

*Iranian – German Cooperation Project*

## **Energy Scenarios for Iran**

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**Science Centre  
North Rhine-Westphalia**  
Institute of Work  
and Technology



Institute for Culture  
Studies  
**Wuppertal Institute for  
Climate, Environment and  
Energy**



 **HEINRICH  
BÖLL  
STIFTUNG**

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Moreover the following workshops and seminars have held:

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4. Workshop in Berlin on 17 – 21 Nov., 2008
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#### Project Team:

 <p><b>Prof. Mohammad Hassan Panjeshahi</b>  <a href="mailto:mhpanj@ut.ac.ir">mhpanj@ut.ac.ir</a></p> <p><b>Dr. Saeed Moshiri</b>  <a href="mailto:moshiri@cc.umanitoba.ca">moshiri@cc.umanitoba.ca</a></p> <p><b>Dr. Farideh Atabi</b>  <a href="mailto:far-atabi@jamejam.net">far-atabi@jamejam.net</a></p> <p><b>Dr. Esfandiyar Jahangard</b>  <a href="mailto:jahangard@atu.ac.ir">jahangard@atu.ac.ir</a></p> <p><b>Mr. Kioumars Heidari</b>  <a href="mailto:gumars_h@yahoo.com">gumars_h@yahoo.com</a></p>	<div style="display: flex; justify-content: space-between;"> <div style="text-align: center;">  <p>Science Centre North Rhine-Westphalia Institute of Work and Technology</p> </div> <div style="text-align: center;">  <p>Institute for Culture Studies <b>Wuppertal Institute for Climate, Environment and Energy</b></p> </div> </div> <p><b>Dr. Stefan Lectenboehmer</b>  <a href="mailto:Stefan.lectenboehmer@wupperinst.org">Stefan.lectenboehmer@wupperinst.org</a></p> <p><b>Mr. Dieter Seifried</b>  <a href="mailto:seifried@oe2.de">seifried@oe2.de</a></p> <p><b>Dr. Nikolaus Supersberger</b>  <a href="mailto:nikolaus.supersberger@wuperinst.org">nikolaus.supersberger@wuperinst.org</a></p> <hr/> <div style="text-align: center;">  <p>UNIVERSITÄT OSNABRÜCK</p> </div> <p><b>Prof. Mohssen Massarrat</b>  <a href="mailto:mohssen.massarrat@uos.de">mohssen.massarrat@uos.de</a></p>
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## **Part I**

**Demand for Energy:  
Business As Usual Scenario**

# **Part I: Demand for Energy in the Business As Usual (BAU) Scenario**

## **1. Introduction**

Energy is becoming increasingly important in the world economy as demand is rapidly rising and supply of hydrocarbon resources is more restricted. Iran is the largest country in the Middle East and as an energy rich country, with 11 percent of the global oil reserves, and 15.3 percent of the global natural gas reserves (second only to Russia). It plays an important role in world energy supply and hence in the global economy. However, Iran has had trouble in capitalizing on its vast resources. It has been experiencing a rapid economic growth for the past two decades, leading to an increasing trend in domestic demand for energy. Iran's generous subsidies program in the energy sector has also contributed to growing energy consumption. Although higher energy consumption may contribute to economic growth, it would restrict economic activities as the oil exports shrink. The Iranian economy is heavily dependent on oil exports revenues as oil exports account for half of the gross government revenues and about 80 percent of the country's total exports earnings. On the supply side, Iran has not been able to catch up with the increasing trend in demand leading to a shortage of energy in industry, transport and residential sectors. Iran is now facing serious challenges in the economy and the energy sector, imminent of which are price reforms by removing heavy subsidies in the energy market and attracting foreign investments to boost its oil and natural gas production and exports. Iran also needs to find a way on how to make optimal use of the

oil revenues in the economy and to invest in ample renewable energy sources. This study intends to tackle some of these challenges and to explore alternative scenarios for utilization of energy resources in Iran in the long run.

### **1.1. Objectives**

The main objective of this study is to analyze alternative scenarios for the energy consumption in Iran for the next 25 years. To this end, the study models the Iranian energy sector and projects a Business As Usual (BAU) scenario taking into account the past trends as well as the future policies and developments in the economy and the energy sector. The study also identifies the potentials for sources of energy conservation and renewable energy, and projects efficiency scenarios for the next 25 years. The outcome of the study will help authorities set up policies to optimize the use of energy and to protect environment without compromising the standard of living.

### **1.2. Methodology**

The main method of the study is the bottom-up approach in which demand side dynamics are modeled using a computational model and the detailed data from different sectors of the economy. In some cases, where the time series data are available, the regression method is also employed to estimate and forecast future values of the variables. The model is first used to calculate a BAU scenario as a scenario that extends the past trends of the economy and the energy sector into the future taking into account the future policies. In the second part of the study, alternative scenarios for energy demand with regard to obtaining higher efficiency and utilizing renewable sources are designed and simulated for the next 25 years. The bottom-up method produces reliable

results in long term scenario analysis as it relies on the fundamental factors, which are not subject to short-term fluctuations . The shortcoming of this approach is that its results depend on many assumptions about the structure of the economy. However, making sound assumptions and scenarios that are more realistic may help alleviate the problem.

### **1.3. Research Organization**

The study has been conducted jointly by the Iran Energy Association (IEA) and the Wuppertal Institute for Climate, Environment, and Energy (WI). To carry out the project, two teams from each institute were organized in the following groups.

1. Steering Committee
2. Project Leader
3. Project Manager
4. Technical Manager
5. Study Team
6. Consultants
7. Research Assistants
8. Secretaries

The research team members met regularly in workshops to exchange the ideas and to review the research method and outcomes. The study started in January 2006 and ended in December 2008.

## **2. Economy and Energy in Iran; an Overview**

In this section, the current conditions of the Iranian economy and its energy sector will be briefly reviewed to set a ground for the BAU scenario analysis.

### **2.1. Macroeconomic Structure and Trends**

#### **2.1.1. The Structure of the Economy**

Iran became Islamic Republic in 1979 after the ruling monarchy was overthrown by the Islamic Revolution. The new constitution became effective on 2-3 December 1979, and was revised in 1989 to expand powers of the presidency and eliminate the prime ministership. The governing system consists of the Supreme Leader elected by the Assembly of Experts, the Majlis (Shoura'e Islami) or parliament, the judicial branch, and the executive branch headed by the elected president.

In addition to the three major branches in the governing body, there are also three oversight bodies as follows: Assembly of Experts, Expediency Council, and the Council of Guardians. Assembly of Experts, a popularly elected body of 86 religious scholars constitutionally charged with determining the succession of the Supreme Leader (based on his qualifications in the field of jurisprudence and commitment to the principles of the revolution, reviewing his performance, and deposing him if deemed necessary). Expediency Council is a policy advisory and implementation board consisting of permanent members, who represent all major government factions and include the heads of the three branches of government, and the clerical members of the Council of Guardians. The permanent members are appointed by the Supreme Leader for five-year terms, and the temporary members, including Cabinet members and Majlis committee chairmen, are selected when issues under their jurisdiction come before the



Expediency Council. The Expediency Council exerts supervisory authority over the executive, judicial, and legislative branches and resolves legislative issues on which the Majlis and the Council of Guardians disagree. Since 1989, it has also been used to advise religious leader on matters of national policy. Council of Guardians of the Constitution is a 12-member board made up of six clerics chosen by the Supreme Leader and six jurists selected by the Majlis from a list of candidates recommended by the judiciary, which in turn is controlled by the Supreme Leader, for six-year terms. This Council determines whether proposed legislation is both constitutional and faithful to Islamic law, vets candidates for suitability, and supervises national elections.

According to the article 44 of the constitution, the economy is divided in three sectors: Public, Cooperative, and Private. The public sector is in charge of the public and national institutions and enterprises such as the national oil and gas companies. The cooperative corporations are supported by the public sector, but run privately.

There have been four Five-Year Development Plans (FYDP) since the beginning of the Islamic Republic, the last of which started in 2004 calling for privatization and economic reforms. There is also a 20-year vision calling for rapid socio-economic development of the country.

### **2.1.2 Macroeconomic Trends**

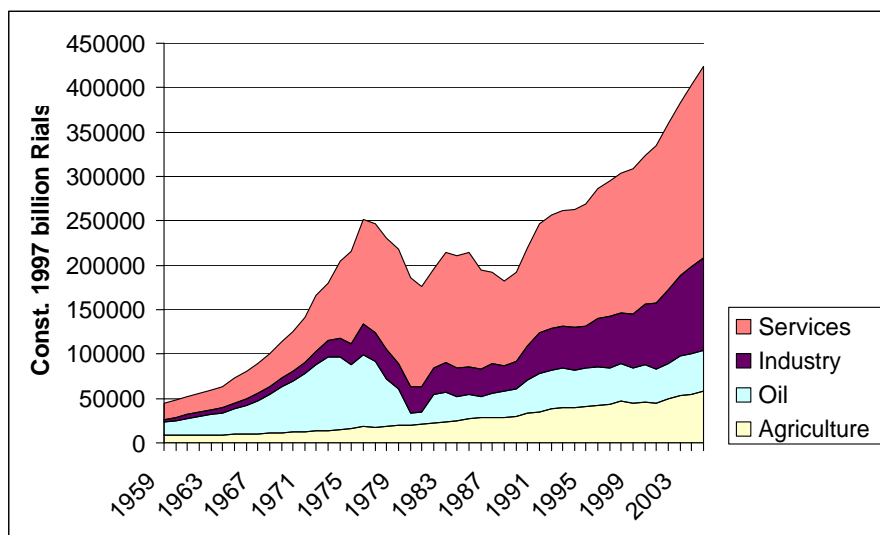
With an area of 1,648,000 km<sup>2</sup>, Iran ranks 16<sup>th</sup> in size in the world. The main mountain chain is the Zagros Mountains, a series of parallel ridges interspersed with plains that bisect the country from northwest to southeast. The only navigable river is Karun, where shallow-draft boats can commute from Khoramshahr to Ahvaz, a distance about 180 km. The most important water bodies are the Persian Gulf, in the south, and the Caspian Sea, in north. Iran has a very diverse climate. In the North West, winters are cold with

heavy snowfall and subfreezing temperatures. In the south, winters are mild and the summers are very hot. In most part of Iran, the yearly precipitation averages 250 mm. The major exceptions are the higher mountain valleys of the Zagros and the Caspian Sea coastal plain, where precipitation averages at least 500 mm annually.

Iran's economy is a mixed economy in which oil and other large enterprises are owned and run by the state, and agriculture, small-scale trading and service ventures are mostly run by the private sector. In spite of diversification policies, the Iranian economy is still heavily dependent on oil exports earnings. Currently, oil exports account for 80 percent of total exports earnings; nearly 50 percent of the government revenue and 23 percent of GDP. Continued favorable conditions in the world oil market have improved the external financial conditions quite considerably. However, the challenge still remains to make the best use of oil revenues, to promote growth and to further diversify the economy. Despite relatively high oil exports revenues, Iran continues to face budgetary pressure. Poverty reduction and heavy subsidy content of budget for basic goods and energy leave the government with inadequate resources for development purposes. Inefficient public sector, state monopolies, and economic sanctions also add more budgetary constraints. Diversification of the economy and energy-related activities require the creation of a more favorable investment environment for both local and foreign investors.

GDP grew annually by 6.15 percent on average in 2001-2004, but slowed down by about 1 percentage point since then. Although the recent economic growth rates are relatively high, thanks to the high oil prices, they are lower than the government targets under the third and the fourth five-year development plans. The estimated GDP for 2006 is US \$599.2 billion(purchasing power parity), ranking 22<sup>nd</sup> in the world, but GDP per

capita is US \$8700, ranking 98<sup>th</sup> in the world (Table 2.1)<sup>1</sup>. Agriculture accounts for 11.2 percent of the GDP, industry 41.7 percent and service 47.1 percent. The oil revenue plays significant direct and indirect roles in the entire economy (Figure 2.1).

