political, and legal supports while in fact will not be realized. Altering the Iran's petroleum act, ease in the political issues (US-Iran relations and the Middle East Peace Process), lead to an increase in the level of investment in the upstream of Iran's oil section. Absent of those conditions the expansion of Iran's oil production is likely to be restricted. Iran is hardly depended to the hard currency revenues of oil export. Resolving the above-mentioned problems in some extent is inevitable.

The same conditions can be drawn for other countries in the region of Persian Gulf. Then the high level of oil production potentials, which EIA/DOE has ascribed to these countries, would not be realized till 2020. Assumed a moderate increase of world oil demand, a gap between the demand and supply would adjust the price of oil on the base of cobweb theory of oil production expansion and price. This will provide the necessary funds for developing the oil production capacity. Supporting the development of oil production some political pressure on the burden of region's countries, especially Iran, will be declined. Further more inevitable Iran's oil opening will provide invaluable opportunities for the dexterous hand of international oil companies.

Conclusion

In this paper we analyzed the current situation of energy demand and oil supply in Iran. We drew the outlook of demand of energy basket up to 2020 via an econometric model. The projection on potential of Iran's oil production by other studies were analyzed and criticized technically and economically. Our result shows that on the base of current structure Iran would be a net oil importer in and after 2016. Achieving the potential of energy conservation would lead to delaying the alteration point. Still Iran would be a net oil importer after 2020 in conservation option. For staying, as an oil

The high level of oil production potentials, which EIA/DOE has ascribed to the Persian Gulf countries, would not be realized till 2020

exporter, Iran should persist on natural gas substitution policy for fueling the future and conservation program as well. Iran has a higher level of energy conservation potential with respect to other countries while our estimation is conservative. Other possibility would be oil production development which is restricted by OPEC quota, investment needs, political issues, domestic legal matters (Iran's Oil Act).

The paper came to the conclusion on the impacts of such a situation on the international oil markets; inevitable relaxation of Iran's legal restrictions on direct investment and finally Iran's oil opening with valuable opportunities for international oil companies as well as ease on political issues from all entities in the play.

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1- The views expressed in this paper are those of the authors and do not necessarily reflect the Iran's energy authorities.

2- For detailed information in this regards one could contact moghaddam@nioc.org.   ∎

Figure 3. Iran's oil export potential

Figure 3. Iran's oil export potential
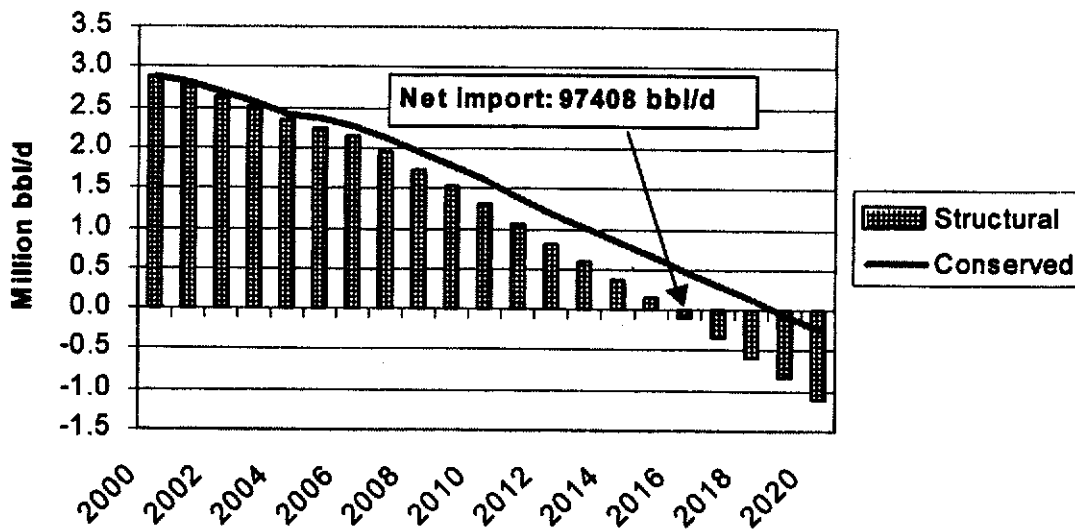
2020 respectively.

