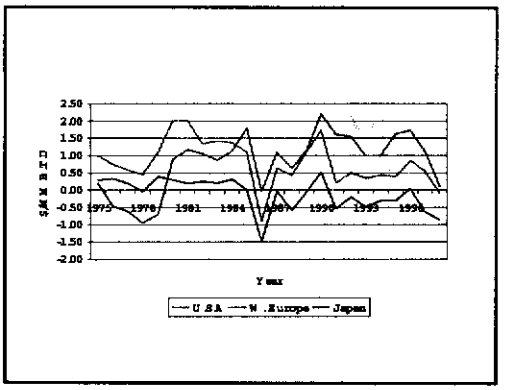


Fig.7: Trend of Natural Gas & Oil Differential Prices (1975-1998)

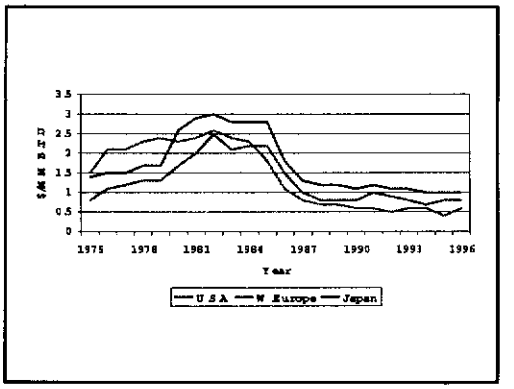


Fig.8: Trend of Natural Gas Real Prices (Base: 1973=100)

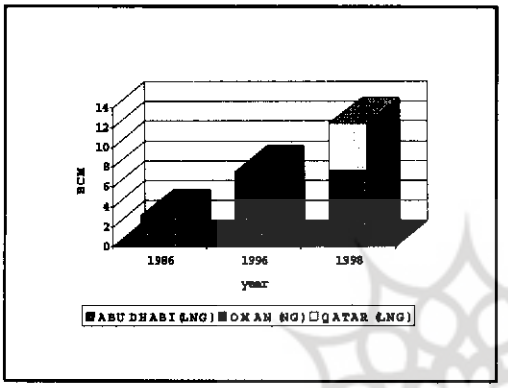


Fig.9: Natural Gas Trade in persian Gulf (1986-1998)

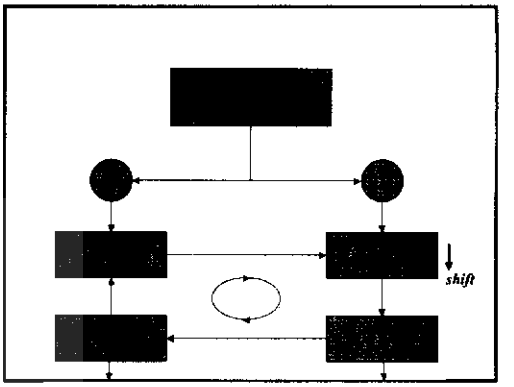


Fig.10-a: The Interdependency of Oil and Gas Markets (closed causality circle)

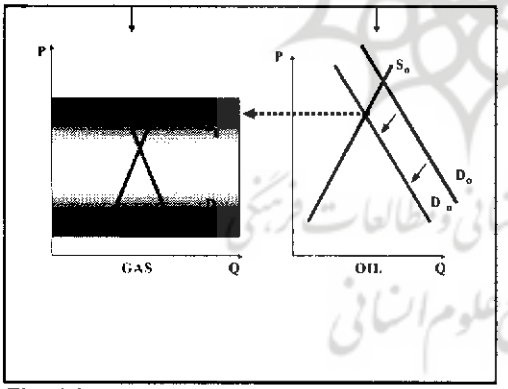


Fig.10-b: The Interdependency of Oil and Gas Markets (closed causality circle)