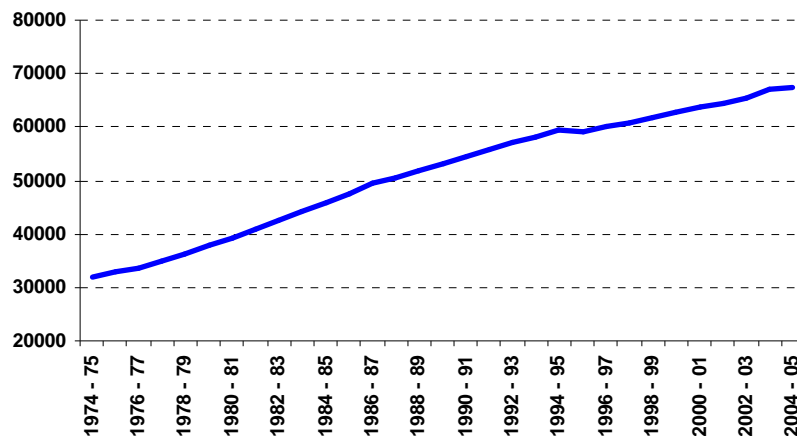


**Figure 2.1. GDP and its Components, Constant 1997 billion Rials**  
Source: IELDB (2005) & Central Bank of Iran (2005)

Population was 70.5 million in 2005, with 48.3 million people living in urban areas and 22.2 million people in the rural areas. The recent population growth has been on average 1.3 percent per year, after very high rates of above 2 percent in the 1980s (Figure 2.2). The population density is 42.2 persons per square kilometer. Active population is 23.1 million, and unemployment rate is about 12 percent, but it is twice as much among youth. Inflation has been in the range of 13-15 percent per year for the period 2000-2004, but has been rising since then with the oil price hike. The price change has been much higher in housing, health care, and recreational activities. The

<sup>1</sup> GDP and GDP per capita using the exchange rate method are \$158.6 billion and \$2,280, respectively (IMF staff report for 2005)

current account balance is about US \$12 billion and the trade balance about US \$15 billion. The total external debt amounts to about US \$24 billion. Iran exports petroleum (80 percent), chemical and petrochemical produces, fruits and nuts, and carpets to Japan (17%), China (11.2%), Italy (6%), South Korea (6%), Turkey (6%), Netherlands (4.6%), France (4.4%), South Africa (4.1%), and Taiwan (4.1%). The imports consist of industrial raw materials and intermediate goods, capital goods, foodstuffs and other consumer goods, technical services, and military supplies. Iran imports from Germany (13.9%), UAE (8.4%), China (8.3%), Italy (7.1%), France (6.3%), South Korea (5.4%), and Russia (4.9%).



**Figure 2.2. Population (1000 persons) of Iran 2005**  
Source: IELDB 2005

**Table 2.1. Economic Indicators of Iran at a Glance, 2005**

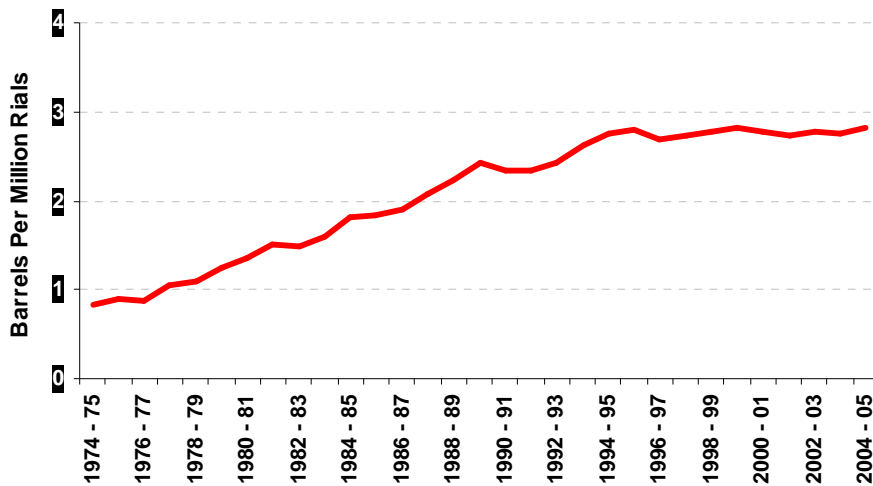
GDP (PPP, \$b.)	US \$ 599.2
GDP per capita	US \$ 8700
Inflation Rate (%)	12
Population (m)	70.5
Unemployment Rate (%)	12
Age structure	0-14 years (31.5%); 15-64 years (63.8%); 65 years and over (4.7%); male/female ratio=1.03
Life expectancy	70 years (male=69 years; females=72 years)
Total fertility rate	2.2 children/woman
Literacy (6 years and over)	87.1 %

*Source: Central Bank of Iran, 2006*

## **2.2. An Overview of the Energy Sector**

Iran is a resource rich country with immense oil and gas reserves. It, however, faces serious challenges to capitalize on its resources because of poor policies, lack of efficiency, and barriers to foreign investment. Iran has the world third, and the Middle East second, largest proved oil reserves with 132.5 billion barrels of oil, and the world second largest proved natural gas reserves with 26.62 trillion m<sup>3</sup> natural gas. In 2005, the total primary energy production was 2120.9 million BOE, 121.6 million BOE imported, and 1185.1 million BOE exported. The oil production in 2005 was about 4 mbl/day, from which 2.5 mbl/day exported. Iran is the world's fourth, and OPEC's second largest oil exporter. Natural gas production in 2005 was 83.54 billion m<sup>3</sup> (bcm), ranking seventh in the world. Iran exported 3.56 bcm to Turkey, but imported 5.2 bcm from its Northern neighbors. The total electricity generation capacity in the country was

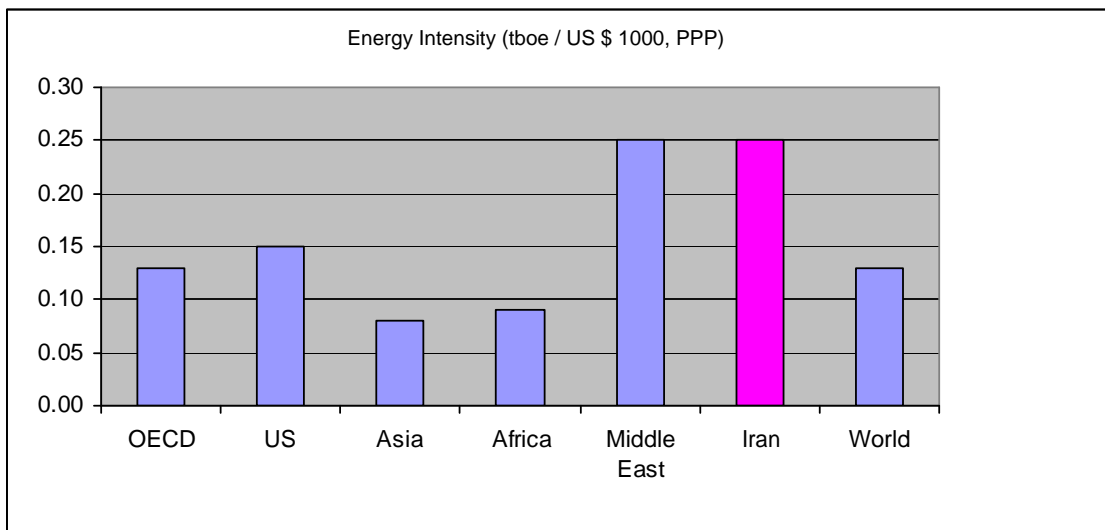
37.3 GW, out of which 40.8 percent generated by steam, 44.3 percent by combined cycles, 13.4 percent by hydro, and 1.5 percent by renewable energy sources (wind, solar, and others). The electricity production in 2005 was 186 billion kWh, ranking 21<sup>st</sup> in the world.



**Figure 2.3. Energy Intensity in Iran, Constant 1997 prices**  
Source: Energy Balance, 2005

The total primary energy consumption in 2005 was 970 million boe. The share of households of the total primary energy consumption was 27 percent, industry 14 percent, transport 22 percent, others including agriculture, public, and commercial 9 percent, and power generating plants 28 percent. The higher shares of energy consumption by transport and households are somewhat consistent with the energy subsidies received by these sectors from the government. Transport received 42 percent of the energy subsidies, household 30 percent, and industry 13.5 percent.

The energy consumption indicators and efficiency measures in the past decades show an increasing trend of energy consumption as well as high level of inefficiency. The energy use per capita has been increasing on average by 5 percent annually for the past 38 years. However, the energy intensity index has been increasing on average by 3.4 percent since 1967 indicating a decreasing trend in efficiency of energy use (Figure 2.3). In Figure 2.4 the energy intensity in Iran is compared to that in the rest of the world. The energy intensity in Iran is as high as in the whole Middle East region, but twice as high as the world average. Figure (2.5) shows the primary energy supply and final consumption, and Table (2.2) summarizes the major energy production and use figures for Iran.

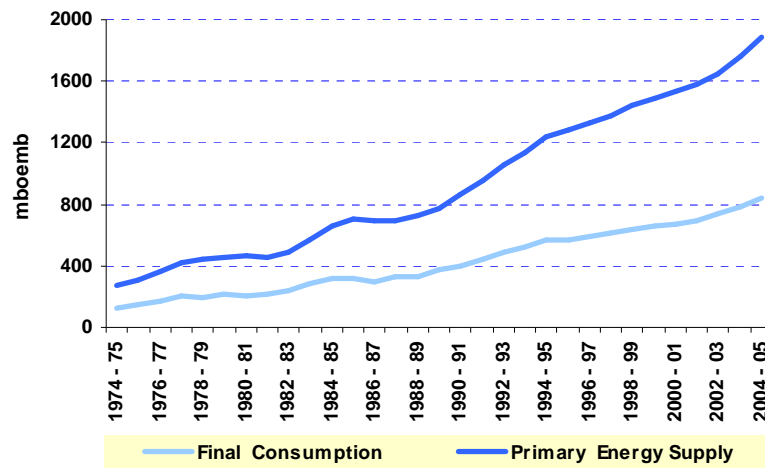


**Figure 2.4. Energy Intensity, Iran and the world**

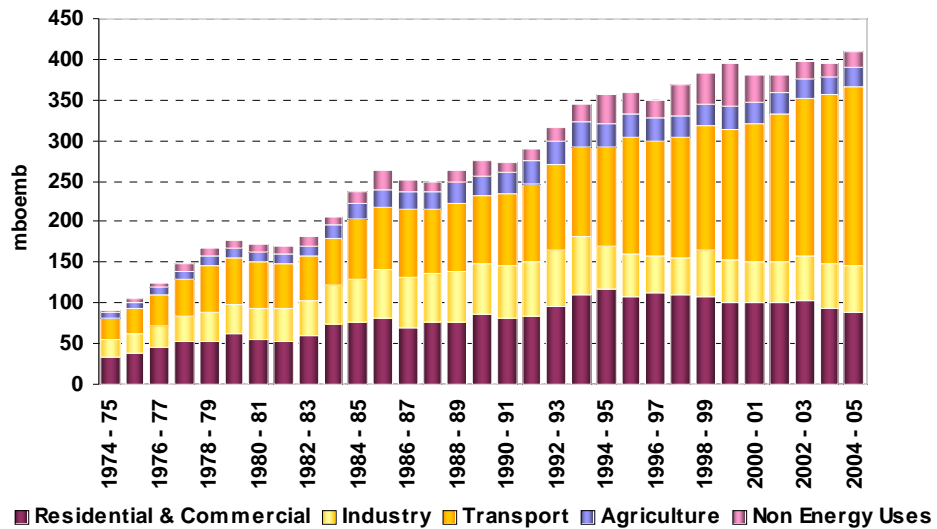
Source: IEA, International Energy Agency, *Energy Balances for OECD and Non OECD Countries*, 2002, 03 and 2005 Edition.

2005. The primary energy supply and final consumption have been increasing smoothly during the 70s and the early 80s, but the rates of increase have risen since then. Figures 2.6, 2.7 and 2.8 show the consumption of oil products, natural gas, and electricity by different sectors. Transport is the major user of oil products followed by households and

industry. Households and Industry are also two major users of the natural gas and electricity. The energy factor, defined as the ratio of the final use growth to the GDP growth, in Iran is also very high compared to the world; It has been on average 1.27 in Iran compared to 0.41 in the world for the period 1990-2003.