With a relatively extensive program of energy conservation the alteration in oil export would be delayed to 2019. In this scenario the level of oil import in 2019 and 2020 is expected to be 69 and 253 thousands bbl/d in 2019 and 2020 respectively. It is necessary to be pointed out that in the case of expanding the oil production capacity and resolving the OPEC quota restriction, "net oil importer" problem could be delayed for some years.

Legal issues

Delaying the alteration point, from an oil exporter to an oil importer country, could be handled via higher level of oil conservation and natural gas substitution in the demand side and increase in the level of oil production in the supply side. Current Iran's energy tags and energy saving rules along with other non-price polices can not guarantee achievement of considerable level of energy conservation. In addition the energy prices are highly subsidized and this policy can not be of benefit in the midterm. The higher level of energy prices the higher level of inflation, inflation expectation and social tensions are expected. Therefore the

With no efforts on energy conservation, despite domestic natural gas subsitution policy, Iran would be a net oil importer after 2015

chance of moderating the growth rate of energy demand in the demand side is low. While the natural gas substitution could save more oil for export. Iran can use natural gas in the transportation sector indirectly as well.

In the supply side the only option for delaying the alteration situation would be development of new fields and redevelopment of developed fields. It should be noted that the maximum durable peak production of oil is restricted technically. Capital investment per bbl of daily production capacity is between 2426 to 3275 US Dollars (EIA/DOE, 1996) demanding a huge amount of Capex. As a matter of fact this would be much higher for redevelopment projects.

For achieving the higher level of oil capacity, Iran should call foreign investment, which is currently faced with US's ILSA sanction. Furthermore Iran's constitution and the Petroleum Act forbid direct foreign investment in oil industry. Therefore Production sharing agreements (PSA), profit sharing (PS), concessions, and other type of direct investment can not be applied. At the time being the only authorized method is service contracts, namely buy back, which restrict the level of investment. Then a higher level of oil production, more than 4 million barrel per day, needs technical,

Figure 2. Iran's oil production projections

Primary-IIES ▨ Secondry-IIES ━━ EIA/DOE
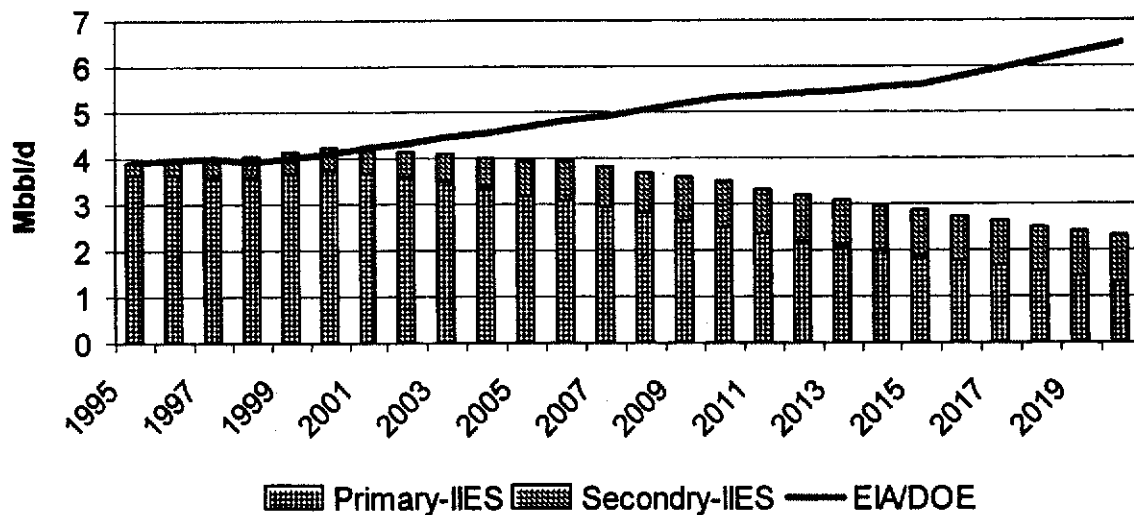
amount of Iran's oil production or it's potential in the years coming.