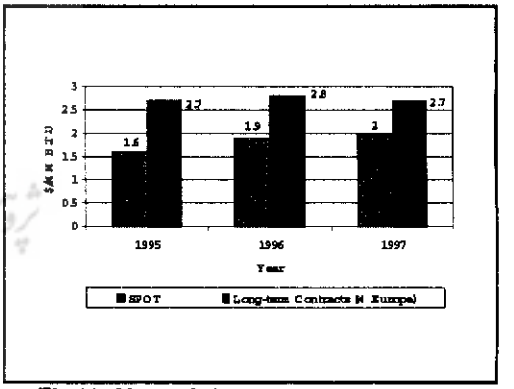


Fig.11: Natural Gas Spot vs. Long-term Contract Prices

Fig.12: Trend of Oil Trade vs. Oil & Gas Basket Trade

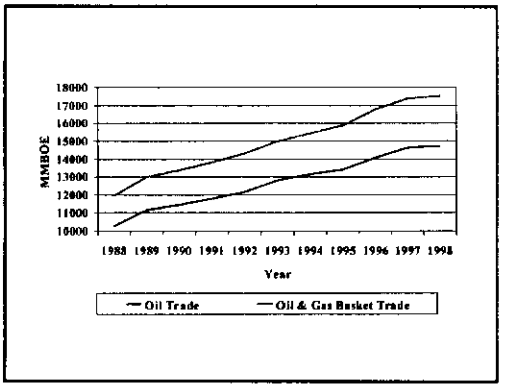
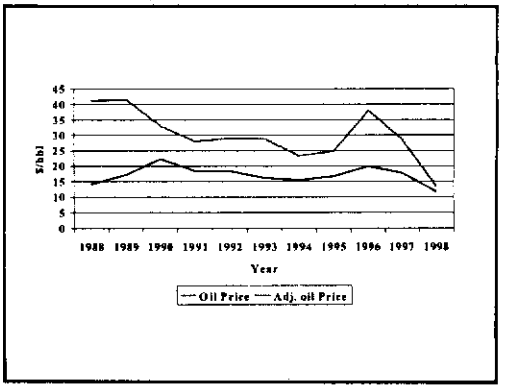


Fig.13: Trend of Actual Oil Price & Adjusted Oil Price (i.e. Without Gas Substitution)



transmission cost, activating the export projects in the region without a suitablepricing mechanism is not possible. Because it could not meet the long-run benefits of exporting countries.

Iran as an important country in the Persian Gulf has a very special geo-economic position in the region. Having direct frontiers with large gas consuming markets, such as India, Pakistan and Turkey, Iran has a crucial role to expand the gas commerce in the region.But this could only happen if and only if the pricing mechanism could rationalize investments and compensate opportunity costs of the gas export projects.

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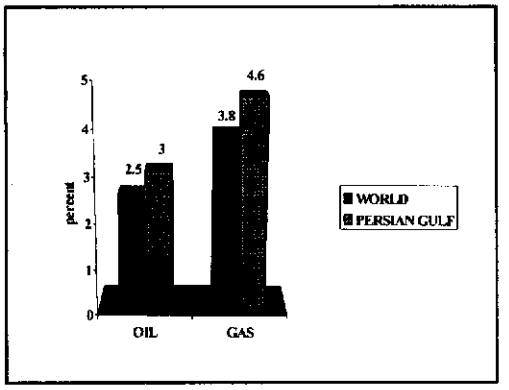

Fig.1: Growth of Oil & Gas Proved Reserves in Persian Gulf & World

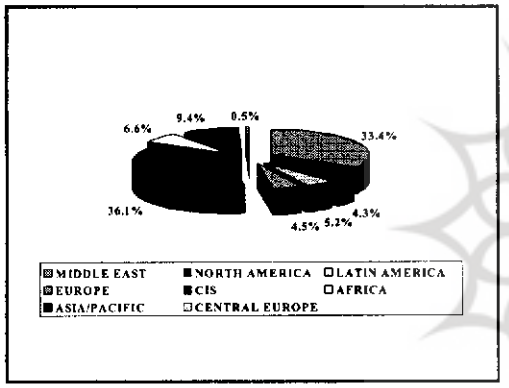

Fig.3: Breakdown of Proved Natural Gas Reserves in the World (1998)

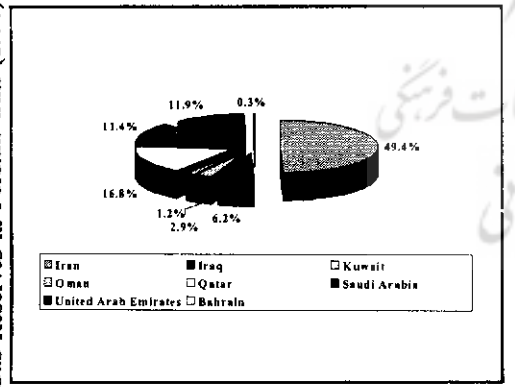

Fig.4: Breakdown of Proved Natural Gas Reserves in Persian Gulf (1998)