**Figure 2.5. Primary Energy Supply And Final Consumption, mboe (1974 – 2004)**  
Source: Energy Balance, Ministry of Energy, 2005



**Figure 2.6. Petroleum Products Consumption by Sectors**  
Source: Energy Balance, Ministry of Energy, 2005



**Table 2.2. Energy production and use in Iran (2003)**

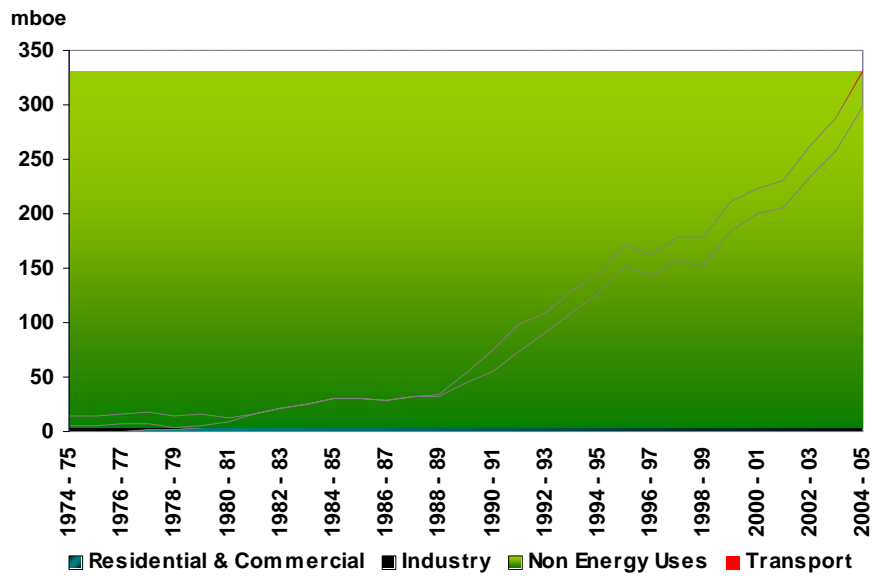
	Amount	Rank
Primary Energy Production	2120.9 mboe	
Primary Energy Exports	1185.1 mboe	
Primary Energy Imports	121.6 mboe	
Primary Energy Use*	970.22 mboe	
Oil Proven Reserve	132.5 bbl	3 (world), 2 (Middle East)
Oil Production	3.979 mbl/day	4 (world), 2 (OPEC)
Oil use	1.51 mbl/day	
Oil Exports	2.5 mbl/day	4 (world), 2 (OPEC)
Natural Gas Reserves	26.62 tcm	2 (world)
Natural Gas Production	83.9 bcm/year	7 (world)
Natural Gas Use**	85.54 bcm/year	
Natural Gas Exports	3.56 bcm/year	
Natural Gas Imports	5.2 bcm/year	
Electricity Nominal Capacity	37.3 GW	
Electricity Production	155 bkWh/year	
Energy Use per capita (energy use/population)	11.5 BOE/cap	
Energy Intensity (boe/million rials)	1.95	
Energy Factor (Final use growth/GDP growth)	1.52	
mboe: million barrel oil equivalent bbl: billion barrel	bcm: billion cubic meter tcm: trillion cubic meter	GW: Giga Watt bkWh: billion kilo watt hour

\*Including primary energy used by power plants

\*\* Excluding natural gas that re-injected, vented, or flared.

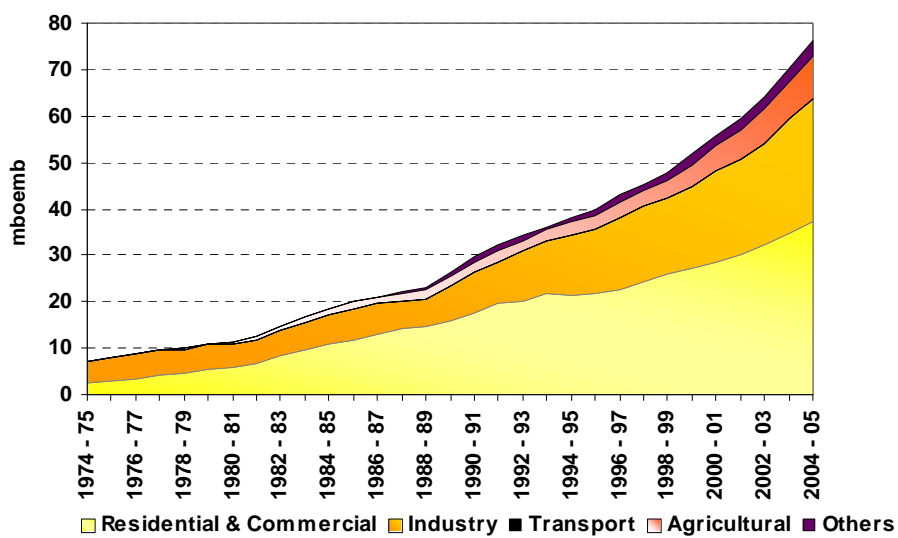
Source: Energy Balance, Ministry of Energy, Iran (2005.)

IEA, Iran, 2005. And The World Facts Book, CIA, Iran (2007)



**Figure 2.7. Natural gas consumption by sectors (2004)**

Source: Energy Balance, Ministry of Energy, 2005



**Figure 2.8. Electricity Consumption by Sectors**

Source: Energy Balance, Ministry of Energy, 2005

### **3. Energy Policies**

Iran's vast energy resources along with inappropriate policies have led to an increasing consumption of energy without much being concerned about efficiency and the adverse effects on environment. As figures 2.3 and 2.4 show, the energy intensity in Iran has been increasing and is almost twice as much as world average. Although Iran has not had any comprehensive plan for energy, it has embarked some short run and medium run plans for energy production and consumption in different sectors. We can identify four main policies that have influenced demand for energy for the past three decades. The first and by far the most important energy policy in Iran has been the heavy subsidization of energy use, especially in households and transport sectors. The second policy is meeting the OPEC production quota. Third policy is development and utilization of natural gas, and the fourth policy electrification of the rural areas. Here, we briefly outline the objectives and the outcomes of these policies.

#### **3.1 Energy Subsidies**

There are many different estimates for energy subsidies in Iran, but it is generally agreed that the Iran's energy subsidies are one of the highest in the world. It ranges between 0.5 to 12 percent of GDP depending on different sources. The huge discrepancies in the estimations of subsidies arise from different calculation methods used to estimate supply cost. The local officials use the strict version of subsidies that includes only the direct payments by government or a difference between marginal or average cost and the price paid by consumers. However, the agencies that report much higher estimates of subsidies include opportunity costs of energy products sales in the domestic market. These estimates compare domestic prices with the border prices and assess the

differences as opportunity costs of forgone revenues and therefore as subsidies. The government estimation of subsidies is more relevant to the government budget accounting; however, the broader estimation of subsidies is more appropriate for policy making where the objectives are optimal use of resources and increasing social welfare.

In OECD countries, governments subsidize energy producers and levies taxes on end-user consumers. The taxes, however, far exceed subsidies; It was \$223 billion in seven largest OECD countries in 2003- at least seven times more than the total amount of energy subsidies for the OECD as a whole. In recent years, the shares of subsidies by types of energy have changed in favour of renewable energy production. This policy is in line with the objectives of energy security by lowering reliance on oil imports and protecting environment by lowering consumption of fuel oil or coal and encouraging environmentally friendlier energy sources. In non-OECD countries, except China, most energy subsidies go to consumers by controlling end-user prices below the economic cost of supply. Most non-OECD countries subsidize electricity, but Iran and Indonesia heavily subsidize oil (IEA, 2006). Table (3.1) shows that transport receives about one third of the total energy subsidies, and household and industry each receive one quarter of the energy subsidies. The distribution of subsidies by energy type also shows that gas oil receives highest share of energy subsidy followed by electricity and gasoline. Since the subsidies are calculated based on the border prices, its distribution among energy types changes as the prices for different types of energy vary. For instance, it is expected that the share of gasoline and natural gas should be higher as their recent prices have been increasing more rapidly.

**Table 3.1 - The Energy Subsidies by Sector and Energy Type, 2000 (percent)**

	Household	Industry	Agriculture	Transport	Commercial	Others	Total
Gasoline	-	0.1	0.0	17.6	0.0	0.1	17.8
Kerosene	7.5	0.0	0.2	-	0.1	0.2	8.2
Gas oil	1.3	3.8	4.2	15.0	0.6	1.4	26.3
Heavy Fuel Oil	-	9.9	0.1	0.6	1.2	0.2	11.9
LPG	2.6	0.0	-	0.4	0.2	-	3.1
Electricity	10	8	3.3	-	1.1	3.4	25.7
Natural Gas	4	2.5	-	-	0.5	-	7
Total	25.4	24.4	7.8	33.5	3.6	5.3	100

Source: Ministry of Energy, 2001

### **3.1.1 Energy Subsidies Objectives**

There are two main objectives in providing huge energy subsidies in developing countries like Iran. First, subsidies tend to make energy more affordable for poor households who would otherwise be unable to pay the full economic cost. Second, they tend to protect domestic producers against foreign competition by keeping the energy cost low. Unfortunately, those subsidies and their sectoral allocation fail to achieve their objectives. They mainly benefit higher income groups because they consume larger amounts of subsidized energy. This is particularly true in oil products, because of a flat price for all levels of consumption, and in transport sector, where the distribution of car ownership is very uneven.

The second objective, which is known as industrialization or infant industry policy in economic development, may work if there is a scheduled and careful plan to invest in certain industries that would benefit economic growth in the long run. The protection policy in Iran has continued for more than three decades, which shows that the protected industries have never grown up to be competitive in the global market. The long run policy of providing cheap energy to industry has led to an inefficient use of energy and a condition in which there is no incentive to improve technology and to innovate. It is evident that the policy of heavy subsidization of industry cannot continue further as Iran is seeking membership in the World Trade Organization.

### **3.1.2 Energy Subsidies Problems**

The continuous energy subsidies program in Iran has caused many economic and social problems some of which are listed below.

- i. Higher energy consumption and waste
- ii. Weakening incentives for innovation and using more efficient technologies
- iii. Degrading environment by lowering quality of air in urban areas<sup>1</sup>
- iv. Placing a heavy burden on government budget, contributing to budget deficit by increasing direct payments as well as foregone income through higher oil exports<sup>2</sup>
- v. Cross-border smuggling of oil products to neighboring countries

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<sup>1</sup> The fuel oil subsidies may have positive effect on environment if it discourages the deforestation in the rural areas. The size of this subsidy, however, would be very small given the small rural population and their low consumption level.

<sup>2</sup> OPEC quotas are for total production not exports. Therefore, Iran can always export more oil and earn foreign income without violating its quota, should its domestic consumption reduces.

- vi. Exacerbating the unfair distribution of income by allocating more subsidies to rich

Although government has raised the energy prices for the past 15 years, the real energy prices have decreased because of higher inflation rates. Since the start of the third FYDP, energy prices have risen on average by only 10 percent per year, but the average inflation rate in this period has been well above 10 percent. The fourth FYDP called for a more aggressive measure to reform the energy market, that is, to increase the gasoline prices to the border prices. However, the new elected government and parliament did not implement the plan and froze the fuel prices in 2006 and 2007.

The subsidy problem is more prominent in the case of gasoline consumption, which receives one third of the total energy subsidies. Gasoline is sold below the market price at around 10 cents per liter, which is about one fourth of the border price and about one fifteenth of the European prices. The very low price of gasoline has encouraged high level of gasoline consumption in large urban areas, especially in Tehran. The growth rate of gasoline consumption has averaged 10 percent annually over the period 2001-2007. It has also led to a high concentration of air pollutants along with other social and economic problems. In response to a rapid growth in gasoline consumption, government drew on the Oil Reserve Fund to import about 40 percent of domestic consumption in 2007. Iran is now the second biggest gasoline importer in the world after United States. In June 2007, government instituted a gasoline rationing system to curb the rapidly growing consumption. In the new system, each private passenger car would receive 30 liters gasoline per month at the fixed price of \$1000 rials or about US 11 cents per liter. The rationing scheme did not have any significant effect on domestic consumption, but it apparently reduced the amount of gasoline smuggled to the neighboring countries.

### **3.1.3 Energy Price Reform**

It is evident that the current subsidy program in the energy sector cannot continue mainly because government has to cut oil exports in response to the growing domestic demand. This will have a dramatic negative effect on government budget causing macroeconomic instability and uncertainties. However, government is faced with many difficult issues regarding the price reform policy. These issues include the question of what type of energy subsidies should be removed, by how much and how. Moreover, the macroeconomic impacts of price reform on inflation, unemployment, and balance of payment are not very clear. Government also needs to have a plan on how to spend the additional revenues that will be generated by removing subsidies. The plan should identify the more vulnerable social groups who would suffer the most under the price reform scheme, and lay out the details on how to compensate for their loss of income.

