economic analysis generally saves time and money in the long run as critical issues can be identified and addressed early on rather than at a later stage where the impact can be a delay in the project which is generally costly.

There is the potential for a feasibility study and economical analysis to show that the project would make money, thus meeting the definition of feasible so that a reserve could be declared. However, the return of investment could be low enough that the company would not want to advance the project. Essentially, in this case the project is feasible but is neither economically attractive nor finance able. Banks are often more interested in cash flow during the loan repayment period not overall project economics. A project may appear economically feasible to a company but not be structured or scheduled optimally for banking financing. Perhaps the greatest danger is the lost opportunity costs that results from companies investigating a project for too long. When a company goes straight to the feasibility stage, the chances to eliminate projects in the early stages are lost. As a result companies focus time and effort evaluating projects that are not worth currently investigating which means that there are reduced resources available to investigate more worthwhile projects, thus lost opportunities.

3 GEOLOGICAL INFORMATION OF GOL-GOHAR MINE

In 1969, The Gol-Gohar ore deposit was discovered by Iran Barite Co. and was appropriated by National Iranian Steel Company in 1974. Historically, mining in this region dates back to 900 years ago. The Gol-Gohar mine includes six ore bodies, spread over an area of 40 square kilometres. The iron ore which deposits in this region are estimated to amount up 1135 million tons (Table 1). Presently, the ore body No.1 with 185 million tons of mining deposit is in operation. Iron ore composition of No.1 body includes:

- 1) Low sulphur and low Phosphorous Magnetite
- 2) Hematite-Magnetite containing low Sulphur and high Phosphorous
- 3) High Sulphur Magnetite

Table 1. Mine able reserve of iron ore body No.1

	Tonnage (Million Tons)	Grade (%)				Magnetite Wt. (%)
		Fe	FeO	S	P	
Top Magnetite	19.1	61.3	18.8	0.041	0.055	78.5
Oxidized Ore	61.7	60.4	8.8	0.311	0.138	43.3
Bottom Magnetite	104.2	54.3	21.4	2.820	0.158	76.2
Total	185	57.1	17.0	1.696	0.141	65.4

The main objective of Gol-Gohar has been to supply Esfahan and Ahwaz Steel Complexes with the iron ore concentrate, which need 5.5 million tons of concentrate annually. Prior to Gol-Gohar foundation, this requirement was imported to the country. Production of Gol-Gohar has reduced the amount of iron ore imports by 50%. Currently, Gol-Gohar is one of the major producers of iron ore concentrate in the country. Annual production in mine division is 17 million tons (11 million tons of ore plus 6 million tons of over burden, waste and tailings) Concentrate production. Capacity of concentrate production is 4.5 million tons a year with chemical composition that contains at least 67.5% of iron with maximum sulfur and phosphorus contents of 0.170% and 0.050% respectively. From the beginning of its operation until the end of March 2005, Gol-Gohar Company has produced over 27 million tons of iron ore concentrate which has been transported to Esfahan and Ahwaz steel Complexes by trains and trucks. Moreover, a considerable amount has also been sold to Bahrain and China (Gol-Gohar reports, 2006).

4 MINING OPERATIONS

The No.1 ore body is an open mine and to obtain a proper feed for the beneficiation plant many selective mining are undertaken simultaneously. Energy consumption is according to table 2:

Table 2. Energy Consumption

	Quantity Per Day	Unit
Industrial Water	3500	Cubic Meters
Power Demand	40	Mega Watt
Gas Oil	20,000	Liter
Heavy Fuel	90,000-100,000	Liter

In this context, to increase efficiency and reduce energy consumption, the energy management unit controls all the utilities from supply to transfer and consumption.

Mining main equipments in Gol-Gohar mine are according to table 3:

Table 3. Mining Equipment

Equipment	Type	Number
Electric Shovels	P&H 1900AL	4
Trucks	EUCLID (R85B) - TEREX TR100	7 – 13
Drilling Unit	INGERSOLL RAND DMH	3
Wheel Loaders	MICHIGAN L480	2
Wheel Dozers	MICHIGAN 280C	2
Bulldozers	KUMATSU D355A	4
Graders	O&K G350	2
Hydraulic hammer	O&K RH30C	1

5 GENERAL INTRODUCTION TO IRON ORE CONCENTRATE PRODUCTION TECHNOLOGY

In this complex, concentrate is produced through crushing, dry and wet grinding and magnetic separation method using low intensity magnetic separators. Dry magnetic separation and the rest obtain 65% of the product by wet magnetic separation.

