Table 1: Natural gas consumption by sector.

Sector	1989-1994 (%)	1995-1999 (%)	2000-2004 (%)
Industrial	30	31	33.8
Residential/Commercial	28.6	33.1	32.3
Power generation	41.4	35.9	33.9

Table 2: Natural gas reserves and planned production.

Fields for Development	Gas-in-place (BCM)	Ultimate Recovery (BCM)	Planned Production (MCM/Day)
Baba-Gir	62.6	43.2	2.83
Tang-e-Bijar	115.6	80.8	5.66
Salakh	58.0	41.0	2.83
Suru	44.2	35.4	2.83
Shanool	328.5	246.4	18.69
Assaluyeh	265.0	192.3	14.16
Kabir-Kuh	1029.8	272.4	18.69
Kaman-Kuh	75.3	52.8	2.83
South Gasho	197.3	143.4	11.33
Mokhtar	168.0	90.7	7.08
West Namak	17.6	12.4	1.13
Varavi	66.7	54.1	5.66
Halush	14.0	10.9	0.57
South Pars	9506.0	7351.0	200.00
North Pars	1880.0	1504.7	100.00
Total	13828.6	10131.5	394.29

firms for developments in the Caspian Sea and Persian Gulf.

- Realization of the fact that developed countries are interested in securing their energy supply, lowering energy intensity by means of moving their energy intensive industries to abroad, and reduce their obligations to conform to the fossil-fuel related environmental issues. This point strengthens the position of oil producing countries for receiving the"technology-finance-market" package and provides the opportunity for investment companies to achieve their financial goals.

Conclusions

Several issues related to slow development of energy and an assessment of future developments have been discussed.To realize the benefit of the natural resources availability and to take advantage of the geographical locality, many infrastructural changes must be made in Iran. Inside the country, the growth of oil and gas industry must be harmonized with the growth of energy consuming sectors so that the offerings and needs of all sectors can be fulfilled simultaneously and the expected economic growth is achieved. At the international front, elements such as regional security, management of highly skilled people, risk management and insurance, protection for intellectual properties, worldwide accessibility mechanism, and communication technologies serve as the key components for attracting foreign financial investments and achieving the expected economic growth. Establishment of foreign relations for attracting capital investment, based on two-way profitability, is identified as a significant catalyst in the forecasted growth progress. In addition, it is realized that the compatibility of the contractual terms and conditions with internationally acceptable format for such activities is a necessity.

growth of energy consuming sectors so that the offerings and needs of all sectors so that the offerings and needs of all sectors can be fulfilled

References

Ardehali, M. M., (2000a), "Rural Energy Development in I.R. Iran: Problems, Resources, and Progressions", Conference, (Under Review).

Ardehali, M. M., (2000b), "Energy Efficiency Standards for Appliances and Industrial Processes Utilizing Oil and Gas", Third National Oil and Economics Congress Proceedings, Tehran.

Country Report 2nd quarter: Iran, (1998), Economist Intelligence Unit Limited, Paris.

Energy Balance, (1997), Ministry of Water and Power, Tehran.

Moshtaghian, A., (1997), " A Strategy for Gas Development in I.R. Iran 2000-2020", Proceedings of Persian Gulf Gas Resources, Tehran.

Ruthledge, I., and P. Wright (1999), "Companies as Sources for Upstream Oil and Gas Information", Journal of Energy Literature, Vol. V, June, 27-43.

Soheylipour, A., (1999), "Gas Industry Development in Iran", Proceedings of Persian Gulf Gas Resources, Tehran.

World Energy Council (WEC), (1995), Rural Energy in Developing Countries, WEC, London.

Xu, X., (1999), "The Oil and Gas Links between Central Asia and China: a Geographical Perspective", OPEC Review, Vol. XXIII, March, 33-53.

World Energy Outlook, (1998),International Energy Agency, Paris.