Removing energy subsidies will have strong effects on prices, exchange rates, trade, and cost of living. Consumers will have to pay higher prices for energy goods (electricity, gas, gasoline) and non-energy goods whose prices will increase to offset the increase in their energy costs and the other inputs whose costs in turn will be affected by energy price rises. While the impact of price rise on energy goods will be immediate, the impact on non-energy goods will take time. Unfortunately, the inflationary effect of energy price reform has been exaggerated leading to an unsubstantiated fear among policy makers. A rise in energy prices will not have a continuous inflationary effect, since it will increase the aggregate price level in the short-term, but inflation rate will return to its past trend after the economy adjusts to its new equilibrium level. In fact, the experiences of energy price reform in some developing countries suggest that inflation rate may even be lower after the reform. For instance, while a rise in diesel and kerosene prices in Indonesia and Turkey led to higher inflation rates by 0.6 and 16



percent, the inflation rates in Malaysia and Zimbabwe were lower by 80 percent and 40 percent, respectively, after two year of price change<sup>1</sup>. A study by World Bank estimates that if energy prices in Iran rise to the border prices, inflation rate would rise by 40 percent in one year, and would remain the same afterward.<sup>2</sup> The higher energy prices will decrease the energy consumption by household, as they will use energy more efficiently. The change in cost of living will vary in different income groups depending on their expenditure patterns as well as price and income elasticities of demand and energy elasticity of output. Government can return the additional revenues generated by removing subsidies to households. Therefore, the total spending of households is expected to rise.

Rising energy prices will also increase the relative costs of energy intensive industries. This will likely lead to a change in trade pattern as Iran will import more goods that use energy intensively, and will export more oil. Exporting more oil will increase foreign reserves leading to an appreciation of the Rial that in turn will decrease exports and increase imports. This will have an adverse effect on domestic industries and non-traditional exports, similar to Dutch disease effect, which usually occurs in oil exporting countries when they receive a huge windfall after a boom in the world oil prices.

Energy price reform in is inevitable in Iran, but it may have striking adverse economic and social impacts, should it not be done properly. Therefore, it is imperative to study all various effects using economic models that take into account all different sectors of the economy and would analyze alternative scenarios. The outcome of such detailed studies would help policy makers to foresee the potential benefits and

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<sup>1</sup> Einar Hope and Blabir Singh (1995), Energy Price Increases in Developing Countries: Case Studies of Colombia, Ghana, Indonesia, Malaysia, Turkey, and Zimbabwe, Policy Research Working Paper, 1442, World Bank.

<sup>2</sup> Iran Medium Term Framework for Transition, Converting Oil Wealth to Development, A Country Economic Memorandum (2003), Report No. 25848-IRN, Social and Economic Development Group, Middle East and North Africa Region

challenges and thus design appropriate policies that would capitalize on advantages and alleviate the adverse effects.

### **3.2 Oil Policy**

Iran is a member of OPEC and is currently the second largest producer among OPEC members after Saudi Arabia. Iran has maintained its production quota in OPEC, but has cut its exports due to higher domestic consumption. Iran has recognized the importance of foreign investment in the oil sector in order to expand new fields and increase the recovery factor in the existing fields. Under the constitution, foreign companies are not allowed to own Iranian natural resources, but Iran has offered a “buy-back” contract to foreign investors. This new form of contract allows foreign companies to invest in oil and gas fields and to share revenues with the Iranian counterparts. Through this new mechanism, many international oil and gas companies, except US companies that are banned from investing in Iran by the US sanction law, have participated in exploration and development of the Iranian oil and gas fields.

Iran’s main policy in the oil sector can be summarized as follows.

- Meeting the OPEC production quota
- Encouraging foreign investment
- Substituting natural gas for oil products in all sectors to free up oil for exports

### **3.3. Natural Gas Development**

The third important of the government energy policy in Iran in the past three decades is the development of natural gas fields. This policy gained momentum when Iran discovered its share of the world largest gas reservoir in the Persian Gulf, i.e, the South Pars field. Iran has been using the large share of its ever-increasing gas production to

substitute natural gas for domestic consumption of oil products in different sectors. Producing natural gas is relatively cheap and its export to the world market is restricted only to neighboring countries. Therefore, the policy of gas substitution has freed up oil for exports generating more revenues for the government. In addition, since natural gas is more environmentally friendly, its use for the domestic consumption would help reduce pollution. Although the lower price for natural gas has made the substitution policy between oil products and natural gas successful, the problem of inefficient use of energy, especially in the residential sector, remains.

Iran has also increased its use of natural gas for injecting it into oil fields. This policy has two positive effects. First, it would lead to a higher production of oil as the recovery factor of oil fields will increase. Second, it will save the injected natural gas for future extraction. Iran has also involved in natural gas international trade, by importing from northern neighbors and exporting to Turkey through a pipeline. Iran is now a net importer of natural gas, but it is expected to become a major net exporter in future. There are different projects such as exporting natural gas to India through Pakistan, and to Europe through Turkey and other Eastern European countries.

### **3.4. Electrification**

The fourth energy policy is the electrification of rural areas by investing in new transmission lines to reach remote areas and by keeping the electricity price very low; more than 40 percent below the border prices. The policy that started in the 1980's has led many rural areas to be connected to the national electricity grid and changed the energy consumption and living conditions in those areas. The policy continues by encouraging rural residents to substitute electricity for oil products in cases like motor pumps.

### **3.5. Other Energy Policies**

Some other important policies in the energy sector can be listed as follows.

1. Ministry of Energy has established two organizations for studying and promoting investment in renewable energy resources: Iran Energy Efficiency Organization (SABA) in 1994 and Iran Renewable Energy Organization (SUNA) in 1995. These two institutes have conducted some projects on wind, solar, and geothermal energy resources in different parts of Iran, but their activities remain insignificant compared to the level of energy consumption in the country.
2. Ministry of Oil established the Iran Fuel Conservation Organization (IFCO) in 2000 to study and invest in energy efficiency in different sectors. IFCO has audited some manufacturing industries and made recommendations for energy conservation in those units. Replacing very inefficient and pollutant old cars with new cars in large cities and using CNG as a substitute for gasoline are some of the projects undertaken by IFCO in recent years.
3. Iran has attempted to develop nuclear energy by completing the Bushehr nuclear plant and making investment in other new plants. It is expected that these plants will deliver at least 1000 MW electricity capacity by 2010.

### **3.6 Future Energy Policies**

Some of the policies outlined above such as gasification are expected to continue, but the energy pricing and the energy subsidy policies seem to have reached the endpoint and are to change. The policy makers are now facing the huge energy demand which puts an enormous pressure on the oil dependent government budget. Fortunately, there is an understanding on the authorities' side that the current pricing policy and the full

control of the energy sector is not sustainable, although the remedies are not so clear. Government is also determined to produce part of the energy by nuclear plants, but its share of the total energy used in the country is not expected to be very significant. There are also discussions and some preliminary projects on the renewable sources which are expected to continue and even gain momentum in the future.

#### **4. Business as Usual (BAU) Scenario**

In this section, we model the energy consumption in different sectors of the economy as a business as usual (BAU) scenario for the period 2005-2030. The economic sectors included in this study are households, industry, transport, and others consisting of agriculture, commercial and public sectors. We also study the energy consumption and production of the power generating plants. We model the energy consumption behaviour in each sector by estimating and finding a pattern in consumption indicators such as energy intensity. The BAU scenario describes a consumption path that can be characterized as development of demand if no far-reaching changes in consumption patterns are made. Therefore, it assumes that the economy and the energy sector will follow the past trends. It also takes into account the new developments in the economy based on patterns of the world economic growth as well as policies outlined in the Five-Year-Development-Plan (FYDP) and the Vision approved by the authorities. Specifically, it assumes that GDP and population as two major determinants of energy demand will grow 5.5 percent and 1.3 percent until 2010, 3.4 percent and 1.4 percent until 2020, and 3 percent and 0.9 percent until 2030, respectively (see Table 4.1). The assumptions on GDP and population growth are consistent with those of the past trends as well as the national plans and the major international agencies' predictions about the Iranian economy.

**Table 4.1 GDP and Population Growth Assumptions in BAU Scenario**

% per year	2005-2010	2011-2020	2021-230
GDP growth	5.5	3.4	3
Population growth	1.3	1.4	0.9

Our methodology in calculating the future energy demand in Iran in the BAU scenario is summarized as follows. We first review the historical pattern of the energy use and identify the major drivers of demand in each sector. We then apply the BAU assumptions to project the future energy demand. We have used all the available information about the current and the future policies and plans with respect to structure of the economy and, in particular, the energy sector. We have applied both computational or bottom-up approach as well as econometrics methods to estimate the effects of the major factors affecting energy demand and to forecast its future values. In some cases, such as transport and natural gas, the relationship between the energy demand and its major drivers is estimated using econometric methods. In other cases, such as electricity, where survey data were available, the computational approach has been used.

## **4.1 Households**

Households are one of the major energy users in Iran accounting for about 40 percent of the total final energy consumption. Specifically, households use about 20 percent of the total oil products, 63 percent of natural gas, and 33 percent of total electricity consumption. The household energy consumption pattern has changed markedly since 1990 because of government's policy of substituting natural gas for oil products. The

households consumption of oil products has increased on average by about half a percent annually, but the consumption of natural gas and electricity have increased by 19 percent and 6 percent per year for the past 15 years, respectively.

We study household demand for energy in two separate sections: Heat and electricity. In the heat section, we model the demand for oil products and natural gas using aggregate data. In the electricity section, we model the demand for electricity using micro level data on appliances used by households.

#### **4.1.1. Oil Products and Natural Gas**

Natural gas is now a major energy carrier in the residential sector. In 2005, the Iranian households used about 63 mboe oil products such as gas oil and LPG, and about 197 mboe natural gas. According to the National Iranian Gas Company (NIGC), 7.5 million households had access to natural gas in 2004, which is projected to grow on average by about 3 percent annually until 2025. This means that every year about 33000 new households will join the natural gas grid. We estimate the relationship between the demand for oil and gas and its drivers using a regression equation. Households demand for oil and gas is assumed to grow with population and income. The estimation results of the regression equation show that both GDP and population are significant factors in explaining the changes in demand for oil and gas by household. The population effect with a coefficient of 4, however, is much stronger than GDP effect with a coefficient of 0.0005. The future demand for oil and gas by households is projected by using the regression equation results and the assumptions on the future values of GDP and population. Using the estimated values for the future demand and the future shares of each energy type based on the existing and the future government policies, we breakdown the results into demand for kerosene, gas oil, LPG, and natural gas. One of

the key factors in estimating the future shares of energy types in household demand for oil and natural gas is the government policy to increase the share of the natural gas in the household energy basket from 79 percent to 95 percent. Based on this policy, the shares of kerosene, gas oil, and LPG are assumed to decrease from 16, 2.6, and 2.7 percent in 2005 to 2, 2, and 1 percent in 2030, respectively.

The use of oil and natural gas by households is broken down to space heating, cooking, and water heating. It is assumed that 100 percent of kerosene is used for cooking, 80 percent of gas oil for space heating and 20 percent for water heating, and 50 percent of LPG for cooking and another 50 percent for water heating. The shares of space heating, cooking, and water heating in natural gas consumption by household are assumed to be 75, 10, and 15 percent, respectively. These shares of consumption types are assumed to remain the same during the study period. It is also assumed that households will start to use solar energy as much as 1 percent of their oil and gas consumption by 2010. The share of solar energy is assumed to grow to 5 percent in 2030. Table (4.2) shows the BAU scenario for household consumption of oil products, natural gas and solar energy in different types of their use. According to the results, household demand for kerosene and LPG will decline on average by 5 percent and 0.7 percent per year, respectively, while the gas oil and natural gas demand will increase by 2.1 and 4.3 percent over the period 2005-2030, respectively. The demand for solar energy will rise on average by 11.7 percent per year for the period 2010-2030. The total demand for oil products and natural gas by household is projected to grow by 3.4 percent per year on average, increasing from 259 mboe in 2005 to 592 mboe in 2030.

