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# Feasibility Study of Liquefied Natural Gas Project for the "South-Pars" Gas Field of Iran

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## Abstract

In this paper we have analyzed the economic feasibilities of producing liquefied natural gas (LNG) using "South-Pars" gas field of Iran based on the most recently built facilities around the world. Iran has the world's second largest reserves of natural gas and can satisfy a significant portion of the anticipated demand of LNG in the next years. The results show that this project is commercially viable based upon the fiscal assumptions evaluated. In order to investigate the most important factors affecting the project, we have used the sensitivity analysis. Based on the results, the price of LNG, fixed investment cost and feed gas price have substantial effects on the project and its IRR.

**Keywords:** Gas Conversion Technologies, Liquefied Natural Gas (LNG); Benefit Cost Analysis, Iran, South-Pars gas Field.

## 1- Introduction

Based on BP (2012) the total proved natural gas reserves in the world are estimated to exceed 7360.9 trillion cubic feet (TCF) at the end of 2011. Russia (21.4%), Iran (15.9%) and Qatar (12%) are major holders of gas reserves. Iran is the second country in the world, and among OPEC members is the first (BP, 2012).

With 1168.6 TCF of proven natural gas reserves, Iran is the fourth largest producer and the third largest consumer (BP, 2012). In order to develop gas reserves and optimize the consumption, Iran can produce clean and inexpensive fuel for domestic and global gas market.

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The development of conversion technologies of gas to export has been emphasized. Due to the changes in natural gas market which its global demand in 2035 is predicted to reach 12.107 billion cubic meters (bcm) per day, The rapid global growth in natural gas demand means an annual increase of 1.6% for gas demand which is more than the demand for other sources of energy such as oil, coal, nuclear energy, or biomass (IEA, 2010).

In order to facilitate the use of natural gas, the following technologies are being utilized:

- Physical conversions
- Chemical conversions
- Converting gas to power
- Converting gas to commodity

There are two objectives for these conversions of the natural gas, i.e. refining natural gas and consuming it as fuel and entering to the global natural gas market, and consuming natural gas by converting it to valuable products.

Each method has its special advantages and disadvantages and each country must consider their own conditions to choose one or a combination of these options to use. In Iran, a combination of pipeline and LNG is considered for exporting natural gas (Energy Ministry of Iran, 2010).

## 2- LNG and its Market

If in atmospheric pressure, natural gas is cooled down to -161˚C or -260˚F, it will be converted to liquid (LNG) that is not chemically different from natural gas. LNG is a clear, odorless, colorless, non-cancerous and non-poisonous liquid which its volume is one six hundredth of that of natural gas.

To produce, transport, and consume LNG, investment in various stages is necessary. These stages include the exploration, production, and transportation to the ultimate destination; which are called LNG value chain (ignoring the connecting pipelines) including exploration and production, sweetening and purifying, liquefying, storage and loading, shipping, storing in the target terminal (reloading), and re-gasifying LNG.

Liquefied natural gas has been used near 50 years as a fuel which is secure, clean, and environmentally friendly. Currently, more than 38 countries are active in international trade of LNG, which 20 of them are

exporting this product: Qatar, Indonesia, Malaysia, Australia, Nigeria, Trinidad and Tobago, Algeria, Russia, Oman, Egypt, Brunei, UAE, Yemen, Equatorial Guinea, Norway, USA, Libya, Peru, Spain and Belgium. These producers have exported 330.8 bcm of natural gas in LNG form in 2011 to the global energy market. Three major LNG producing regions in the world were South-Eastern Asia, North Africa, and the Middle East in that year (BP, 2012).

On the other hand, 23 countries of the world are major importers and consumers of LNG including Japan, South Korea, Taiwan, India, China, Kuwait and UAE in Asia, Spain, United Kingdom, France, Italy, Turkey, Belgium, Portugal and Greece in Europe, USA, Mexico, Chile, Brazil, Canada, Argentina, Dominican Republic and Puerto Rico in America. The Asian countries of OECD (Japan and South Korea) with 47.2%, and 8 European countries with 27.4% are the major importers of LNG in the world (BP, 2012).