Naragi (2000) pointed that " If Iran is to maintain its current OPEC production shares of about 14%, then it is expected that the country's oil production must be increased to around 6.1 million barrel per day by 2007-2008". Considering a capacity utilization of 85 percent the production capacity should be about 7.2 million barrels per day in 2007-2008. The same has addressed by Iran's petroleum minister and deputy minister for exploration and production. The current production capacity of 4 million barrels per day should be nearly doubled by the end of next decade (Zangeneh, 2000; Mirmoezi, 2000).

The forecasts of EIA are questionably high and technical information of oil reserves in Iran does not support the quantities projected. In the low-price case the ascribed oil production potential for Iran is 4.7, 5.3, 5.6, and 6.5 million barrels per day by years 2005, 2010, 2015, and 2020 respectively. The figures are not supported technically and economically. The peak filed production, bopd, over the field size, MMbbl, for zagros Mesozoic Play in Iran, has estimated to be only 0.02 percent. This figure for the average yearly peak production is about 7 percent of field size (EIA, 1996). It should be noted that most Iranian oil fields have been

Total amount of energy conservation in the whole period will be about 7 billion BOE, which is a considerable amount of energy, equal to Azerbaijan proven oil reserve

developed before and are old. The natural decline of production for these developed fields is expected.

The oil production forecast based on field by field assessment has done by IIES. At the time being the Iran's production capacity of crude oil is about 4 millions bbl/d. Regarding the reduction of reservoirs pressure, the oil production in 2010 is expected to be less than 3 millions bbl/Day. If the National Iranian Oil Company (NIOC) would manage to develop all new fields the production in 2010 is estimated to be about 3.5 millions bbl/d. Continuing the natural decline of production of the reservoirs the production capacity would be about 2.3 million bbl/d by 2020 (IIES, 1997). Figure 2 shows the projected trends of oil production potential up to 2020 by IIES and EIA/DOE.

By the way two scenarios can draw the amount of oil for export. On the base of current structure and conservation program scenarios, on demand side, and the IIES projection on oil production, on supply side, the oil available for export is projected up to 2020. As figure 3 shows with no efforts on energy conservation, despite of domestic natural gas substitution policy, Iran would be a net oil importer in and after 2016. The amount of oil import is expected to be 97408 bbl/d and 1.11 mbbl/d in 2016 and

Figure1 . Iran's Primary energy basket up 2020
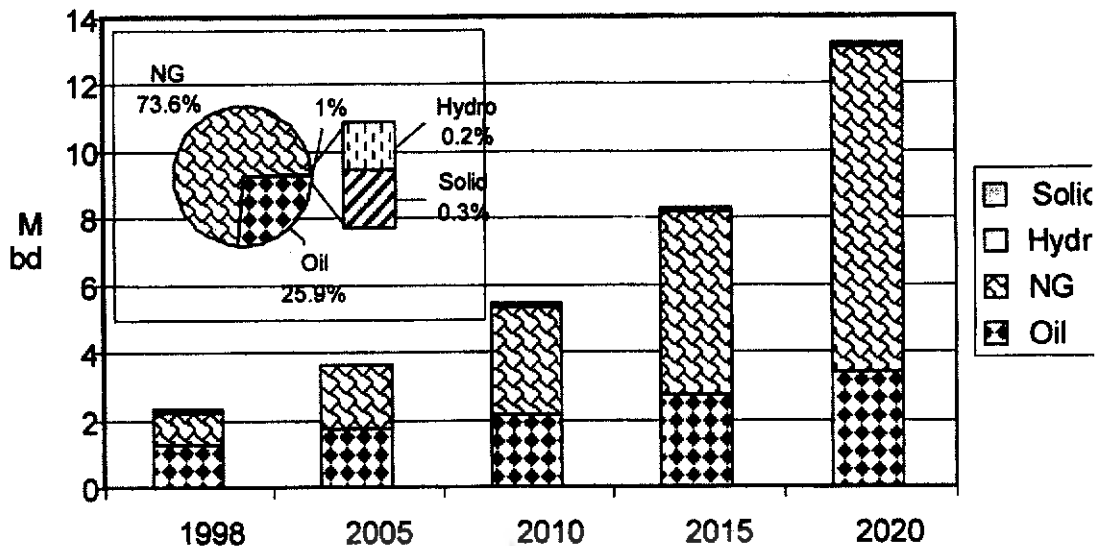
potential is cost-effective (considering opportunity cost) but it couldn't be achieved in the early years of conservation program. It is assumed that accumulated percentage will reach the full potential in 2020. This is a case of planning and it is related to the Iran's energy authority decision. Simply it is assumed that the policy makers allocate their forces to achieve the full potential in the target year of 2020. It is assumed that each year about1.5 percent of the whole potential will be gained.