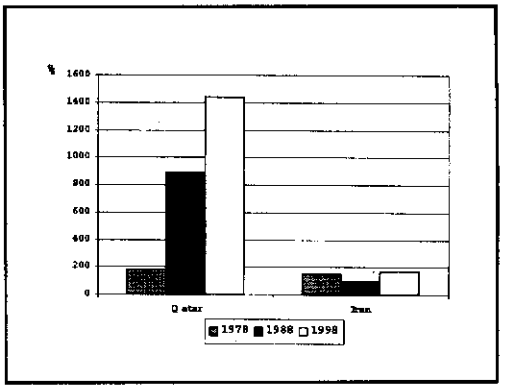

Fig.2-a: Gas/Oil Reserves ratio in Persian Gulf

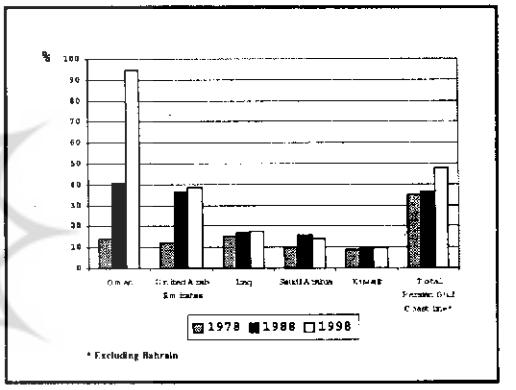

Fig.2-b: Gas/Oil Reserves ratio in Persian Gulf

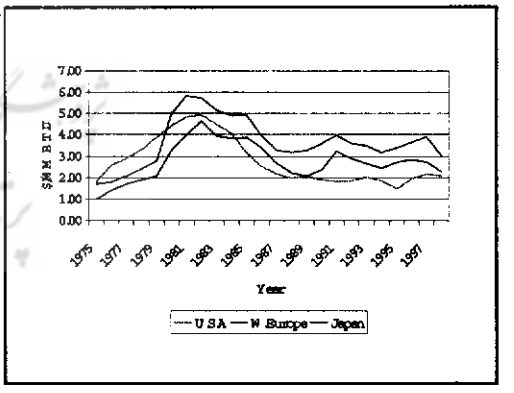

Fig.6: Trend of Natural Gas Prices (1975-1998)

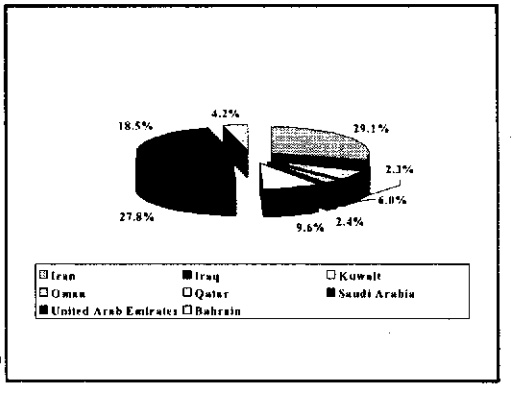

Fig.5: Breakdown of Natural Gas Consumption in Persian Gulf Region (1997)

energy cost. On the other hand, because of dependency of gas prices to oil prices, low oil prices do not let gas prices rise and cause more demand for gas, and this causes another downward shift and another oil price fall, in turn. Therefore, there is a closed causality circle in International market that causes a downward tendency for gas prices (see Fig. 10-a).

Demand and Supply curves of gas have some properties, which are distinguished by upper and lower bounds. The demand curve has an upper bound, which is confined by economic variables. These are as follows: Inter-fuel competitiveness, competitive interaction between gas import and internal gas, positive externalities such as environmental effects of gas consumption. The lower bound of gas demand is confined by those energies, which have low socioeconomic values (such as coal). So the gas demand like all normal demand curves has a downward slope and is constrained with these two bounds. The supply curve is S shape and has upper and lower bounds. Upper bound is determined by economic variables such as production cost, supply of substitute fuels, exploration cost, production from remote fields and/or fields that are in secondary and tertiary recovery, coal gasification cost. The lower bound of supply curve, in fact, is confined by long run marginal cost of gas. Because of special characteristics of gas industry, the slope of supply curve has been influenced by the trend of demand and the committed price is chosen in the feasible boundary (Fig 10)

The equilibrium gas price is between the upper bound of demand and lower bound of supply curves. An area, which defines importer's maximum desire to pay and supplier's minimum desire to get.