It is necessary to know that the LNG production has doubled during the last decade and reached to 297.63 bcm in 2010. This is 9.39% of the global consumption of natural gas (3169bcm). The predictions of International Energy Agency (IEA) and BP show that world LNG production capacity will increase from about 227 bcm in 2007 to 538 bcm in 2035. Also it is expected that the amount of LNG trade will be roughly 13% of the global consumption of natural gas. This means that the amount of LNG trade grows 8% annually.

According to Wood Mackenzi, the LNG demand will probably increases in future years which leads to growth in LNG prices. Thus, it is predicted that until 2013-2014, the demand of LNG surpasses its supply; although there is adequate LNG for the customers that can afford higher prices.

If this demand-supply gap of LNG happens, the presence and activities of new producing countries in LNG industry will be assured. If there is higher demand in a long time for LNG product than its supply, the producers will be in a secure position and the companies will produce with higher certainty. Iran which has major gas reserves can utilize LNG technology and export it to the far regions. Also, geographically, Iran has advantages to secure the demand of Europe, Asia, and even America.

## 3- LNG Projects in Iran

In the early 2000, by developing the "South Pars" gas field; new projects were defined and gradually the number and production capacity of these projects have increased.

In this paper economic evaluation of LNG project in Iran which uses feed gas from “South Pars” gas field, has been studied.

It is highly difficult to consider investment costs of LNG installations. Because these costs depend on various parameters including the location and the size of infrastructure adjacent, office conditions, the real amount of LNG exploitation, storage volume (which is based on the capacity and number of tanks and loading conditions), and finally, liquefying process, quality and the pressure of delivered gas. The bigger the size of LNG installation, the more economical it will be.

Generally, there are two structures for the economic assessments of LNG projects; i.e. integrated and disintegrated. In the integrated structure, the partners participate in gas field development, gas processing and its conversion into LNG (in an integrated form). However, it is possible for the partners (without developing a gas field) to purchase gas from a company or government that holds the gas resources (i.e. disintegrated project).

In this paper due to the current situation, we have considered the disintegrated structure.

In the disintegrated projects, by considering a determined price for each unit of natural gas, only the investment and operation costs and the incomes of LNG installations are calculated.

Before articulating the benefits and costs of the LNG project we should point out that the “South Pars” field is a shared gas field, so in addition to NPV, IRR and other economical factors one must also consider the opportunity cost of not exploiting the share of Iran.

Besides there are risks and uncertainties in these kinds of projects which cannot be calculated by economic engineering methods but they are important. These points show the complexity of analysis and comparisons.

## 4- The appraisal

The most effective parameters in the economy of LNG projects which we have considered are:

Capital expenditures, operating costs, inflation rate, feed gas price, depreciation costs, debt, interest rate of debt, LNG price, by-products price, by-products volume, required feed gas during operating life and the security for gas supply, tax rate, plant capacity, plant life period and also construction period.

Given the information and the latest data, a base case scenario has been designed; then, alternative scenarios have been presented to study the effect of changes in capital expenditures, LNG price and feed gas price. Table 1 shows the assumptions for the base case scenario.

**Table 1: Base Case Scenario Assumptions of Economic Evaluation of LNG Project in Iran**

| Factor | Unit |
|---|---|
| Capital Expenditures | $1000/ton |
| Operating Costs | 3% Capex |
| Feed gas price | $2/MMBtu |
| Depreciation | 4% |
| Debt | 50% |
| Interest rate of debt | 6% |
| Inflation rate | 2% |
| Crude oil price | $100/b |
| NGL price | $105/bbl |
| LPG price | $102/bbl |
| By-products volume | 10% Feed gas |
| Required feed gas during operating life | 375 Bcm |
| Tax rate | 25% |
| Plant Capacity | 10000000 Tons a year |
| Total Investment | 10 billion $ |
| Plant life period | 25 years(350 day per year) |
| Construction period | 4 years |
| On stream factor | 95% |

- Investment costs are 800 to 1200 dollars for production capacity of each ton per years; 50% is provided by the shareholders and 50% by the loans.