One could ascribe the whole conservation to the energy carriers based on their shares in the basket. Based on this assumption total final conservation will be 30000 BOE per day in 2001 and will reach to 3 million BOE per day in 2020. Total amount of energy conservation in the whole period will be about 7 billion BOE, which is a considerable amount of energy, equal to Azerbaijan proven oil reserve, (BP, 1998). The potential of oil saving in the whole period in the final energy demand level will be about 2.2 billion BOE.

Considering the conservation potential of energy sub-sector one could calculate the optimal basket of primary energy demand labeled as conserved scenario. We considered 10 percent conservation potential for electricity generation and transmission

Given a GDP growth rate of 3.6 percent per annum, total primary energy demand will reach 13.2 MBOE per day in 2020 from 2.2 MBOE in 1998 indicating an annual growth rate of 8.6 percent

losses on the basis of international experiences. Also five percent of oil feed in the base year of 1998 was considered as potential for petroleum refineries. It is assumed that these percentages will be gained fully by 2020.

Total conservation in the energy sub-sector will be about 1 billion BOE. The oil conservation potential in this sector will be about 352 MBOE for whole period. Based on oil shares in final basket, transmission, and transformation sectors, the potential of oil conservation is estimated. It will be 20 thousand barrel of oil per day in 2001 and 580 thousand barrel per day in 2020. Total possible conservation for oil will be about 2.6 billion BOE for the whole period.

3.4 Possible oil available for export

In order to forecasting the potential of oil for export, the projection of domestic oil production is driven from other studies. The forecast of oil production is an economical-technical issue, which in turn makes the projection uncertain. The Institute for International Energy Studies (IIES, 1997), Energy Information Administration (EIA/DOE, 2000), and National Iranian Oil Company (NIOC) and other researchers have forecasted the

Table 4. Average annual growthrate of variables involved in the model

Period	1974-1998	1988-1998	1995-1998	1999-2020
Population	2.8	2	2.2	2
Urban population	4	2.8	2.1	2.8
Rural households	1.3	1.1	2.5	1.1
GDPm82	2.1	5.1	3.6	3.6
Liquidity	22.3	23.9	23.2	24
Inflation	18.4	21.4	18.4	Forecast of model
Energy price*	14.4	21.4	23.8	10
Products demand	5.6	3.3	1.3	Forecast of model
Natural gas demand	14	18.1	12.6	Forecast of model
Electricity demand	8.9	7.6	5.5	Forecast of model
Total Final Energy Demand	7.2	6.8	5.2	Forecast of model
Total primary Energy demand	7.2	6.4	4.7	Forecast of model
Energy intensity	5.1	1.6	1.7	Forecast of model

* Weighted average

covers, LPG, jet fuel, kerosene, gasoline, gas oil, fuel oil, natural gas, electricity, and solid fuels. The model is formulated for final energy demand, which the output is inputted to the model of transformation and transmission. Therefore the model is able to forecast the final and primary energy demand up to 2020 (Moghaddam, 2001[2]).

3.2 Primary energy demand forecast

The scenario labeled as "structural" means that the economy as a whole would not practice drastic changes i.e. the average growth rate of exogenous economic variables would be the same as average of these variables within whole period or the recent years after ceasing Iran-Iraq war in 1988. On

the base of Table 4 the structural scenario is drawn.

On the base of the above-mentioned information and the current efficiency of the transformation and transmission sector the structural scenario is constructed and the demand of primary energy is forecasted up to 2020. Table 5 contains the primary energy demand forecast by fuel type.

Given a GDP growth rate of 3.6 percent per annum, total primary energy demand will reach to the level of 13.2 MBOE per day in 2020 from a level of 2.2 MBOE in 1998 indicating an annual growth rate of 8.6 percent.