According to the current gas pricing mechanisms, oil equilibrium price (intersection of oil supply and demand curves) dictates the upper bound of gas demand. Ofcourse if social and environmental effects of gas to be considered the upper bound must be higher than the price in which is taken from oil market. Market pricing could not take such positive externalities into account. Furthermore, the empirical experiences on gas pricing in International markets show that gas price has always been lower than oil equilibrium price.

Given the closed causality circle for gas, with more substitution of gas for oil, gas upper bound price will be lower and lower and will approach to lower bound. In other words gas price will be bonded closer and closer. Stopping gas projects, in fact means the upper bounds of gas demand curve is low as compared to lower bound of supply curve. In other words importer's maximum desire to pay is lesser than exporter's minimum desire to get. Existent current gas pricing mechanism in International market mostly ignores economic advantages of gas such as social welfare and environmental effects, which plays a crucial role in developed countries. In those countries, consumer desires are controlled by fiscal instrumental policies.

Another important point about existent gas pricing mechanism is that, what could happen if the substitution of gas for oil did not meet? In order to answer this question we should study demand and supply elasticities.

So far, there are several studies on demand elasticities of oil in the world. DOE's estimation show that demand elasticities could be -0.06 in 2000. This measure for supply elasticities could be 0.06-0.12 in 2000. Elasticities of demand and supply are increasing during the time, because of possibility of substitution and technological improvements. Therefore, supposing elasticity for demand and supply equal to 0.06,we have an over estimated value for our analysis, or it is a pessimistic value for evaluation of substitution in absence of gas in energy market.

If the substitution of gas for oil did not occurr, the energy needs would be demanded by oil,instead. Our evaluation indicates that during 1988-1998, average price of oil and gas basket in the world would be 3.1 $/BTU, with such an assumption. It would meet the higher oil prices. Within this period of time the average oil price has been 5.5$/MMBTU. Therefore the occurred gas substitution has caused a reduction equal to 2.4 $/MMBTU (Fig.12 and 13)

6. Concluding Remarks

So far, keeping the relationship between oil and gas prices, the existent gas pricing mechanisms have never taken socioeconomic advantages of gas into account, and gas market has never been considered independently. Although, such advantages have always been considered in developed countries at national levels.

According to international market characteristics, importers and exporters of gas have always been accepting considerable percent of risk in their trade. But most of such a risk must not to be imposed on exporters by downward price push. Such a pressure is an important restricted factor for future gas export projects. The Persian Gulf is known as one of the strongest potential in exporting gas in the world. In order to reach to the world's largest consumption markets (Far East and Europe), gas must go through a long distance route both in marine and land. This causes highly risky investments and highly costly projects.

Extraction and production costs in the Persian Gulf as compared to other regions is too low, because of huge amount of reserves (a well-head production of gas in Qatar is estimated 0.5 $/MMBTU, while this measure for Asia/Pacific is estimated 1.5 $/MMBTU). According to high

non-industrial oil exporter countries) limited the use of associated gas in producer countries. Therefore, it caused to the belief of "its sale at any price represented an economic gain", (Joyce and Khan, 1981);2) NG production surplus was a main reason for less attention to pricing mechanism (NG supply had not any opportunity cost).

During 1970s, as NG demand increased and supply shortage appeared in several countries (e.g. U.S.), the real worth of NG has been recognized. So a new period of negotiation has started to establish the structure of NG pricing that would compensate the producers while keeping a competitive price for NG in the international market.

Theoretically, there are several methods for NG pricing. Although some of them have never been practicable and been discarded, they could help decision-makers and researchers finding reasonable solution for NG pricing.

Cost-Based Pricing: In this method NG is priced on the basis of wellhead cost. That was abandoned in the late 1960s. One of the characteristics of NG market in that decade was being an artificially low NG price because of abundant supply of associated gas. Low prices encouraged wasteful use of NG and slowed down development of NG resources in that time.

Value-Based Pricing: This concept has a great appeal among economists. It relates the price of gas at burner-tip to the cost the other best alternative fuel (normally oil products). Because of unreliability of NG supply and some other reasons, burner-tip price might be determined lower than what it could be. It is more likely that NG price would be higher than burner-tip price because of being cleaner and more convenient than fuel oil and other oil products. The burner-tip parity pricing was as a negotiation basis in 1970s contracts.