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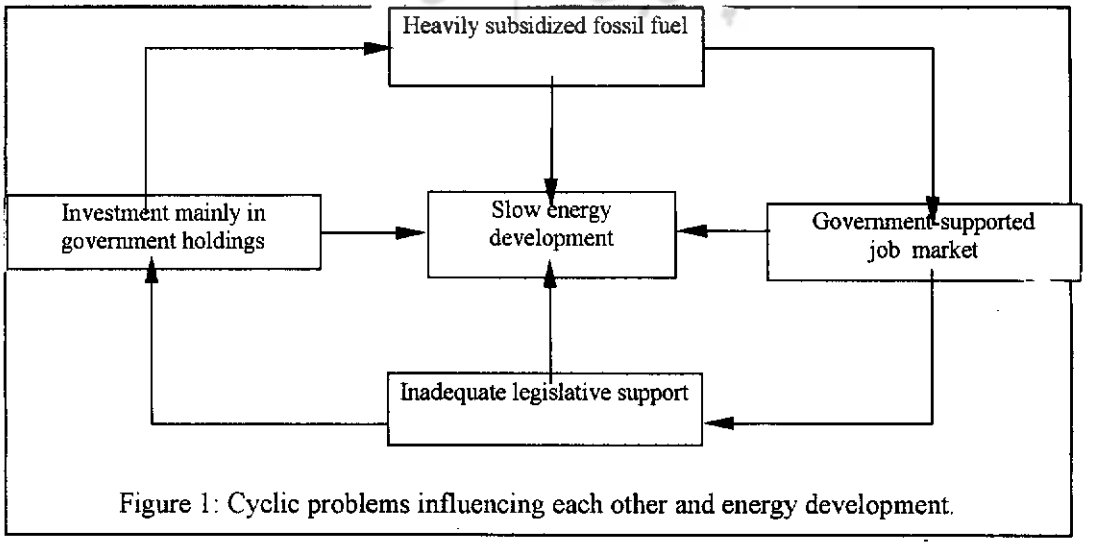

Figure 1: Cyclic problems influencing each other and energy development.

and Indian Ocean waterways (Fig. 3). Recently, many countries are making extensive efforts to participate in the distribution of gas across the world (Xu,1999), however, Iran's locality and ownership of both oil and gas provide the simple means for exchange at boarders. The strategic location of Iran allows for receiving oil and gas and shipping the same or equal at land or sea and conceptually, the country can serve as the transition center for a good share of nearly 70% of oil reserves available in the world with predicted potential income of $350 billion in 2050 (World Energy Outlook, 1998). These features can be viewed as opportunities for development and growth at the international level only when the security of this region is assured. The current government policies are focusing on creating positive atmosphere for dialogues and establishing working relationships with nearly all developed or developing countries, which should induce the needed security in the region.

The finance aspect of developing projects involves long periods of working with multi-national corporations and international banking and credit institutions, which requires the knowledge of managing highly educated multi-lingual groups of people. Also, due to the high volumes of oil and gas being displaced, there is a need for addressing necessary risk management and insurance for the participating firms and interacting countries. Therefore, procurement of international development projects mandates availability and adaptation of supporting services, such as, the latest worldwide accessibility mechanisms, communication technologies (Ruthledge and Wright, 1999), as well as specialized and trained personnel for processing information and data regarding fluctuations in the energy market and corresponding monetary issues.

It is estimated that annually 40% of the total energy consumed in the country can be conserved

For the purposes of renovating and stimulating the oil and gas industries in the country during the next twenty years, there is a need for foreign investment of $50 to $80 billion. It is estimated that, annually, $3 to $4 billion for maintaining crude oil production and $2 billion for expansion of the refineries and the distribution pipeline system, at three times the current capacities, is required.

Strategic Resource Development and International Marketing

The process of positioning the country at the level where resource potentials can be fully exploited requires systematic addressing of several management issues, including, establishment of long- and short-term goals, preparation of strategic market-sensitive planning and scenarios, development of realistic methodologies and action recourses designed for series and parallel execution, and adopting effective marketing mechanisms specifically designed for energy resources. As such, it is logical to expect meaningful cooperation and working relationships that are in accord with the needs of the country and the oil and gas clienteles. Because adequate supply of oil and gas and their timely availability are crucial to both the developed and developing countries, realization of their economic and political motivations and the fact that the bottom line can not be consequential and must be necessarily substantial to both participants is essential. Hence, the country's position can not be defined without regards for proper management methodologies and the worldwide economic and political atmosphere.

Since the beginning of 1980 and during the last decade, the economic and political changes have always had a direct or indirect association with energy resource matters in both the inside and outside of the country. For the purposes of forming strategies for attracting foreign investment and active participation in the market, the following issues must be addressed.

- Infrastructure changes in strategies and policies in pursuit of achieving economic goals along with establishment of international economic relationships as a basis for creating political stability.
- Creating commercial passageways and international banking opportunities.
- Reducing government involvement and privatization of production, distribution, and transportation of gas and oil.
- Promoting free-market economy.
- Providing the means for transfer of technology based on natural gradients.
- Establishing the international relations necessary for exchange of information.
- Designing a "technology-finance-market" package for foreign investment companies so that the goals of transfer of technology, financing, and international marketing can be achieved simultaneously.
- Inviting and serving as the participating manager of international

the future.

Though during the last decade, the gas production rate has been steadily higher than that of oil (Fig. 2), the share of natural gas is currently at 32% of total energy production in the country. In the near future, provided that there is sufficient funding available for full coverage by the pipeline network, natural-gas share of total energy distributed is expected to increase by 73% and that for oil is to decrease by 58%. As a result, the near-future energy needs are to be fulfilled by gas at 56% and oil at 41% of total. However, the success of replacing oil by gas depends heavily on the development of distribution-piping network throughout the country, as the demand for gas is growing beyond the distribution capabilities available.