Despite of natural gas substitution the demand of oil will reach to the level of 3.4 million barrel per day in 2020 from 1.3

million barrel per day in 1998, indicating a growth rate of 4.6 percent per annum. As figure 1 shows in the course of time the primary energy basket will be changed in the benefit of natural gas. Natural gas will get a share of 73.6 percent assuming continuing the current policies, as it is.

3.3 Energy conservation

Considerable potential of technical energy conservation is available in Iran. Considering the opportunity cost of energy the potential for economic conservation is still considerable. The potential for residential, commercial, industry and transport sectors is more than 30 percent of 1998 energy consumption, which is considerable. Although this amount of

Table 5. Demand of primary energyin Structural scenario*

Unit: MBOE

Year	Oil	NG	Hydro	Solid	Total	Total /day
1998	467.41	337.23	4.63	10.4	819.67	2.2
Share	57.0	41.1	0.6	1.3	100	100
2005	626.4	676.49	6.22	11.2	1320.31	3.6
2010	787.62	1155.2	7.67	11.7	1962.19	5.4
2015	989.65	1994.07	9.47	12.3	3005.49	8.2
2020	1243.76	3540.73	11.68	12.9	4809.07	13.2
Share	25.9	73.6	0.2	0.3	100	100
Growth rate 2000-2020	4.6	10.8	4.3	1	8.3	8.3

* It is assumed that the policy of natural gas substitution by oil will be continued.

Table 2. Iran's energy intensity

BOE/ Million Rials

	1977	1980	1985	1988	1990	1995	1996	1977	1998	1977-98 %	1988-98 %
Primary	22.4	26.4	33.9	39.7	47.5	52.6	52.0	54.2	54.7	4.3	3.2
Final	18.5	22.2	28.0	32.7	37.2	40.0	40.4	41.8	42.2	3.9	2.5

Source: Energy Balances of Iran, Ministry of Energy, 1999;Collective economical and social data of time series of Iran 1997, PBO [in Farsi]; Iran's economic reviews of 1998, [In Farsi], Central Bank of Iran, 1999. GDP is in constant price of 1982.

growth rate of 1.3% within 1977-1998.

Energy intensity

For each million Rials of Production (GDP 1982 constant price) about 22.4 BOE of primary energy was consumed in 1977; it reached 54.7 BOE in 1998 (see table 2). The annual average growth rate of primary energy intensity was 4.3% and 3.2% within 1977-1998 and 1988-1998 respectively. The growth rates for final energy intensity was 3.9% and 2.5% in the same periods. Despite some fluctuations in recent years, the trend of energy intensity has been increasingly.

Energy prices and subsidies

Although Iran's economy has practiced a pseudo market mechanism but the government intervention has been increasing especially after revolution of 1978. This makes a great distortion in pricing and in turn misallocation of resources. The main adjustments in the price of energy were started in the second five-year plan (1995-1999). These adjustments have approved to be continuing in the third

five-year plan (2000-2004). The price of gasoline based on Rial value has increased 34% per year over 1994-2000 where it has increased 14.9% per year based on Dollar value. This is due to Rial devaluation (see table 3).

The domestic price of gasoline, kerosene, gas oil, and fuel oil was 4.7, 1.3, 1.3, 0.7, US cents in 2000. In addition, the price of electricity and natural gas were 62 Rials (3.5 USS-Cent) per kWh and 39.4 Rials (2.2Cents) per cubic meter in 1998. For comparison the price of premium leaded gasoline in OECD Europe was 89.7 USS-cent in 1999. For Norway and France it has been 1.065 USS 0.901 USS in this year (IEA, 2000). Furthermore the international price of gasoline, gas oil and fuel oil in Rotterdam market in 1999 was 13.6 USS-Cent, 13.78 USS-Cent, and 6.11 USS-Cent respectively (ASB, 1999).

The average annual growth rate of inflation was 23.7% within 1990-1999 whilst this was 24.7% for energy prices indicating a low increase rate of real price of energy as a whole.