The debt is 50% of total investment cost that financed by National Development Fund and the interest rate for these loans will be 6%. After a break of 6 months, the repayment will start in the first year of production and continue 4 years.

Annual production capacity is 10 million tons of LNG in 2 trains. Their capacities are equal and in the first year of operation, 50%, in the second year 70% and in the third year 100% of the first train capacity will be exploited. In the second train, the exploitation starts in the second year and will respectively increase during four years (50%, 70%, 100%). As a whole, the on stream factor is 95% of nominal capacity.

- The production cost of gas in majority of gas fields in Iran is less than 50 cents per million Btu (MMBTU) and the price of the delivered gas to the domestic petrochemical units is 2$ per MMBTU[1]. In this project (with disintegrated structure), some contractual guarantees are required that the feed gas price cannot be arbitrarily increased by the government to have a secure and steady supply over the life of the project. Feed gas price for each LNG unit in the base case scenario is considered 2 dollars per MMBTU.
- In this project, besides the main product (LNG), 720 thousand tons of LPG, and 300 thousand tons of NGL is produced. The LPG and NGL price based on the average price during 2004-2010, reveals that the price of LPG, in average is two dollars more than the price of crude oil and for NGL this premium is 5 dollars. Price fluctuations of by-products depend on the fluctuations in oil price which can be assessed in different scenarios. Based on the prediction of international institutions, the price of each barrel of crude oil has been considered to be 100 dollars; this will minimize the risk of decrease in the crude oil price in the economy of the project. (BP, 2012; EIA, 2010; IIES, 2010; Petroleum Argus, 2011; Platts Crude Oil Market, 2010).

1- Iranian National Gas Company (NIEC), Sales Accounting of Financial Management.

- Operation and maintenance costs are 3% of investment costs in a year. This includes insurance costs, labor costs, repair and maintenance costs and the costs of unpredictable circumstances or events in the operation time.
- The project has been calculated in dollar and we have assumed the inflation rate as 2% in a year.
- Since this project is for "Assaluyeh" port which belongs to the less developed regions in Iran, there is a ten-year tax holiday based on the article no.132 of reformation in “direct taxes law” issued by the Tax Organization of Iran[1]. However, in the 11th year of exploitation and after that, the annual income tax will be 25% based on the article No.105, direct taxes law of Iran[2].
- Discount rate is 11%[3].
- Depreciation cost for each LNG unit is linearly 4% in plant life with the scrap value of zero at the end of operational period.
- Feed gas which is used in LNG units will be provided from the South Pars shared gas field. To produce 10 million tons of LNG, almost 15 bcm of natural gas is needed.
- Crude oil price is 100 dollars for each barrel. LPG and NGL (the by-products) prices depend on oil price, so we consider the price of crude oil in our calculations.
- Average LNG price, on the harbor (FOB) is around 10 dollars per MMBTU.

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1- Direct Taxes Law, the article No.132: 80% of the income from producing and mining activities, which is derived and declared by producing and mining enterprises of cooperative or private sectors for whom exploitation licenses are issued, or with whom extraction and sale contracts are concluded, from the beginning of the year 2002 onwards by relevant ministries, shall be exempt from the tax set forth in the Article 105 hereof for a term of 4 years beginning from the date of exploitation or extraction. As regards the less developed regions, the exemption shall apply to 100% of the income for a term of 10 years.

2- Direct Taxes Law, the article No.105: The aggregate income of companies, and also the income from the profit-making activities of other juridical persons, derived from different sources in Iran or abroad, less the losses resulting from non-exempt sources and minus the prescribed exemptions, shall be taxed at the flat rate of 25%, except the cases for which separate rates are provided under the present Act.

3- President Deputy Strategic Planning and Control, the Guide to Provide the Report for Technical, Financial, Economical and Social Justifications of Plan.No.3122.

## 5- The results

The net present value (NPV) in the base case scenario is 15.5 billion dollars and the internal rate of return (IRR) is 31% which means that the project of LNG production in Iran is profitable. The project will return the whole invested capital in the fourth year of exploitation; this is another critical and attractive issue.

The diagram below represents NPV of the project in different rates of return. In the rate of 30.99% (IRR), NPV of the project will be zero.