The current natural gas consumption in the country is 290 million-barrel-of-oil equivalent per year (mboe/y). To offset the needs in 2015, provided that the South Pars, North Pars, and other gas fields (Table 2) (Soheylipour, 1999) are fully developed, the production of gas must be at 930 and 985 mboe/y based on 3.5 and 7% economic growth rates, respectively. It is certain that the associated costs for full development of these fields are beyond what the economy can afford and attraction of foreign capital investment is essential. The lack of such investments would force to maintain oil as the primary energy source in the country or plan on importing gas from one of the neighboring countries. Of course, as noted earlier, introducing energy management programs and conservation strategies would assist in reducing the energy intensity but would not be considered as a long-term alternative to developmental strategies.

Investment in Gas and Oil Projects

Maintaining the existing gas and oil plants in current production capacities and development and exploration for new resources, for the purposes of increasing production, mandate strategic financial planning based on several trends and observations.

First, in the past few decades, income from oil export has served as the key source for development of oil and gas related industries in the country, and any reduction in production has a direct influence on the future of such activities. During the pre-revolution period, the peak production rate of oil reached 6 million barrels of oil per day (mbo/d). After the revolution, a reduction by 37% in oil production lowered the peak to 3.8 mbo/d (Fig. 2). Focusing on recovery form the imposed war damages took a heavy toll on oil-production related issues and lack of acquiring gas-injection technologies for maintaining pressure in the oil wells has had negative effects on the availability potentials. Further, the war-induced damages halted production from the Persian Gulf installations and the production of 0.650 mbo/d from that region was introduced as an added load to the land installations and, as a result, difficulties associated with maintaining oil-pressure became worsened.

Second, the current laws and conditions for attracting foreign investments in the oil and gas industries are restrictive and do not allow for ownership of fields by foreign companies. The article 81 in the constitutive laws and, specifically, the fossil-fuel-related laws passed in 1987 prohibit any foreign participation in exploration, discovery, and production of oil and gas. Additionally, the imposed U.S. economic sanctions has not had a substantial influence on the production and export of oil, however, it has created some negative outlook for foreign investors to actively pursue the tremendous existing potentials. As a result, with respect to the political atmosphere at the international level and the current legal procedures in the country, the only successful mechanism for development has been the buy-back contracts with Asian and European companies. This type of contractual agreement is becoming more attractive, at the international level, as the economic goals and transfer of technology for the country and financial profitability for the foreign-investing companies are inherently weighted properly. However, the lack of protection for intellectual properties has been somewhat prohibitive for full-scale participation by large international firms.

Aside form political and legal problems, the economic situation is the country has partially been responsible for limited activities in development of new opportunities. The necessary prerequisite for enhancement of international participation and financial investment affairs is a steady and healthy economic growth in the country. Several factors, namely, inappropriate method of distributing subsidies, incompatibilities between legal procedure and processes for exporting non-oil products, unhealthy competition in the private sector, fluctuating foreign exchange rates, inflation rates, and under-developed markets in and out of the country have been responsible for the lack of steady economic growth at the national and international levels during past two decades.

Regardless of all the existing limitations, there are numerous advantages for establishing working relationship with Iran, for example, ownership of nearly 9% and 15% of world's oil and gas reserves, respectively, and strategic geopolitical and geographical location that provides access for the Central Asia to Europe as well as the newly formed Caspian ountries in the north to the Persian Gulf

1995). The heavily subsidized fuel prices allow for energy consumption rate in Iran to equal to world's average and several times higher than majority of developing countries. The low cost fossil fuel and electricity and gas make it impossible to have a reasonable payback period for implementing an energy efficiency measure such as building envelope insulation. In larger cities, the insufficient incomes can only be complemented with supplementary earnings from activities that require low cost fuel. The basic objective of energy development is to improve the economic and social well-being of people, and to redress the economic imbalances. Any form of energy development in the country must be (1) proportional to the present and future growth and (2) based on the availability and type of resources.

It is estimated that annually 40% of the total energy consumed in the country, 630 toe in 1997 (Energy Balance, 1997), can be conserved. The difficulty with high energy intensity stems from the fact that people do not separate out problems of energy from their other problems. Also in the process of industrialization, the transfer of technology has been primarily focused on energy intensive manufacturing processes, which has put a greater demand on internal consumption of energy produced.