Energy subsidies based on market, export, and official exchange rates have estimated about 15.02, 13.63, and 11.64 billions of US Dollars respectively in 1997. Supposing the market exchange rate as realistic rate, total implicit energy subsidies in Iran has amounted 106.2 billions of US Dollars within 1990-1997 indicating an average of 13.3 billions of U.S. Dollars per year (Fattollahzadeh, et. al, 2000).

Outlook to 2020

In the last sections the current situation of Iran's energy was analyzed. In the following via developing an econometrics energy demand model the outlook of energy demand, oil production and available oil for export is forecasted assumed continuing the current energy situation as well as in the conserved scenario.

3.1 The model

The forecasting Iran's energy demand model is an econometric fuel model, which

Table 3. Iran's nominal petroleumproducts price

Year	Gasoline	Kerosene	Gas oil	Fuel oil	LPG	Jet fuel
	US$-Cent per liter (market exchange rate)					
1994	1.9	0.6	0.4	0.2	1.0	0.9
1995	2.5	0.5	0.5	0.2	0.7	0.7
1996	2.9	0.7	0.7	0.3	1.2	0.8
1997	3.3	0.8	0.8	0.4	1.4	1.0
1998	3.1	0.8	0.8	0.4	1.4	0.9
1999	4.2	1.2	1.2	0.6	1.5	0.9
2000	4.7	1.3	1.3	0.7	1.6	1.0
G1994-2000	14.9	14.1	20.8	20.8	7.8	1.1

Source: Energy Balance of Iran, 1998; Mazraati, 1999; economic trends, Central bank of Iran, 1999

econometric model. Also the potential of domestic oil production are criticized on the base of different studies. This leads to an estimation of oil available for export up to 2020. Section 4 analyzes some legal issues of direct investment on Iranian oil industry and the problem of sanction. Last section concludes.

Current Iran's energy situation analysis

The Iranian economy is characterized by a large share (51.2% in 1998) of young people, a high population growth (1.5% within 1986-96), fast growing cities, a high rate of unemployment, a low rate of GDP growth with an even lower rate of productivity, low rate of investment, and a high rate of consumption. Iran's economy depends heavily on export income from its main resource oil. Focusing on the energy sector some energy economics variables and indices are reviewed.

Reserves

In situ reserves of oil in Iran are about 521.4 billion barrels, of which 86.4 billion barrels is recoverable in primary and secondary production. With the current level of technology, production-reserve ratio is about 60. This is equal to 8% of world reserves and 10% of OPEC's reserves. Reserve of natural gas in Iran is about 24.3 trillion Cubic Meter (TCM) or 857 Trillion Cubic Feet (TCF), which is equivalent to 148 billion bbl of crude oil. With the current level of production and technology, Iran's production-reserve ratio is about 160 years.

Iran also has a large potential of other energy resources including coal, hydroelectricity potential, solar, and wind which are estimated 12.7 billion tons, 42000 megawatt, of which only 4.7% is under production, 130 billion barrel of oil equivalent, 6,500 megawatt respectively (Ministry of energy, 1999).

Energy consumption

From 1977 to 1998, consumption of primary energy has increased more than 337 percent, from 243.3 to 849.5 million BOE (barrel of oil equivalent). The average annual growth rate of primary energy was about 5.9 percent with in 1977-1998. The oil and natural gas provide more than 97 percent of Iran's primary energy supply.

As Table 1 shows the major source of energy, crude oil, supplied to meet domestic national demand has grown from 551 thousands bbl/day in 1977 to 1.33 Mbbl/day in 1998. The average annual growth rate of domestic supply of oil within 1977-1998 has been about 4.2%, however its share in domestic energy basket has come down from 82% in 1977 to 57.6% in 1998 which is still considerable.

Since Iran has an abundance of natural gas (24 TCF which is 15.8% of world reserves and 1.7 time more than proven extractable oil reserves), a major change in the domestic energy market over the last decade has been the replacement of oil products by natural gas. Primary consumption of natural gas in 1998 (340.6 MBOE) is about 10.9 times more than in 1977(31.6 MBOE). The average annual growth rate of primary natural gas consumption within 1977-1998 was 11.3 percent while in recent years it has been 15.5 percent. The policy of development of natural gas market prompted after ceasing the Iran-Iraq war in 1988.