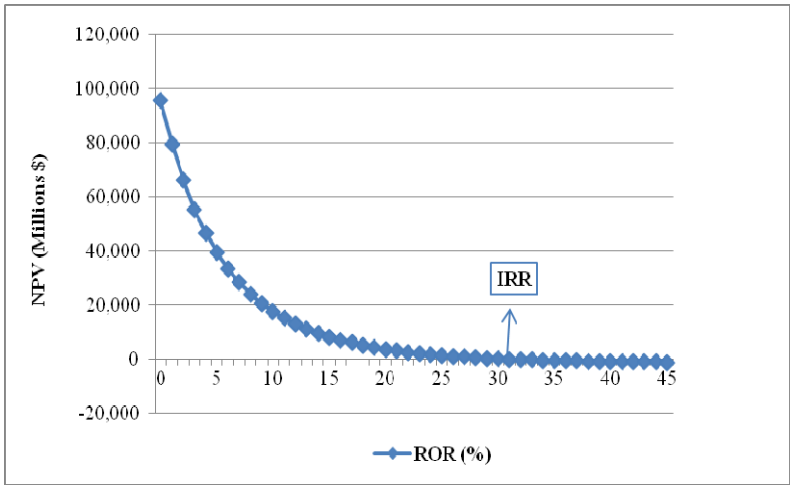


**Figure 1: Relationship between NPV and Different Rates of Return**

In order to analyze the effects of most important parameters in this project, we have assumed different scenarios which are shown in the table 2. As can be seen, the investment costs are assumed to be 800, 1000 and 1200 dollars per each ton of production capacity[1], and the sales price of LNG is in the range of $8, $10 and $12 for each MMBTU. Also the price of feed gas will be $1, $2 (the delivered price to the petrochemical units), and $3/MMBTU. The considered prices for the natural gas in these scenarios are relevant to the new policy of subsidy reform plan in Iran.

1- Based on the Prediction of the Experts of Gas Industry.

**Table 2: Different Scenarios of LNG Project**

| Capital expenditures | Feed gas price | LNG price | NPV | IRR |
|---|---|---|---|---|
| ($/T) | ($/MMBtu) | ($/b) | billion $ | (%) |
| **800** | 1 | 8 | 14.206 | 33.9 |
| | | 10 | 19.342 | 39.9 |
| | | 12 | 24.478 | 45.3 |
| | 2 | 8 | 11.750 | 30.5 |
| | | 10 | 16.886 | 36.9 |
| | | 12 | 22.022 | 42.6 |
| | 3 | 8 | 9.294 | 26.9 |
| | | 10 | 14.430 | 33.8 |
| | | 12 | 19.566 | 39.8 |
| **1000** | 1 | 8 | 12.441 | 28.2 |
| | | 10 | 17.577 | 33.7 |
| | | 12 | 22.714 | 38.6 |
| | 2 | 8 | 9.985 | 25.2 |
| | | 10 | 15.526 | 31 |
| | | 12 | 20.258 | 36.1 |
| | 3 | 8 | 7.529 | 22 |
| | | 10 | 12.666 | 28.1 |
| | | 12 | 7.802 | 33.6 |
| **1200** | 1 | 8 | 10.677 | 24 |
| | | 10 | 15.813 | 29 |
| | | 12 | 20.949 | 33.6 |
| | 2 | 8 | 8.221 | 21.2 |
| | | 10 | 13.357 | 26.6 |
| | | 12 | 18.494 | 31.3 |
| | 3 | 8 | 5.765 | 18.4 |
| | | 10 | 10.901 | 24 |
| | | 12 | 16.038 | 29 |

In the optimistic scenario, it is possible to produce and export LNG with investment cost of 800 dollars for each capacity unit, the LNG price of 12 dollars for each MMBTU, the feed gas price of $1 per MMBTU. In this case NPV of the project is 24.48 billion dollars; IRR will be 45.3%.