6 ECONOMIC ANALYSIS

The economics of the mineral industries are unique. All mining is subject to uncertainties not applicable to other industries. Every mine is different. Industry economics are difficult to quantify and categorize. Information is very costly. Table 4 shows Gol-Gohar iron ore Co. properties value in the last financial year.

Note: One million Rials is almost equal of 100 US dollars.

Table 4. Prime costs during last financial year in Gol-Gohar mine

Description	Retained	Additional	Sold assets	Other Changes	Retained
	(At the year-begin)	assets (During year)	(During year)	and adjustments (During year)	(At the year-end)
	Million Rials	Million Rials	Million Rials	Million Rials	Million Rials
Land	2,559	-	-361	-	2,198
Buildings and Installations	281,272	1,690	-	5,050	288,012
Machineries and Equipments	313,467	23	-64	83,379	396,805
Vehicles	2,867	-	-17	267	3,117
Furniture and appointments	16,391	7	-	2,339	18,737
Sum	616,556	1,720	-442	91,035	708,869
Under completing properties	13,454	146,217	-1,242	11,662	170,092
Orders and prepaid	90,510	99,024	-456	-103,679	85,400
Capital supplies	4,471	29,042	-	-16,885	16,627
Sum	108,435	274,283	-1,698	-108,902	272,119
Total Sum	724,991	276,003	-2,140	-17,867	980,988

Mines that have been operating for some time all have records of the costs of operating the equipment and this is an important input for any economic evaluation. Nevertheless, this information is reliable only for the equipment in use and for the conditions applying up to that time. The calculating techniques are derived from first principles and apply to equipment working in any conditions; this allows auditing and analysis of existing cost information.

Table 5. Accumulated depreciation during last financial year in Gol-Gohar mine

Description	Retained of accumulated depreciation (At the year-begin)	Depreciation (For financial year)	Sold assets accumulated depreciation (For financial year)	Retained of accumulated depreciation (At the year-end)
	Million Rials	Million Rials	Million Rials	Million Rials
Land	161	49	-	210
Buildings and Installations	106,019	16,261	-	122,280
Machineries and Equipments	106,390	33,996	63	140,323
Vehicles	2,138	222	16	2,344
Furniture and appointments	11,564	1,175	-	12,739
Total Sum	226,272	51,703	79	277,896

The most useful and easy-to-use application of time-value concepts is to translate into comparable terms the capital costs of equipment and alternatives that have different mixes of capital and operating cost.

Table 6. Balance sheet for last financial year in Gol-Gohar mine

Properties	Worth (At year-end)	Worth (At year-begin)	Liabilities	Worth (At year-end)	Worth (At year-begin)
	Million Rials	Million Rials		Million Rials	Million Rials
Current assets:			Current liabilities:		
Cash	20,052	15,864	Current account payable	3,084	12,327
Short term investment	276	-	Other account payable	174,777	111,446
Current account receivable	109,639	45,942	Tax allowance	74,977	64,361
Other account receivable	99,330	84,185	Stock dividend payable	208,812	183,724
Goods and materials stock	327,765	266,572	Short term receivable financial facilities	139,598	86,474
Orders and prepaid	27,118	38,740	Sum of current liabilities	601,248	458,332
Sum of current assets	584,180	451,303	Fixed liabilities:		
Fixed assets:			Long term receivable financial facilities	81,464	111,923
Tangible fixed assets	703,092	498,719	Long term payable note	-	97
Intangible assets	7,671	7,213	Money stockpile for employee bonus	17,341	19,776
Long term investment	9,760	6,785	Sum of fixed liabilities	98,805	131,796
Other assets	87,822	89,440	Charge for appreciation of stocks	-	220,000
Sum of fixed current assets	808,345	602,157	property rights of stockholders	440,000	220,000
Sum of fixed assets	1,392,525	1,053,460	Legal reserves	35,869	23,139
			Second provision in budget law	-4,381	-4,381
			Accumulated income statement	220,984	4,574
			Sum of property rights of stockholders	692,472	243,332
			Sum of property rights of stockholders and liabilities	1,392,525	1,053,460

Almost all decision making in a mine involves trading off current costs and benefits with expected future costs and benefits.