The shares of hydroelectric energy, solid fuels (such as coal), non-commercial (wood and charcoal) fuels in total primary energy consumption are 1.5%, 1.2% and 0.5% respectively denoting the low share of these energies in the primary energy basket.

Primary energy is supplied into the domestic energy sector, then transformed and transmitted to the final sectors. The waste and fuel of energy sector has increased from 43.5 MBOE in 1977 to 190 MBOE in 1998 indicating an annual 7.1% and 10% growth rates within 1977-98 and 1988-98 respectively. The ratio of waste & fuel of energy sector to the primary energy consumption has grown from 17.4% in 1977 to 22.9% in 1998 indicating an annual

Table 1. Iran's primary and finalenergy basket

Unit: MBOE

Energy carriers	1977	1980**	1985	1988*	1990	1995	1996	1997	1998	Growth % 1977-98	Growth % 1988-98
Crude oil	201.3	216.4	325.9	318.9	330.5	458	484	482.7	486.7	4.2	4.2
Natural gas	31.6	29.3	57.6	72.5	140	286.2	282.1	305.3	340.6	11.3	15.5
Hydroelectric	6.6	8.8	8.7	11.4	9.5	11.3	11.5	10.5	10.9	2.4	-0.4
Solid fuels	0.3	4.1	4.9	6.4	2.7	8.9	7.4	6.9	8.3	15.8	2.6
Non-commercial	3.5	3.4	3.5	3.4	3.2	2.7	2.1	3.1	3	-0.7	-1.3
Total Primary	243.3	262	400.6	402.1	485.9	752.3	752.5	818	849.5	5.9	7.5
Waste & fuel	43.5	39.4	68.1	70.8	109.3	174.5	170.1	186.6	193	7.1	10.0
Of primary %	17.4	16.0	17.3	17.6	21.6	23.9	22.3	22.8	22.9	1.3	2.6
Total Final	207	207	325	331	397	555	593	633	651	5.5	6.8

Source: Energy Balances of Iran, Ministry of Energy, 1999

* * Starting war; * Ceasing war

Would Iran be a net oil importer up to 2020 ?

International and national Impacts[1]

Mohammad Mazraati (Ph.D.)

Energy Economist

Institute for International Energy Studies

Mohammad Reza Moghaddam (M.Sc.)

Iran's Ministry of Petroleum

Abstract

This paper deals with the current situation of energy demand and oil supply in Iran with an outlook to 2020. Considering the trend of oil demand and production the potential of oil for export is estimated. The final and primary energy demand is forecasted via an econometric model while the potential of oil production is taken from other studies. The EIA/DOE outlook for Iran's oil production is technically and economically questioned. The development of oil production is considered with the problem of direct investment on Iran's oil industry and impossibility of applying the PSA, PS, and Concession contracts. Finally the paper concludes that, Iran would be a net oil importer in and after 2016 assumed current structure be continued. Conservation efforts, with an accumulated 30 percent of the consumption level in 2020, will delay the alteration point to 2019. The possibilities for being an oil exporter would be more energy conservation, fueling the future via more natural gas substitution, and increasing the level of oil production. The lattermost calls ceasing some political issues, adjusting Iran's oil act and more competitive presence of international oil companies in Iran's oil industry, given sanctions relaxed.

Introduction

Iran is a prominent member of OPEC and its main export commodity is crude oil. For many years Iran subsidizes domestic energy use and its prices are among the lowest in the world. As a result, the energy intensities of Iran's economic sub-sectors that resulted from domestic energy policies increased rapidly and are high compared to other countries.

The domestic primary energy consumption has grown from 0.312 MBOE per day in 1967 to 2.42 MBOE in 1998, most of which is met by oil products (Ministry of energy, 1999). This has resulted a domestic demand for oil of 1.33 million barrels per day. As a member of OPEC, Iran's total crude oil production is restricted by OPEC quota. The increase in domestic oil consumption limits the amount of oil that can be exported. The available oil for export would also be affected by decline in the level of oil production.

Domestic primary energy reserves, production, consumption, and energy intensity along with the prices of energy and implicit energy subsidies identify the situation of Iran's energy sector. Section 2 covers all the above-mentioned issues. Section 3 discuses the future situation of energy demand basket via developing an