The worst case is the conditions which investment costs increase to1200 dollars per ton of LNG. With no subsidies for energy prices, the delivered feed gas of the project turns to be $3 per each MMBTU. If the sales price of LNG in the global market decreases to $8 per each MMBTU, then the LNG

production is still economical for Iran because IRR of the project in the most pessimistic case is 18.4% and NPV is 5.765 billion dollars.

By assuming other parameters include sales price of LNG and investment cost are fixed, the feed gas price of 8.157 dollars per MMBTU is the boundary price, causes NPV to become zero. This means it is the maximum price for feed gas that the project can afford. With the same logic, the 4.11 dollars per MMBTU sales price of LNG is the minimum price that the project can survive. Finally the maximum investment cost for the project is 2715 dollars per ton of LNG, that the project will be justified economically.

In order to see the most effective parameters in this project we have conducted the sensitivity analysis. An increase in capital expenditures and the price of feed gas directly decreases the IRR and NPV. An increase in the price of LNG and crude oil price will increase the IRR and the NPV. These parameters also affect the payback period.

Figure (2) illustrates the results of the sensitivity analysis for price of feed gas, sales price of LNG, investment costs and the oil price.

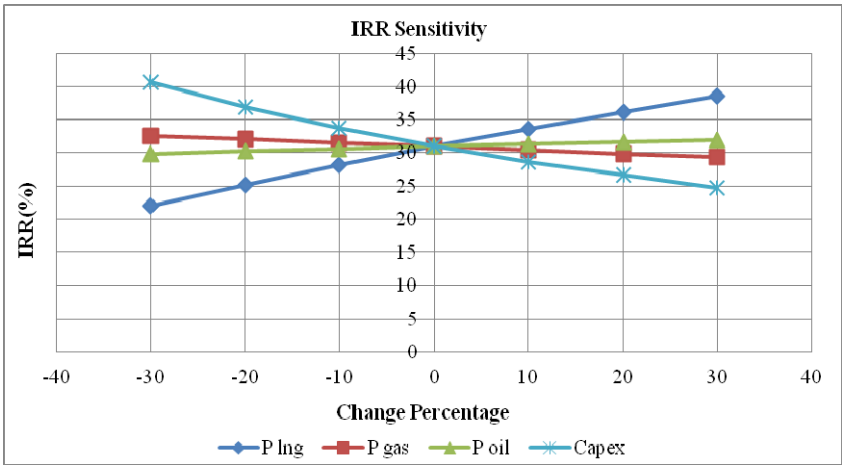


**Figure 2: Sensitivity of IRR to Changing the Most Effective Factors of the Project**

As can be seen from figure 2 the most sensitive parameter is the LNG sales price which has the steepest slope. The investment cost is the second most effective parameter which affects IRR negatively. The feed gas price has also a considerable effect on IRR.

## 6- Conclusion

Natural gas plays determining role in political-economical relations in recent years. The oil reserves in the world will soon finish and there will be global demand for substituting energies. Iran has more than 15.8% of the approved gas reserves of the world.

An important issue about gas reserves in Iran is the shared gas fields between Iran and its neighboring countries.

According to the predictions the demand of LNG surpasses its supply in near future. With this demand-supply gap of LNG, Iran which has major gas reserves can utilize LNG technology and export to the far regions.

According to the results of base case scenario, NPV of the project during 25 years is around $15 billion and IRR is 31% with the payback period of four years.

The sensitivity analysis shows that the LNG price is the most sensitive factor in this project, then come investment cost and feed gas price respectively.

Additionally, due to its market conditions, the foreign investors can be motivated to participate in these kinds of projects.

Regarding to gas condition of Iran it has confronted some challenges. Domestically, energy consumption and allocating it to different economic sectors need adequate decision making and accurate planning; externally, the energy export is one of the best ways to enter various areas in the world, to increase the foreign incomes, to establish diplomatic relations with different countries and plan the profound political and economic relations.

Another issue about Iran and its gas reserves is the common gas fields for Iran and other countries. In these cases, it is essential to exploit in the maximum amount even though there is not a ready market for it. In this condition exploited gases could be stored.

It is suggested to partially use the resources of the National Development Fund to provide investment cost of the project. Since this money supply is an inter-generational treasure, it must be used in such projects with the highest IRR and NPV.

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