Table 7. Income statement list for recent two financial years in Gol-Gohar mine

Description	Amount (For last financial year)	Amount (For financial year before last)
	Million Rials	Million Rials
Net sale	898,652	582,959
Product costs	-388,518	-311,634
Gross income	510,134	271,325
Marketing-Administration-General costs	-202,649	-83,497
Net of other incoming and operation costs	3,403	-1,359
Operation benefit	310,888	186,469
Financial costs	-14,470	-16,519
Net of other incoming and non-operation costs	17,486	13,504
Income before tax	313,904	183,454
Income tax	-59,304	-32,251
Net income	254,600	151,203

Economic analysis of mining operations is further complicated by undesirable criteria in the national economy. These include inflation of prices and uncertainties present outside the project under consideration and within the economy. Inflation of prices causes increases in the current price levels. This makes economic calculations difficult and in some cases unreliable. The often forgotten shortcoming associated with the presence of inflation in the general price level is, however, something totally different. Price inflations cause fluctuations in the constant price levels over time and this being an indirect determinant, is believed to be the most detrimental disadvantage of inflation in the general price levels.

The occurrence of fluctuations in the constant prices is equivalent to the presence of uncertainties or risk in the economy. Other types of uncertainties inherent in different economies will have similar effects on all industrial projects in general and on mining projects in particular. They all tend to reduce the volume of voluntary investment that seriously and adversely affects the economic growth. Iranian economy has been characterized by high rates of inflation during the past three decades. Although seemingly under control, it stands at some 15% at present. It is believed that the economic recession that has deeply penetrated the mining industry of Iran, is, amongst other things, due to sustained inflation in the general price levels. In order to utilize more of the undeniably valuable potentials of extensive mineral reserves, high volumes of voluntary investment are required for relatively long periods of time and the prerequisites of such actions will be: certainty, continuity and stability. Although in firms such as Gol-Gohar, where both the producing and consuming sides are state owned and operated entities, the destructive effects are not realized in the short run, but reflect themselves in the overall health of the economy as a whole in the long run. Gol-Gohar Company can simply increase its selling prices in accordance with the inflation rate on annual or even semi-annual basis and since both parties involved have monopolistic powers, agreements are reached without thorough regards to economic variables. In such negotiations, indeed local and national political variables often constitute the overriding criteria. Such selling prices are therefore determined outside the free market and hence of limited validity in any decisive analysis. Any attempts to calculate feasibility of such inherently risky projects as mining operations will only arrive at unreliable outcome and any effort to measure or analyze productivity of such investment will merely mislead the analyst by obtaining ambiguous and grossly inaccurate conclusions. In such situations, however, the results obtained in any feasibility studies are further distorted by inflation. The level of such distortion increases exponentially by the level at which the inflation rate stands. This is due to the discount factors used in DCF methods of project appraisal. These factors cannot realistically and accurately be determined in inflationary periods, and whichever of the available method is used in such calculations, there always remains an unjustifiably wide gap between what project appraisal analysts advocate and the course of action that industrial investors adopt in practice.

Such projects are therefore frequently carried out by governments, who by the nature of their existence, consider some non-economic factors in their decision making process. In Iran and particularly in the central parts of the country, where most large scale mining activities, including Gol-Gohar, are carried out, sustained employment levels amongst local communities can be recognized as a major socio-economic objective pursued by the national government.

7 CONCLUSION

Iran has large resources of world class deposits of high grade iron ore (Approximately, 2% of total iron ore of the world is in Iran). Because of the high quality of Iran iron ore, there is big export demand. However, domestic demands are increasing with enhanced industrial activity. Therefore, iron ore mining industry as well as steel marketing industry has bright prospect for business. Results that extracted from income statement list have been shown that net benefit has been increased by almost 68.4% in only a year. Such increasing in benefit is interest when this fact consider that in the same financial year many industries involved depression and they lost their worth of equities too many. Balance sheet table presents to increase value of properties and liabilities by 16.1% approximately. This considerable amount of growth in properties can cause that volume of company will grow double in only 6 years from now. Taking in to account the increasing domestic and global demands and the regional and international markets for steel products, and considering the existing infrastructure in the company and various plans to expand production capacity have encouraged Gol-Gohar Co. to have development programs. Outline of the projects are:

Plan for setting up a palletizing factory; Hematite reclamation plant; Project for mining processing& palletizing of iron ore anomaly 3; Installing GHPGR mills; Fine Hematite recovery.

Two billion US dollars has been appropriated lately by executor bank for the development programs.

8 REFERENCES

- 1- Oraee Kazem, 1998, *Analysis of productivity*, Tehran: Ketab Marv
- 2- Oraee Kazem, 2001, *Engineering Economy*, Tehran: Hormozgan university
- 3- Gol-Gohar iron ore Co., 1998-2006, *Reports of Gol-Gohar iron ore Co.*, Sirjan