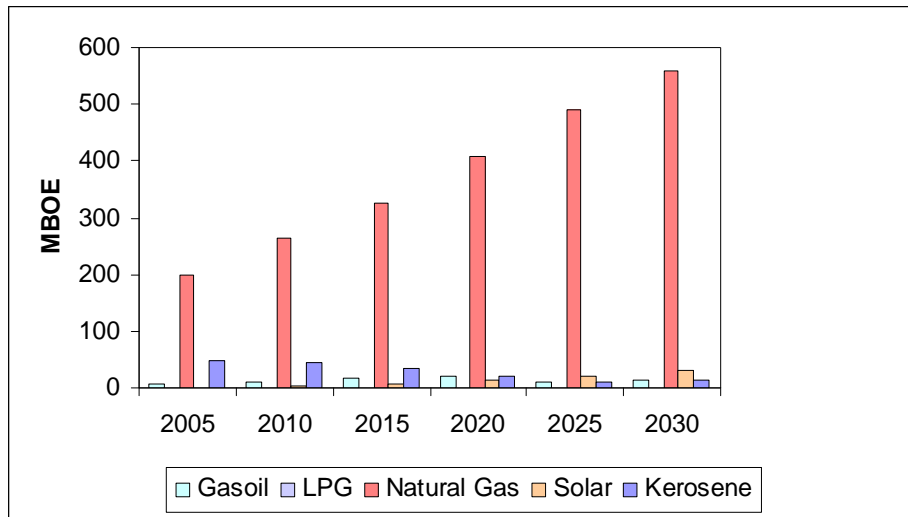


**Table 4.2 - The BAU Scenario Results for Household Demand for Oil Products, Natural Gas and Solar Energy by Application (2005-2030)**

		2005	2030	
	Share (%)	mboe	mboe	Growth (%)
<b>Kerosene</b>		47	13	-4.97
Space heating	0	0	0	
Cooking	100	47	13	
Water heating	0	0	0	
<b>Gasoil</b>		8	13	2.11
Space heating	80	6	10	
Cooking	0	0	0	
Water heating	20	2	3	
<b>LPG</b>		8	7	-0.68
Space heating	0	0	0	
Cooking	50	4	3	
Water heating	50	4	3	
<b>Natural Gas</b>		197	559	4.25
Space heating	75	148	420	
Cooking	10	20	56	
Water heating	15	30	84	
<b>Total</b>				
<b>(Oil &amp; Natural Gas)</b>		<b>259.5</b>	<b>591.9</b>	<b>3.35</b>
<b>Solar* share</b>		<b>0</b>	<b>30</b>	<b>11.65</b>
Heating	1-5	<b>0</b>	<b>21</b>	
Cooking	1-5	<b>0</b>	<b>4</b>	
Warm water	1-5	<b>0</b>	<b>4</b>	

\* The solar share will increase from 1 percent in 2010 to 5 percent in 2050.

Figure (4.1) shows the trend of the future demand for oil, natural gas, and solar energy by households.



**Figure 4.1. Household Demand for Oil Products, Natural Gas, and Solar Energy - The BAU Scenario (2005-2030)**

#### 4.1.2. Electricity

Household demand for electricity is estimated using a bottom-up approach. This approach uses micro level data that allows for analyzing various scenarios regarding the changes in technology, penetration rates, and other determinants of demand. General information about the residential electricity use in Iran is presented in Table (4.3). In 2005, about 16.4 million customers used electricity in Iran, from which 73 percent were urban. The ratio of customers to population is 0.25 in the urban areas and 0.20 in rural areas. That is, on average an urban customer consists of four persons and a rural customer five persons.

**Table 4.3- Household Electricity Demand, 2005**

	Urban	Rural	Total
Number of customers (million)	11.99	4.41	16.40
Population (million)	48.24	22.23	70.47
Customer per person	0.25	0.20	0.23
Consumption (MkWh)	39,790	6,836	46,626

Source: Electricity Statistics, Ministry of Energy, 2005.

Although very detailed and extensive micro data on household consumption of energy are not available in Iran, there are some survey data in Tehran along with other published reports by TAVANIR, which can be used to analyze and estimate the electricity demand for household at a disaggregated level<sup>1</sup>. We take the following steps to model the electricity consumption by households using the survey data. First, a list of all major appliances and their penetration rates are estimated for Iranian rural and urban households. Second, the electricity use by those appliances and total electricity use per household are estimated. Third, using the information on number of households with access to electricity, the total amount of electricity use by households and appliances are calculated. The details of the calculations and estimations are presented below.

The major appliances used by Iranian households are reported in Table (4.4). There is no data on appliances for the rural areas, but using some general information about living condition of the households in rural areas, the penetration rates of appliances for rural households are estimated. For instance, the penetration rates for appliances such as freezer, microwave, and washing machine are assumed zero and for

<sup>1</sup>. A study of household's electricity consumption pattern and their satisfaction in Tehran, Tehran Regional Electricity Company (TREC), different years

appliances such as TV and refrigerator a fraction of the urban penetration rates. The total penetration rates are obtained by applying the appropriate weights, which are the shares of urban and rural households using electricity. The results are presented in the Table (4.4).

**Table 4.4. The Penetration Rates of the Appliances Used by Iranian Households, BAU Scenarios (2005-2030)**

Appliance	Urban		Rural	
	2005	2030	2005	2030
Lamp<100 W	3.98	3.5	3	4
Lamp 100 W	2.83	2.83	2	2.83
Fluorescent Lamp <sup>1</sup>	2.61	2	2	1.5
Low consumption Lamp	0.22	1.50	0.22	1.50
Refrigerator	1.02	1.05	1	1.05
Freezer	0.44	0.7	0	0.3
Mixer	0.47	0.47	0	0.2
Soft cooker	0.29	0.4	0	0.1
Microwave	0.17	0.5	0	0.2
Tea-coffee Maker	0.04	0.5	0	0.2
Vacuum Cleaner	0.76	0.9	0	0.3
Washing Machine	0.65	0.9	0	0.5
Iron	0.88	1	0	0.5
cooler(water system)	0.83	0.8	0.70	0.7
Air Condition	0.10	0.3	0	0.1
TV	1.01	1.2	0.7	1
Computer	0.25	1	0	0.4

*Source: A study of household's electricity consumption pattern and their satisfaction in Tehran, Tehran Regional Electricity Company (TREC), different years, and authors' estimation*

<sup>1</sup>. Fluorescent lamps are old long or round fluorescent lamps, but Low Consumption Lamps are the new fluorescent lamps.

To estimate the cooler penetration rate, the information on electricity use in the “very hot” and “hot” regions is used. In the very hot and humid regions, like southern and some northern areas, people use air condition in hot months. We first estimate the number of coolers used by households using the household electricity consumption information for those regions in hot and cold months<sup>1</sup> and the average electricity consumption by type of coolers used in Iran. In total, there are about 16 million households using electricity in Iran, from which about 3.2 million households live in the hot areas (70 percent in very hot areas and 30 percent in hot areas.) The water system and gas system cooler penetration rates are calculated based on the weighted average of the cooler stock in Iran. Table (4.5) shows the average electricity consumption by households and by appliances in 2005 and 2030.

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<sup>1</sup>. The number of hot months is assumed three.

**Table 4.5. Average Electricity Consumption by Appliances**

	<b>Average electricity consumption of households (kWh, year), 2005</b>	<b>Average electricity consumption of households (kWh, year), 2030</b>	<b>Growth (%)</b>
Lamp<100 W	391	329	-0.69
Lamp 100 W	485	561	0.58
Fluorescent Lamp	315	132	-3.4
Low consumption Lamp	1	53	17.8
Refrigerator	590	525	-0.47
Freezer	186	308	2.04
Mixer	9	8	-0.50
Soft cooker	31	48	1.84
Microwave	16	67	5.94
Tea-coffee Maker	1	26	12.21
Vacuum Cleaner	60	83	1.36
Washing Machine	69	113	1.99
Iron	157	252	1.90
Cooler (water)	111	83	-1.15
Cooler (gas)	170	387	3.34
TV	233	424	2.42
Computer	13	95	8.17
Total	2,837	3,493	0.8

The average electricity consumption by appliances will grow on average by 0.8 percent per year. Appliances such as low consumption lamps, microwave, tea and coffee maker, air condition, and computer will grow by 3 to 18 percent and traditional lamps and

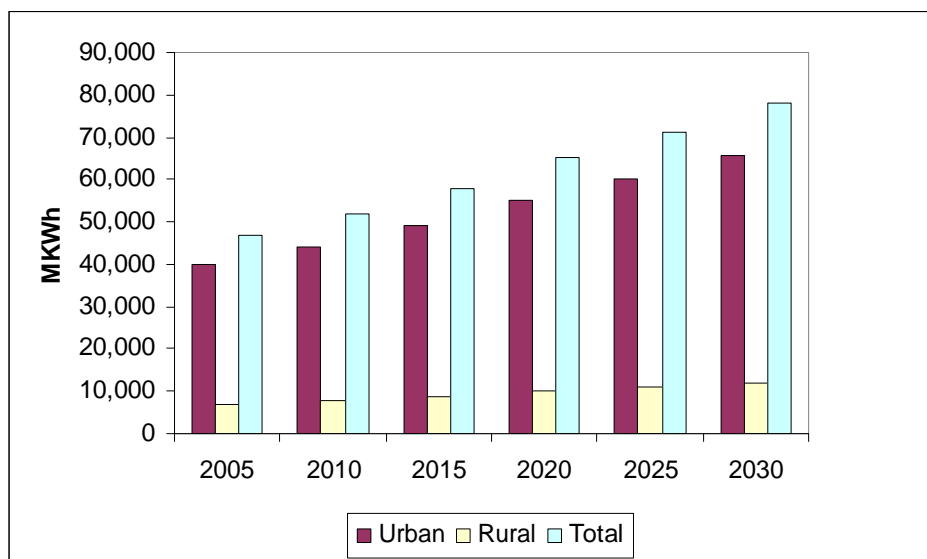
water cooler will grow negatively. The number of households using electricity is linked to population and its future values are estimated using the household to population ratio. In 2005, the household population ratio was 0.25 for the rural areas and 0.20 for the urban areas. The total electricity demand by households for the period 2005-2030 is obtained by multiplying the number of households by the total electricity consumption per household. In estimating the household future electricity consumption, it is assumed that the penetration rates of the appliances will change as shown in Table (4.4).

Table (4.6) shows the results of the BAU scenario for the household electricity demand for the period 2005-2030. The number of customers, consumption per household, and total consumption of electricity by households will grow more rapidly in rural areas than urban areas. The share of electricity consumption of urban households in total households' electricity consumption will reduce by 0.5 percentage point from 85 percent to 84.5 percent. The number of residential customers (households) will grow by 1.2 percent, consumption per household by 1 percent, and the total electricity use by households by 2 percent on average for the period 2005-2030. Figure 4.2 shows the future trend of the residential demand for electricity.

**Table 4.6 – Residential Demand for Electricity, BAU Scenario (2005-2030)**

	2005	2030	Growth (%)
<b>Urban</b>			
Number of Customers (million)	12.14	16.3	1.19
Consumption per household per year (MkWh)	3,319	3,742	0.48
Total Consumption (MkWh)	39,790	65,890	2.04
<b>Rural</b>			
Number of Customers (million)	4.4	5.96	1.22
Consumption per household per year (MkWh)	1,538	2,565	2.07
Total Consumption (MkWh)	6,836	12,119	2.32
<b>Total</b>			
Number of Customers (million)	16.6	22.3	1.19
Total Consumption (MkWh)	46,626	78,008	2.08





**Figure 4.2. Residential demand for electricity- MkWh (2005-2030)**

Table (4.7) presents the total electricity consumption by appliances in 2005 and 2030. Lighting is the major component of electricity use by household and will remain so in the future, but its share will reduce from 42 percent in 2005 to 31 percent in 2030 as the more efficient light bulbs will be substituted for the currently used low efficient light bulbs. Refrigerators use 21 percent of the total electricity consumption by households, but its share will reduce to 15 percent in 2030, as low efficient refrigerators will be phased out. The share of other appliances such as TV, air condition, iron, freezer, and computer will increase slightly because of urbanization and changes in the households' life style.