Parity Pricing: In this concept, energy is considered as its heating value regardless of its form. For example, BTU is the unit of heating value for all enrgy carriers. This way of pricing seems a very simple conceptual sense, because gas and oil price changes have never behaved in the same manner.

This concept can principally be interpreted as the criteria of decision for consumers at the point of use, and it could be considered as the structure of end-use "parity price". The initial point of party pricing might be the wellhead parity price.

Equivalent Border Price: Under this concept all imported gas regardless of their sources would receive the same price where it entered into the pipeline network. Although, this concept has defined under a simple and regular mechanism, but it eliminates the principle of "location value" from the price structure. This method would increase economic gain of countries that are nearer to importer countries.

Replacement Cost Pricing: At present, the methods of "parity pricing" and "net back pricing" consider crude oil, petroleum product and local NG as the imported gas substitutes, and a combination of these energy's prices have been considered as "marker price" of energy. Under "replacement cost pricing", the price of other energies, which are available or are substitutable, is considered, during the contracts period. Substitutable energies in this case could be synthetic gas derived from coal (gasified coal) or even solar enrgy.

5. Traditional Pricing for Gas in the World up-to-now

Gas pricing trend Analysis shows that in most cases gas price is lower than price of other substitute fuels (e.g. Crude oil and products). there are some exceptions about LNG price because of the high capital cost of LNG projects. Gas trade as compared to oil trade has three special characteristics: 1) gas Transmission is usually for long distance routes for specific destinations, whether by pipeline or tanker, 2) Close interdependency between importers and exporters at least during contract's period and 3) highly risk intensive.

Regarding the above-mentioned characteristics, contract prices should be determined in a way in to keep security of supply and bring some gains for gas suppliers in order to support investment requirement for development of their gas exporting projects. Flexibility of contracts is very important to keep exporters benefits. Unilateral interruption of supply by Iran and Algeria showed nonflexibility in the signed contracts.

At 1980 OPEC meeting in Algeria, the problems about gas trade were debated and it concluded that all gas suppliers want to sell gas at least on the base of oil market price. So it will encourage development of gas projects. Although the meeting could not suggest any specific solution for "parity mechanism", some countries like Libya and Algeria showed their tendency to the equity of FOB prices of both oil and gas in the international market.

Historical Analysis of several NG pricing formulations in previous decades and in different regions shows that the NG pricing has often been influenced by oil and oil products prices. There are noteworthy points about current gas pricing that should be considered carefully: A new belief on International gas trade and especially economic pricing of gas is needed. Such a belief would bring an effective evulution for gas and also for oil trade. By such an approach gas supply will be secured and more projects in gas industry will be activated.

In most cases, Oil and Gas are suitable substitutes for each other. So gas demand reduces demand push effect in Oil International market. In other words more gas demand shifts Oil demand curve downward, and this decreases oil price. So the expansion of gas supply is a positive factor for oil importing countries to reduce their

3. Trend of Gas Prices

Europe, Asia, and America are the main gas importer regions in the world. So price trend analysis has been carried out for these regions.

NG trade in these regions has different nature, because of their distances from exporter countries. Because of suitable land and marine routes in America and Europe regions, there would be proper access to exporter countries by pipeline and/or tanker; as a result the required gas both in the form of NG or LNG have been imported by them.

So far, American NG requirement have mainly been provided by pipeline from other Region's countries and the NG shortage (demand that imported gas can not meet it) has been covered by LNG import. Share of LNG is not significant in this region. Average NG price in American region is always lower than the other regions.

Europe is the largest NG consumer in the world.Gas has been mainly traded by pipeline and only 10 percent of its trade have been in the form of LNG. This region considers diversification policy in NG trade, so it imports NG from several sources. This policy has increased a competitive atmosphere and pushed the NG price downward.

Japanese market represents mainly the Asian NG international trade. Because of strict dependency on energy import (especially NG) and geographical condition, its NG trade is so much and significantly by tankers. Other Asian countries like Taiwan, South Korea, Singapore, and Hong Kong mainly import gas in the form of LNG too. Of course there are negligible amount of NG import by pipeline from some neighbor countries. Japanese market has the highest NG price in the world and this is because of high production cost of LNG as compared to NG and the considerable transportation cost Like European countries, Japan has also the same diversification policy for its gas import. Therefore, pricing mechanism has significantly influenced by this policy, especially for long term contracts.