In search for solutions, the key element to note is that fossil fuel resources are utilized to serve as a source for energy and as a national income distributed through subsides to people. The plan for enhancement of resource utilization should include two complementary stages, namely, (i) development of energy efficiency standards by the government and (ii) distribution of subsides as encouragement for participation in implementing the standards (Ardehali, 2000b). The needed systematic methodology to identify solutions and to promote efficiency requires tools such as demonstration facilities and development of performance indices and consumption standards for all sectors. In support for the efficient use of energy, the activities are to address energy requirements in the following sequence:

(a) Minimize the impact of the functional requirements,

(b) Minimize loads,

(c) Improve the efficiency of distribution and conversion system, and

(d) Integrate subsystems into an efficient whole.

More recently, upon reviewing and consulting with numerous energy efficiency laws and regulations from other countries, there is a special section of the law (Subsection of Provision 19 in the second- and third-five-year development plan) developed and written for promotion and implementation of energy efficiency matters in the country.

The basic objective of energy development is to improve the economic and social well-being of people, and to redress the economic imbalances

Economic Growth and Energy

The energy demand for economic growth rates of 3.5 and 7%, during a twenty year period, is estimated at 1500 and 2600 million barrels of oil per year (mbo/y), respectively, while the production of oil is anticipated to reach its peak between 2300 to 2500 mbo/y. (Moshtaghian, 1999). As a result, under the conditions of lower production rate of 2300 mbo/y and higher demand rate of 2600 mbo/y, there shall be a need for 300 mb/y that must be imported in 2015. The anticipated economic growth rate of 3.5% per year can not suffice the requirements of constraints imposed by population growth and increasing trends in changeover from rural to urban lifestyle. However, the prerequisites for reduction in unemployment rate, increase in job production, promotion of oil-free economics, and procuring of the financial needs for industrialization as well as the requirements of the noted constraints can only be met by an economic growth rate of 7% per year, at minimum. Due to the lack of oil availability for export in 2015 and the concurrently needed economic growth rate of 7%, a stringent planning for increasing the export of non-oil-based industrial products is in order. Clearly, as experienced by other developing countries, the process of industrialization in Iran is inevitably energy intensive (Table 1). However, enforcing energy efficiency standards and simultaneous implementation of energy management and conservation strategies in all sectors are regarded as practical solutions for lowering demand and consumption. Development of gas energy resources can not only help to solve oil-based energy shortages, but also serve as the key alternative to support the necessary economic growth rate. It is of note that with the 3.5% economic growth rate, the level of investment for expansion of the oil and gas resources and implementation of energy management and conservation strategies shall be limited, whereas, the higher economic growth rate would allow for achieving the goals of more sustainable economic development in

Assessment of Energy Sector and Development of Gas-Resources-Based Opportunities in I.R. Iran

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Abstract

The availability of gas resources in I.R. Iran, which has been estimated at 24 trillion m3, is speculated to serve as the effective means for augmenting the needed economic growth and development. Nevertheless, the existing cyclic socio-economic problems in the country are restrictive to the expected growth and long-term strategic planning is required to overcome them. Further, the country's position can not be defined without regards for proper management methodologies and the worldwide economic and political atmosphere. The objectives of this paper are to (1) identify factors responsible for slow energy development inside the country and (2) present an assessment of future economic developments based on utilization of gas resources in Iran for the next 20 years. It is concluded that the expected economic growth rate of 7% can be made possible, by attracting foreign financial investment, when regional security, management of highly skilled people, risk management and insurance, protection for intellectual properties, worldwide accessibility mechanism, and communication technologies are attained.

Introduction

Establishing the necessary grounds for utilizing the available energy resources in developing a stable economic growth rate has been recognized, and the newest role of the government in Iran has been to encourage and, whenever possible, assist in these endeavors. The objectives of this paper are to (1) identify factor responsible for slow energy development inside the country and (2) present an assessment of future economic developments based on utilization of gas resources in Iran for the next 20 years. There are many social and economic benefits that are gained from the use of needed technology for energy development in Iran. Realization of these benefits is an ongoing and changing process that must be sensitive to the specific technology itself and its potential for effective change or improvement. As depicted in Fig. 1, the factors responsible for slow energy development of the country are identified as (Ardehali, 2000a):

- Lack of understanding for importance of energy (heavily subsidized fossil fuel and electrical energy).
- Low and inconsistent income (nature of government-supported job market).
- Lack of proper management and adequate basic infrastructures for energy matters (inadequate legislative support).
- Uneven development within the country (investment mainly in the government holdings).

The causes for slow development are inter-related and they form a closed cycle making it difficult to approach problems on individual basis (Fig. 1). Of course, the key factor contributing to this phenomenon is the uneven development at the global scale as the government manages 87% of the economy (Country Report 2nd quarter: Iran, 1998). The single most influential reason affecting the energy development is the improper distribution of fossil fuel subsidies. Energy pricing policies should be reviewed so as to eliminate distortions that have created barriers to development (World Energy Council,