**Table 4.7- Total electricity consumption by appliances- BAU Scenario (2005-2030), (MkWh)**

	Urban		Rural		Total		Share (%)	
	2005	2030	2005	2030	2005	2030	2005	2030
Lamp<100W	5,309	5,436	1,120	1,905	6,429	7,341	14	9
Lamp 100W	6,723	9,872	1,244	2,648	7,967	12,520	17	16
Fluorescent Lamp	4,249	2,564	924	387	5,173	2,951	11	4
Low consumption Lamp	11	937	4	251	14	1,189	0	2
Refrigerator	7,107	9,245	2,591	2,480	9,699	11,725	21	15
Freezer	3,054	6,163	0	709	3,054	6,872	7	9
Mixer	141	145	0	24	141	168	0	0
Soft cooker	504	1,014	0	68	504	1,082	1	1
Microwave	260	1,373	0	123	260	1,496	1	2
Tea-coffee Maker	24	523	0	51	24	574	0	1
Vacuum Cleaner	979	1,712	0	153	979	1,865	2	2
Washing Machine	1,129	2,187	0	326	1,129	2,513	2	3
Iron	2,586	4,961	0	665	2,586	5,627	6	7
Water Cooler	1,657	1,690	168	165	1,825	1,856	4	2
Air Condition	2,793	7,924	0	709	2,793	8,633	6	11
TV	3,046	8,241	784	1,228	3,830	9,469	8	12
Computer	220	1,902	0	227	220	2,129	0	3
Total	39,790	65,890	6,836	12,119	46,626	78,008	100	100

## 4.2. Industry

Industry accounts for about 42 percent of the Iranian GDP, and uses 164.5 mboe or 17 percent of the total energy consumption. Natural gas is the dominant source of energy in industry, which accounts for nearly half of the total energy used in this sector. The share

of natural gas in the total energy use by industry has been increasing because of government's aggressive policy of substituting natural gas for oil products. This has caused some difficulties to industries during cold winter months. The National Gas Company cuts off supply of natural gas to manufacturing industries in order to respond to household demand, which rises rapidly in winter. We model energy demand in industry using the survey data on large (more than 10 workers) manufacturing industries available through the Statistics Center of Iran. We use information at the two digit ISIC<sup>1</sup> level in which the manufacturing industries are classified into nine main industry groups. The list of industries is presented in Table (4.8). Machinery and Equipment manufacturing industry is the largest industrial group in Iran accounting for about 36 percent of the total manufacturing industries value added. Chemical and Basic Metals each produce 13 percent, and Refinery produces 9 percent of the total value added by industrial groups. The shares of Food and Beverages, Non-Metallic Minerals, and Textiles and Leather in the total valued added are 9, 8, and 6 percent, respectively.

Chemical industry shows the highest energy use (27 percent) among the manufacturing industry groups, followed by Basic Metals (18 percent), Non-Metallic Minerals (16 percent), Refinery (11 percent), and Food and Beverages (10 percent). 47 percent of energy used by manufacturing industries is natural gas, 26 percent fuel oil, 17 percent electricity, 7 percent gas oil, 1.7 percent liquefied petroleum gas (LPG), 0.6 percent gasoline, and 0.3 percent kerosene.<sup>2</sup>

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<sup>1</sup> International Standard of Industry Codes

<sup>2</sup>.There is a discrepancy between the data published by the Iranian Statistics Center (ISC) and the Ministry of Power in the Energy Balance (EB) on the energy use by the manufacturing industries. This is mainly due to the difference in the samples used by these two agencies. Here, we have taken the total energy use from EB and distributed its difference with ISC among the industries using their shares from ISC.

**Table 4.8– Manufacturing Industries Value Added and Energy Use (2005)**

	<b>Value Added</b>	<b>Share</b>	<b>Energy Use</b>	<b>Share</b>
	Constant 1997 b. Rials	%	mboe	%
Food and Beverages	7,083	9	17	10
Textile and Leather	4,426	6	5	3
Wood and Wood Products	279	0.4	1	0.5
Paper, Pulp and Printing	1,440	2	4	3
Chemical and Petrochemical	10,598	13	44	27
Refinery	7,184	9	19	11
Non-metallic Minerals	6,610	8	26	16
Basic metals	10,008	13	29	18
Machinery and Equipment	28,854	36	7	4
Other industrial	3,119	4	13	8
Total	79,579	100	164	100

Source: The Large Manufacturing Industries Survey, Statistical Center of Iran, and authors calculations.

To estimate the future energy demand by manufacturing industries in the BAU scenario, the following procedure is used. First, the current rial value added for the nine large manufacturing industry groups are converted into the constant rial value added using the corresponding price deflators from the Central Bank Price Surveys. Second, the future value added is of each manufacturing industries projected by taking into account the past growth rates as well as the objectives outlined in the Ministry of Industry plans, the fourth FYDP and the vision. According to the results, most manufacturing industries would grow on average at the rate of 8 or 9 percent at the beginning of the period and at the range of 4 to 6 percent per year at the end of the study period. Third, the energy intensity for each manufacturing industry group is

obtained using the data on the energy consumption and the value added. The results are shown in Table (4.9). The energy intensity in the manufacturing industry has been decreasing on average by 7 percent for the past 15 years, but the rate of decrease has slowed down since 2000. It is assumed that the overall energy intensity in the manufacturing industry would continue to decline but at a much slower rate, that is, one percentage point per year. Fourth, the future energy demand for manufacturing industry groups is estimated given the energy intensity and the estimated value added for each group in the next 25 years. In deriving the BAU scenario, the gasification policy of the manufacturing industry, particularly in Food and Beverages, Wood and Wood Products, Textile and Leather, and Paper, Pulp and Printing industries, is also taken into account. The results are shown in Table (4.10) and figure (4.3).

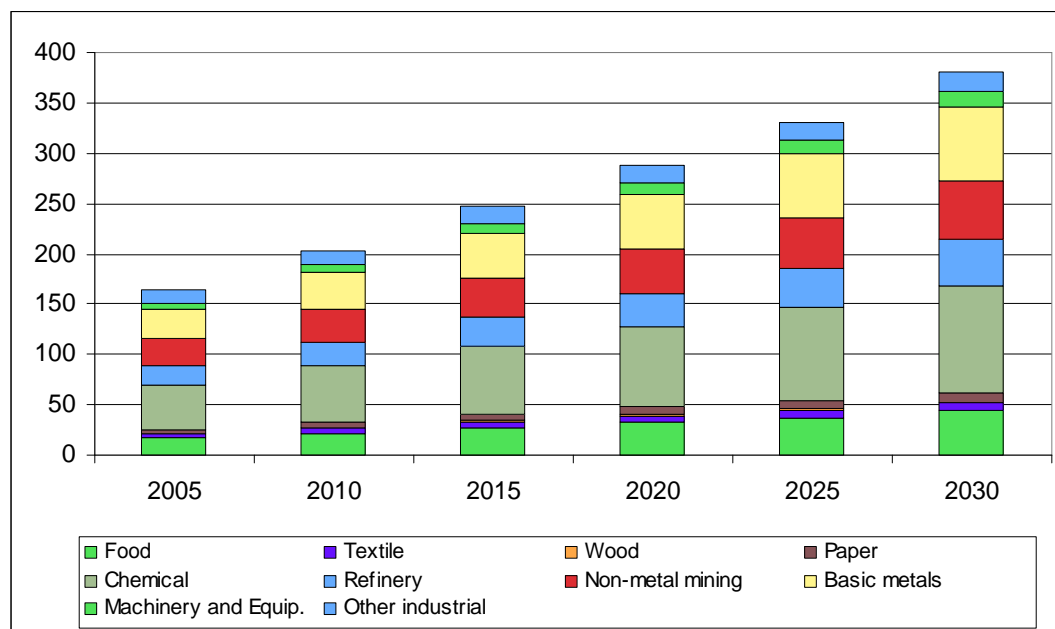
**Table 4.9 – Energy Intensity in Manufacturing Industries- BAU Scenario (2005-2030)**

	<i>BOE/billion rials (constant 1997)</i>	
	2005	2030
Food and Beverages	2.33	1.82
Textile and Leather	1.02	0.80
Wood and Wood Products	2.87	1.73
Paper, Pulp and Printing	2.91	2.26
Chemical and Petrochemical	4.19	3.26
Refinery	2.62	2.04
Non-metallic Minerals	3.93	3.05
Basic metals	2.89	2.24
Machinery and Equipment	0.23	0.18
Other industrial	4.25	3.31
Total	2.06	1.58

The total energy demand by the manufacturing industries will grow on average by 3.4 percent per year reaching from 164 mboe in 2005 to 380 mboe in 2030.

**Table 4.10 – Manufacturing Industries Demand for Energy, BAU Scenario (2001-2030),**

	<i>mboe</i>		
	2005	2030	Growth (%)
Food and Beverages	17	44	4
Textile and Leather	5	8	2
Wood and Wood Products	1	1	1
Paper, Pulp and Printing	4	10	4
Chemical and Petrochemical	44	106	4
Refinery	19	45	4
Non-metallic Minerals	26	59	3
Basic metals	29	72	4
Machinery and Equipment	7	16	4
Other industrial	13	19	1
Total	164	380	3.4



**Figure 4.3. Total energy demand by manufacturing industries, BAU (2005-2030), mboe**

### 4.3. Power Generating Plants

The power generating plants are important part of the energy sector as they are both energy users and energy producers. In 2005, the power generating plants used 270 mboe oil and natural gas accounting for 28 percent of the total energy used in the country and generated 110 mboe electricity. The power generating plants use different types of the energy depending on the type of technology they employ, and produce electricity for different sectors of the economy. In 2004-2005, about 37.3 GW total installed capacity was contributed by steam (38%), natural gas (30%), combined cycle (17%), and hydro (15%) power plants. The electricity generation by renewable resources is negligible, and by nuclear plant has not been materialized yet. Table (4.11) presents the structure of the existing power generating plants in Iran.

**Table 4.11- Installed Capacities of Power Plants, 2005**

Type	GW	Share (%)
Steam	14.12	38
Gas	11.2	30
Combined Cycle	6.3	17
Hydro	5.6	15
Renewable	0.034	00
Total	37.3	100

To estimate the electricity production by power generating plants, three steps have been taken. First, the future demand for electricity by each sector of the economy is estimated using the future value added as well as the energy (electricity) intensity. It is assumed that the energy intensity will decrease on average by 0.1 percent per year. The total electricity demand is obtained by adding the transmission and distribution losses as well as power plants' own use, which are assumed to decline by 1 percent based on the Ministry of Energy plan and the 2007 budget law. The total generation capacity by the power generating plants is then estimated using the average load factor. The new capacity needed is assumed to be met by a combination of combined cycle, nuclear, and renewable power generating plants, as outlined in the energy policies by Tavanir. In 2010, thermal plants will produce 94 percent and renewable and nuclear plants 6 percent of 220 GWh total electricity production.. It is assumed that combined cycle plants will generate 80 percent and gas turbine plants 20 percent of new thermal capacities. In addition, the nuclear plants will generate 6000 MWh by 2010, large hydro 18652 MWh, small hydro 2213 MWh, wind power 550 MWh, solar thermal 4 MWh, and biomass 18 MWh. The pump storage in Siah Bisheh project will also generate 1971



MWh in 2010. Table (4.12) shows the total electricity capacity generation by power generating plants for the period 2005-2030.

**Table 4.12. Total Electricity Generation in Iran, BAU Scenario (2005-2030)**

	2005	2030
Total Electricity Consumption by All Sectors (million kWh)	144,296	284,250
Transmission and Distribution Losses (million kWh)	33,847	49,878
Power Plant Own Consumption (million kWh)	8,394	12,246
Total Electricity Generation (million kWh)	186,537	346,375
Average Load Factor (%)	57	57
Total Installed Capacity (GW)	37.35	69.27

Source: Ministry of Energy, Tavanir, and the study projection

Table 4.13 shows electricity generation by existing and future power generating plants. It is assumed that the nuclear plants will generate the base load with 1000 MW capacity in 2009 and the thermal plants along with renewable sources will generate the rest. Based on the Ministry of Energy plan, the new thermal plants will be combined cycle and the main renewable sources hydro and wind power plants. Hydro installed capacity will be more than 7000 MW capacity until 2011 and 8500 MW in 2030. The wind power capacity will increase from 37 MW in 2005 to 1187 MW in 2030. The small hydro plants, solar thermal, geothermal, and biomass will generate 720 MW, 1 MW, 55 MW, and 5 MW, respectively. A pump storage plant in Siah Bisheh will be installed in 2010 with the power of 1000 MW.

# why are the numbers in black or red? This has to be mentioned in the legend of the table. Please note that some numbers are inconsistent.