Studying trend of NG prices in different NG markets show that there is close relationship between oil and gas prices (Fig.6). After the first oil shock in 1973, gas prices also changed following sharp increasing in oil price The differential gap of oil and gas prices has always been lower than 1$/MMBTU during those years and gas price higher than oil price occasionally occurred; because of gas production cost and the lag of affecting the oil price on gas price (Fig.7).

In 1980s, oil prices increased sharply again (second shock) and this influenced gas prices once more, but the price of import gas was not so elastic as compared to the gas demand (because of non-flexibility of the contracts conditions). Therefore, differential price of oil and gas highly increase (especially in European and American markets).

After the fall of oil prices in mid. 1980s, the three regional NG markets had not the same reaction. In US market, the historical differential prices of oil and gas remained constant and occasionally even increased, so that, this differential in some years was more than 1.5$/MMBTU, But the situation was completely different in European and Japanese markets. in these two markets because of higher share of LNG in the trade basket, the gaps returned to the post second shock period (before 1980s).In the Japanese Market, because of the nature of LNG export costs; the LNG price was even slightly higher than oil prices.

In a comparative study of real gas prices, this measure in each country is dependent on exchange rate and inflation deflators. The studies show that real value of gas export has significantly reduced in 1990s as compared to second half of 1970s (Fig.8).

Preservation of purchasing power of gas revenues for gas exporting countries, which has weak economy and suffers from the lack of infrastructure investment, are seriously important. These countries need to achieve the new and high technology, and for this purpose they need higher export revenues, and higher purchasing power in International economy.

LNG spot market has started by the end of 1986 in Indonesia. The onset of such a market was a drastic innovation for LNG industry. So gas market is going to be more flexible than before. Although, Spot Market has caused use of idle capacity or stand-by LNG plants for exporting countries and it has also provided a better solution for the peak shaving management for consumer countries, the final impact of such a market has not been favorable for improving the gas prices. Gas price in spot market has always been lower than long-term contracts (Fig.11).

4. The Concepts and Methods of Pricing for Gas

Natural gas pricing is always distinguished from pricing of ordinary commodities which is normally traded in international commerce, and it is not even similar to petroleum pricing. These differences cause confusion and misunderstanding about NG pricing concepts.

Before 1980s, NG has never enjoyed a free market in the same sense as crude oil. NG has always been considered as a by-product of oil production and governments influence the NG pricing. Therefore an artificial restrained market has been created for NG.

NG pricing was defined under producers' beliefs in early 1970s. They were paying a little attention to NG pricing as an economic subject, for two reasons: 1) Ng was considered as an unwanted by-product of oil production. Absence of suitable technology, necessities for transmission of NG to final consumers (especially in large

such as ease of availability, friendly environmental impacts and convenient use). This makes NG vulnerable to oil crises.

2. An Overview of International NG Trade

Proven NG reserves as compared to oil has had a greater growth rate. In the recent 20 years, average growth rate of NG reserves has been about 1.5 percent greater than for oil. In this period, oil and gas reserves of the Persian Gulf have had a faster growth as compared to other regions in the world (Fig.1). Average annual growth rate of oil and gas in the Persian Gulf region within 1978 to 1998 was 3 and 4.6 percent, respectively. So gas/oil reserves ratio in the region has increased from 35 percent in 1978 to 48 percent in 1998. This ratio for Iran and Qatar, the two largest NG reserve owners in the Persian Gulf region, indicates that NG reserves in terms of oil equivalent exceed oil reserves (Fig.2-a). For other countries in the Persian Gulf, oil reserves exceed NG reserves (Fig.2-b).

Countries of the Persian Gulf region comprising two third of Countries of Middle Eastern nations own as 33 percent of the world's NG reserves (The share of the other Middle Eastern countries is 0.4 percent). As an owner of NG reserves, the Persian Gulf is ranked in second order after FSU (Fig.3). Approximately 39 percent of NG reserves of the region are offshore. This has considerably influenced the exploration and production costs.

Iran owns largest NG reserves in the Middle East and the Persian Gulf region. This country holds 25 trillion cubic meters NG reserves and has a strong potential of NG supply (Fig.4). At the moment, Iran holds 16 percent of world NG reserves and 49 percent of Persian Gulf NG reserves. Qatar with 5.5 percent of the world's NG reserves and 17 percent of the Persian Gulf NG reserves, is ranked after Iran.