**Table 4.13. Electricity Generation by Renewable and Non Renewable Sources (GWh)- BAU Scenario (2005-2030)**

	2005	2030
Total Electricity generation (million kWh)	186,537	346,375
Thermal Power Plants	181,817	330,264
Nuclear Power	0	6,000
Renewable Sources	4,720	10,111
Hydro power	4,500	6,750
Wind power	220	2,730
Photovoltaic	0	7
Geothermal	0	303
Solar thermal power	0	4
Small hydropower		280
Biomass	0	18

Source: Tavanir and authors' estimation

The fuel use by the power plants is estimated assuming that the future thermal power plants will only use natural gas and that the average efficiency rate will rise from 39.7 percent to 46.1 percent in 2030 because of a better technology. The results are presented in Table (4.14). The total fuel demand by the power generating plants will grow on average by 1.81 percent per year for the period 2005-2030. Demand for gas oil, heavy fuel, and natural gas for the existing plants will decrease on average by 0.22 percent per year, but demand for natural gas by the new power plants will increase by about 15 percent per year. It is also assumed that solar heat power plants, which will generate 4 GWh electricity, will need about 1.81 GWh natural gas by 2030.

**Table 4.14 – Energy Demand by Power Generating Plants, BAU Scenario (2005-2030), GWh**

	2005	2030	Growth (%)
Total Fuel	458,500	717,184	1.81
Gas Oil	47,312	44,827	-0.22
Natural Gas (existing plants)	326,435	309,289	-0.22
Natural Gas (new plants)	-	282,729	-
Solar Heat Power Plants	-	37.28	
Heavy Fuel	84,753	80,302	-0.22
Average Efficiency Factor (%)	39.7	46.1	

#### 4.4. Transport

In 2005, the transport sector used 54.7 percent of the total oil product consumption, 0.16 percent of natural gas, and 0.07 percent of electricity. About 450 billion passenger kilometers were travelled in 2005 by car (54%), bus (41%), train (2%), and airplane (2%). About 208 billion tones kilometer freight has been transported by trucks (92%) and train (8%). The main energy types used in the sector are gas oil, gasoline, kerosene, and jet fuel. Natural gas (LPG and CNG), has been also added to the energy basket of the sector, but its share is negligible. To estimate the future demand for energy in the sector, we first model the demand for energy by finding the relationship between the consumption and the major drivers in each sub sector of transport through regression equations. We then estimate the future values of demand by applying the basic assumptions about the future economic and population growth.

#### **4.4.1. Passenger Transport**

Passenger transport includes road (car, bus), train and air transport. The basic information about the road transport is summarized in Table (4.15). There are four important indicators in the road transport as follows: Number of cars, travel distance per car and year, load factor, and the specific energy consumption. The number of passenger cars is about 6 million in 2005 and it will grow with per capita income. The results of the regression equation is used to estimate the future number of cars based on the basic assumptions about the GDP and population growth. The regression results indicate that in the past 30 years (1977-2005), for every 1 billion rials (constant 1997 values) on average 2,000 new vehicles, and for every 1 million addition to population, 17,000 new vehicles are added to the transport system. Because of a low gasoline price, a boom in car manufacturing industries, and high income, the number of cars has been growing rapidly in recent years, but it is expected to stabilize when the market is saturated. According to the estimation results, the number of cars will grow on average at the rate of 4.5 percent per year reaching 18.26 million cars in 2030. The total travel distance per car per year is 24,000 km on average, which is expected to reduce to 22,000 km as public transport will grow rapidly. The load factor is 1.7 passenger/km per car/km, which will decrease to 1.5 as more people will have car. The average gasoline consumption by passenger cars is 14 liter per 100 kilometers, which is very high compared to the international standards. We assume that the technology improvements and the higher income will allow for the use of more efficient cars in the future reducing the gasoline consumption to 7.5 liter per 100 km in 2030. Total gasoline consumption by passenger cars, which is obtained by multiplying the total travel distance by the specific energy consumption, is 20 billion liter or 108 mboe, but will grow on average by 1.62 percent per year reaching about 30 billion liter in 2030.

The numbers of buses for public transport is 233,000, and since 1991, on average about 5000 minibuses and buses are added to the public transport system every year. The average total travel distance by bus is 45,000 km per bus per year that will decrease to 41,250 km in 2030. The total travel distance by bus will increase from 10.5 Mkm in 2005 to 17.2 Mkm in 2030. The average consumption of gas oil by bus, which is 51 liter per 100 km, will decrease to 25 liter per 100 km in 2030 declining at the rate of 2.81 percent per year. The total gas oil consumption by buses can be calculated similar to gasoline consumption by car using indicators above. It is 5.3 billion liter in 2005, but will decrease on average by 0.87 percent per year reaching 4.3 billion liter in 2030. The reason for a decline in gas oil demand by bus is that the specific energy consumption will decrease at a faster rate than the total travel distance will increase.

In 2005, 11.15 billion passenger km were traveled by train and about 11 billion passenger km by airplane. Since there are no detailed data in these two transport modes, we assume that train transport will grow on average by 5 percent until 2010, 4 percent until 2025, and 3 percent until 2030, and air transport will grow on average by 4 percent. The average gasoil consumption by train is 0.0085 liter per km and is assumed to remain unchanged. The total gasoil consumption by train is 121 million liter which will grow to 253 million liter in 2030. The total jet fuel consumption is 1.6 billion liter, which will increase to 3.2 billion liter in 2030.

CNG as an environmentally friendly and a cheaper fuel is recently introduced to the Iranian traffic system as a substitute for gasoline and gas oil. There is an ambitious plan to build the required infrastructure for production and distribution of CNG, particularly in large cities. We assume that CNG will account for 5 percent of total energy use by passenger transport.

**Table 4.15. Passenger Transport Indicators – BAU Scenario (2005 - 2030)**

	2005	2030
<b>Private</b>		
Number of cars (million)	6	18.26
Average total travel distance by a passenger car per year (km/year)	24,000	22,000
Total travel distance by passenger cars per year (million km/year)	144,000	401,632
Average load per car (person)	1.7	1.5
Total travel distance by passengers (million person km/year)	244,800	602,449
Average gasoline consumption per car (liter/100 km)	14	7.5
Total gasoline consumption by passenger cars (m. liter)	20,160	30,122
<b>Public</b>		
Number of buses	233,000	358,000
Average travel distance by bus per year (km/year)	45,000	41,250
Total travel distance by bus (mkm/year)	10,496	17,219
Total travel distance by passengers – bus (million person km/year)	182,682	382,497
Average gas oil consumption by bus (liter/100 km)	51	25
Total gas oil consumption by bus (million liter)	5,353	4,305
Total travel distance by train (million person km)	11,149	29,708
Total gasoil consumption by train (million liter)	95	253
Total travel distance by air (million person km)	10,985	29,284
Total fuel consumption by airplane (million liter)	1,630	3,166

#### 4.4.2 Freight Transport

The freight transport in Iran consists of truck, train, air, and sea. Truck accounts for 92 percent and train about 8 percent of the total freight transport. The shares of air and sea are negligible. Using the travel distance by trucks and trains and their specific energy consumption, we obtain the total energy consumption by these two transportation

modes. The results are presented in Table (4.16). The freight transport by truck uses about 9 billion liter and by train 239 million liter gasoil. They will increase to 21 billion liter and 600 million liter in 2030; that is, a growth rate of 3.5 and 3.75 percent on average per year, respectively. The total consumption of gasoil by freight transport is 108 BOE, which will increase to 161 in 2030.

**Table 4.16 - Freight Transport Indicators – BAU Scenario (2005-2030)**

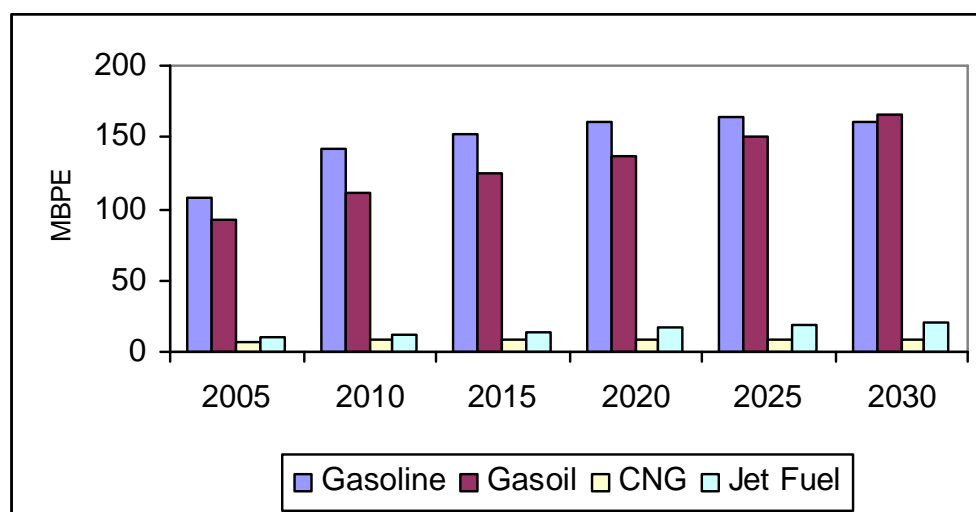
	2005	2030
Freight transport by truck (million tones km)	208,263	553,389
Freight transport by train	19,112	47,980
Total fuel consumption by truck (million liter)	8,955	21,029
Total fuel consumption by train (million liter)	239	600

The ship transport consumes about 1.4 percent of the total Iranian gas oil consumption. Since there is no direct and reliable data on the details of this sector, we assume that this ratio will remain constant in the study period. Table (4.17) shows the total consumption of different energy types used by transport sector in BOE unit. Gasoline and CNG will be the major energy types used in the sector. The total final energy demand in transport sector, which is 217 mboe in 2005, will grow on average by 2 percent per year reaching 354 mboe in 2030.

**Table 4.17 - Final Energy Demand by Transport Sector- BAU Scenario (2005-2030) - mboe**

	2005	2030	Growth (%)
Gasoline	108	161	1.62
Gasoil (buses and trucks)	88	156	0.99
CNG	6	8	2.31
Gasoil (train)	2	5	3.82
Jet fuel	10	20	2.69
Ship fuel	2.48	3.82	1.75
Total	217	354	1.98

Figure (4.4) shows the current and BAU scenario for the fuel consumption by transport mode in the transport sector.



**Figure 4.4- Energy Demand by Road Transport, BAU Scenario (2005-2030), mboe**



## 4.5. Other Sectors

In this section, we model the energy consumption by public, commercial, and agriculture sectors. These three sectors account for 57 percent of the total value added of the economy, but use less than 10 percent of the total energy consumption.

### 4.5.1. Public Sector

Public sector accounts for 15 percent of the GDP and uses about 2.5 percent of the total energy consumption in the economy. More than half of the energy used in the sector is electricity and one quarter is gas oil. Table (4.18) shows total consumption of different types of energy and their energy intensities in the public sector. Since there is no individual data for the consumption of natural gas by public sector, we estimate it by assuming that natural gas has substituted fuel oil for the past 10 years. Therefore, the consumption of natural gas for the period 1996-2004 will be equivalent to the reduction in fuel oil consumption in public sector.