Although the Persian Gulf region is rich in NG reserves, its share of the world NG consumption is not significant. In 1998, this region's share amounted to 7 percent of the world's NG consumption. The share of Iran and Saudi Arabia from NG consumption in the Persian Gulf region was 29 and 28 percent, respectively (Fig.5). International NG trade in the Persian Gulf region began is 1970. NG export from this region is mainly in the form of LNG and export by pipeline has negligible share of region's NG trade (less than 1 percent). Although the world volume of NG trade has been tripled from 1986 to 1998, the share of the Persian Gulf region in the world NG trade is still negligible. In 1998, the region's NG export amounted to only 0.1 percent of the world NG trade and 10.5 percent of the world LNG trade. In this year, share of the Persian Gulf region from the world NG export was only 3 percent (Fig. 9).

In 1977, the first liquefaction NG plant of the Persian Gulf was commissioned in Abu-Dhabi with the capacity of 2.5MMton/y. Second LNG plant with 3MMton/y capacity was commissioned in 1994. Therefore by 1994 total liquefying NG capacity and export potential of the region reached 5.5MMton/y. Until Mid. 1990 Abu-Dhabi was the sole LNG exporter in the Persian Gulf region. In 1996, Qatar joined to LNG exporting countries. First LNG plant of Qatar has a capacity of 4.5 MMton/y, which was commissioned in this year.

Until the end of 1988, nearly 11 percent of the world LNG capacity has been built in the Persian Gulf region. Qatar 6.6 MMton/y of liquefaction capacity (in 1999) and first LNG plant of Oman with a capacity of 6.6MMton/y are anticipated to be commissioned in 1999 and early 2000, respectively. Therefore total LNG supply capacity will reach 23.2 MMton/y within the next few years.

Bahrain and Iran are the sole NG exporters of the region, using pipelines to neighboring countries (Oman, Azerbaijan, Armenia).

Because of Iran's geo-economic position (its proximity to potentially strong NG markets- India, Pakistan and Turkey),its huge resources, as well as its well developed gas infrastructures, this country can join the international NG export market It is anticipated that in the next decade, Iran will be the largest NG exporter by pipeline in the Persian Gulf, starting with NG export to Turkey (the contract was signed in 1996).

Although, the Persian Gulf and the Middle East in general are considered as being too for from the European and the Far-Eastern gas markets, they seems to be the only significant sources of gas reserves which can supply the aforementioned markets in the not too distant future. To date, there are potentially several NG commercial projects in the Persian Gulf region (e.g. exporting gas to Pakistan/India by pipeline and/or to India in the form of LNG). But the success of these projects will depend on numerous factors including security of supply for importers in the context of commercial contracts, prices and political factors.

Geo-economic characteristic, huge NG reserves and high potential demand for NG are the driving factors for overcoming problems to improve the situation of the Persian Gulf NG trade. Cooperation between exporters and importers countries is the foundation of these efforts. NG prices and pricing mechanisms have always been at issue and in some cases these factors caused disruption of NG exports. Having a Comprehensive consideration fo the NG pricing (taking economic, social and environmental effects into account) by both exporters and importers could create a suitable framework for improving NG markets and to revive NG projects.

Natural Gas & LNG Pricing in International Trade

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The main objective of this paper is to delineate Natural Gas (NG) pricing mechanism in the international markets; as well as todiscuss the most important factors, governing such mechanism. The other objective of this paper is to investigate the role of economic and social welfare criteria on shaping traditional pricing mechanism. The study shows in the traditional NG pricing mechanism, there is a closed causality circle in the NG international market that causes a downward tendency forgas prices. The traditional NG pricing mechanism has less attention to positive externalities and advantages of NG utilization. Therefore, the current pricing mechanism needs to be modified on the base of market economy rules.

1. Introduction

Formation and development of International energy trade especially NG trade has always been influenced by political and economic forces. The international NG trade is risky and capital intensive. Therefore, price and cost are two most important determining factors for developing NG trade. This paper is divided into four sections:

- An overview of international NG trades,
- Trend of NG prices in the international markets and its relationship to oil prices,
- The concepts and mechanisms of pricing for NG,
- Traditional pricing for NG in the world up-to-now

Various studies show that in many of international contracts (both for NG or LNG) there is close relationship between NG price and the basket price of several crude oil or products. This is due to easy substitution capability of the above mentioned energy carriers. One of the most important factors for NG pricing is to keep competitiveness of NG against other fuels (in spite of NG positive characteristics and externalities,