**Table 4.18. Energy Consumption And Energy Intensity In The Public Sector (2004)**

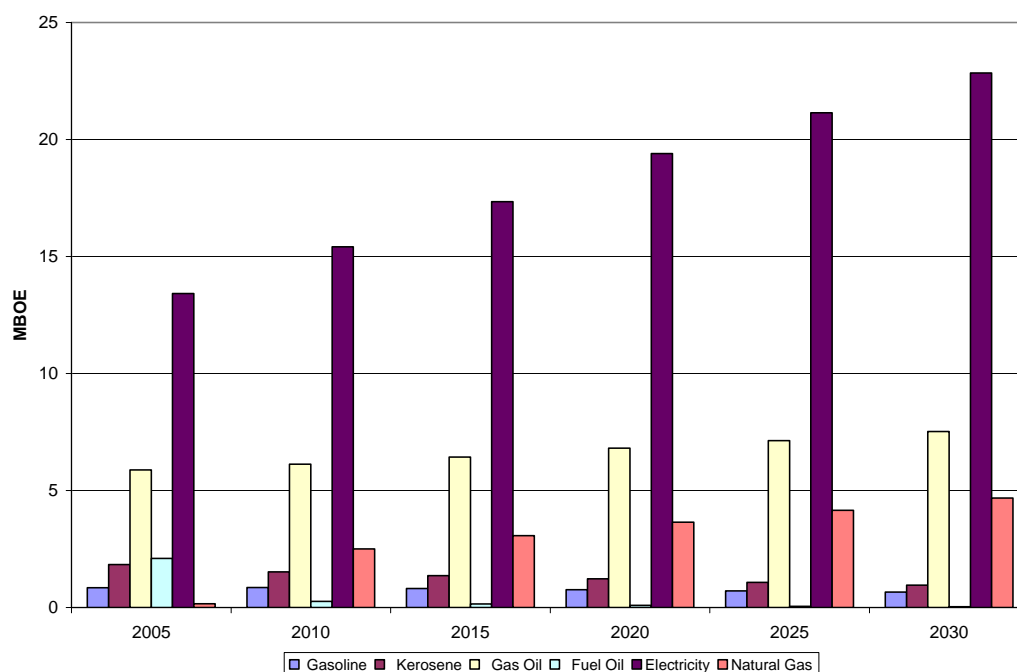
Energy Consumption (mboe)		Energy Intensity (BOE/Constant 1997 million rials)
Gasoline	0.81	0.013
Kerosene	1.74	0.029
Gas Oil	5.58	0.093
Fuel Oil	1.99	0.033
Electricity	12.74	0.213
Natural Gas	0.16	0.003

Source: Ministry of Energy, and the study's estimation

The future energy consumption of public sector is estimated by multiplying the future value added of the sector by the future energy intensities. According to the FYDP and the Vision, the share of the public sector will decrease in the future, as privatization of public enterprises continues. Therefore, we reduce the share of the public sector in the economy from 15 percent in 2005 to 10 percent in 2030, which leads to an average of 2 percent annual growth of value added. The energy intensities for different energy types have been decreasing for the period 1996-2004 and we assume that the trend will continue in the future, but at slower rates. The only exception is the natural gas whose intensity has been growing and will continue to grow but at a slower rate. The estimation results for the energy demand by public sector are shown in Table (4.19). According to the BAU scenario results, the total energy demand in public sector will grow on average by 1.67 percent per year for the period 2005-2030. Electricity and natural gas will be two major energy types used in public sector in 2030. Figure (4.5) shows the future trend of the demand for energy in public sector.

**Table 4.19- Public Sector Energy Demand, BAU Scenario (2005-2030), mboe**

	2005	2030	Growth (%)
Gasoline	0.85	0.66	-1
Kerosene	1.83	0.95	-2.6
Gas Oil	5.88	7.52	1
Fuel Oil	2.10	0.03	-15
Electricity	13.42	22.84	2
Natural Gas	0.16	4.68	14
Total	24	37	1.67



**Figure 4.5. Demand for Energy In Public Sector, BAU Scenario (2005-2030)**

#### 4.5.2. Commercial Sector

Commercial sector accounts for about 30 percent of GDP and has been growing by about 4 percent for the past 10 years. It uses about 2 percent of the total energy consumption in the economy from which 24 percent is electricity, 47 percent fuel oil, 20 percent gas oil, and 5 percent natural gas. Table (4.20) shows consumption of different energy types in the sector and the energy intensities. Since the individual data for natural gas consumption is not available, we estimate it by assuming that natural gas is substituted for fuel oil in the sector since 1996.

**Table 4.20. Energy Consumption and Energy Intensity in the Commercial Sector (2004)**

	<b>Energy Use</b>	<b>Energy Intensity</b>
	<b>(mboe)</b>	<b>(BOE/constant 1997 million rials)</b>
Gasoline	0.06	0.0036
Kerosene	0.44	0.0342
Gas Oil	4.19	0.0795
Fuel Oil	9.72	0.0405
Electricity <sup>a</sup>	4.96	0.0004
Natural Gas	32.12	0.2627
Total	51.47	0.42

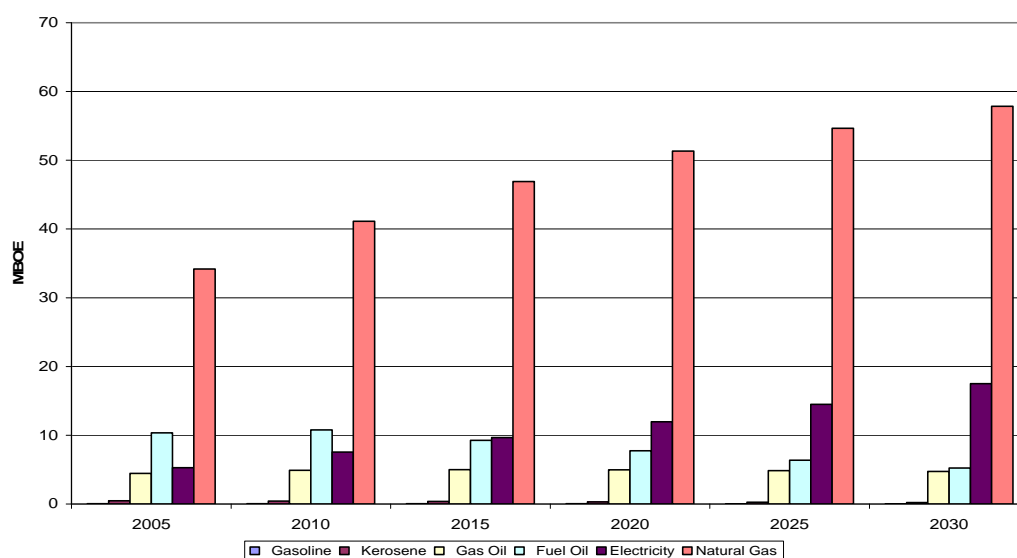
*a. Electricity and natural gas intensities are calculated for 2005.*

The total demand for energy in the commercial sector is estimated using the future value added of the sector and the energy intensities. The future value added of the commercial sector is estimated assuming that the share of the sector in GDP will increase from 31 percent in 2005 to 33 percent in 2030. This means that the sector will grow on average by 4.9 percent per year in the next 25 years. The energy intensities in the sector have been decreasing for kerosene, gasoline, and fuel oil, but increasing for natural gas, electricity, and gasoil. We assume that the future energy intensities will follow the past trend, but at slower rates. Table (4.21) shows the total energy demand by the commercial sector for the periods 2005 and 2030. The energy demand will decline for gasoline, kerosene, and fuel oil by an average of 3 percent, but will grow for electricity and natural gas by an average of 5 and 2 percent per year, respectively. The total demand for energy in the commercial sector will grow on average by 2 percent per year for the period 2005-2030.

**Table 4.21 – Commercial Sector Energy Demand, BAU Scenario (2005-2030), mboe**

	2005	2030	Growth (%)
Gasoline	0.06	0.03	-3
Kerosene	0.47	0.21	-3
Gas Oil	4.45	4.74	0
Fuel Oil	10.34	5.24	-3
Electricity	5.27	17.51	5
Natural Gas	34.17	57.84	2
Total	54.77	85.57	2

Figure 4.6 shows the future trend of the energy demand in the commercial sector. Natural gas and electricity will remain the main source of energy in this sector in 2030.



**Figure 4.6. Demand for Energy in Commercial Sector (2005-2030)**

### 4.5.3. Agriculture

Agriculture accounts for about 12 percent of GDP and uses 32.2 mboe or 3.6 percent of the total final energy consumption. The main source of energy in agriculture is gas oil, which accounts for 98 percent of fuel consumption in the sector. The use of electricity is very low but has been increasing for the past decades. Table (4.22) shows the use of different energy types and their energy intensities in the sector in 2004.

**Table 4.22- Energy Consumption And Energy Intensity in Agriculture, 2004**

	Energy Consumption	Energy Intensity
	(mboe	(BOE/constant 1997 million rials)
Gasoline	0.08	0.001
Kerosene	0.47	0.009
Gas oil	22.34	0.410
Fuel Oil	0.03	0.001
Electricity	9.76	0.179

*Source: Energy Balance, Ministry of Energy, Iran, 2004, and authors' calculations*

Similar to other sectors, we use valued added and the energy intensities to project the future consumption of energy in the agriculture sector. The future value added of the sector is obtained assuming that the share of agriculture in GDP will be decreasing gradually in the next 25 years. Specifically, the agriculture share of the GDP will decrease from 13.9 percent in 2005 to 11 percent in 2030. Given the assumption for GDP growth, this means that the agriculture sector will grow at the rate of 5.1 percent in

2005-2010, 3 percent in 2011-2020, and 2.6 percent in 2021-2030<sup>1</sup>. The details of the energy intensity for different types of energy in agriculture are shown in Table (4.23). The energy intensities for all energy types but electricity have been decreasing for the past 10 years, with kerosene and fuel oil having the highest decline rates. It is assumed that the energy intensities will continue to decline but at lower rates. The future demand for energy in agriculture is estimated using the future value added and the energy intensities for the period 2005-2030. The results are shown in Table (4.24).

**Table 4.23. Energy Intensity in the Agriculture Sector (2004)**

	<b>Energy Intensity* (2004)</b>	<b>Change in Energy Intensity 1996- 2004(%)</b>	<b>Change in Energy Intensity 2005-2030 (%)</b>	<b>Energy Intensity (2030)</b>
Gasoline	0.001	-2	-1.6	0.001
Kerosene	0.009	-19	-6.7	0.001
Gas oil	0.410	-4	-2.2	0.23
Fuel Oil	0.001	-22	-7.3	0.0001
Electricity	0.179	2	1	0.23
Total	0.59	-3.4	-1	0.47

\* BOE/Const. 1997 million rials

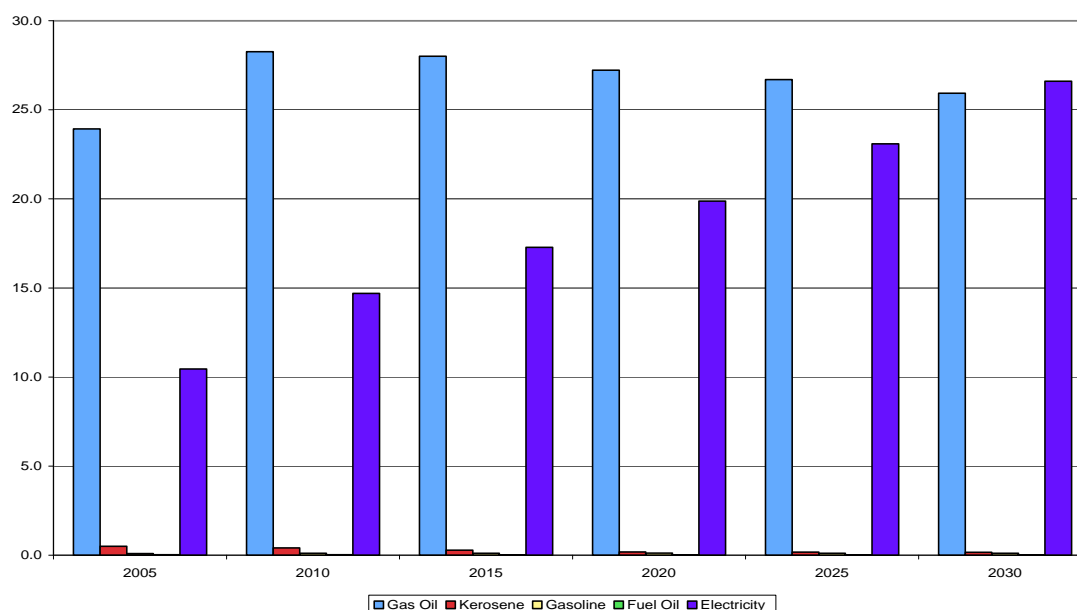
1. The Vision has projected the future growth of the agriculture sector as 6.5 and 5.6 percent. These growth rates do not seem to be realistic given the past trend and restrictions such as the scarcity of the water resources.

**Table 4.24 – Agriculture Demand for Energy (2005-2030)- mboe**

	<b>2005</b>	<b>2030</b>	<b>Growth (%)</b>
Gasoline	0.09	0.12	0.91
Kerosene	0.50	0.17	-4.06
Gas Oil	24	25.9	0.31
Fuel Oil	0.03	0.01	-4.87
Electricity	10	26.6	3.66
Total	35	52.8	1.60

The energy demand in the agriculture sector will grow on average by 1.60 percent per year reaching from 35 million BOE in 2005 to 52.8 million BOE in 2030. Demand for kerosene and fuel oil will decline, but demand for gas oil, gasoline, and especially electricity will increase. The higher growth in electricity demand in the sector is consistent with the current policy of making electricity accessible to all rural areas and particularly of encouraging people to switch from the gasoline or gasoil water pumps to electrical pumps. The future trend of energy use in the agriculture sector is shown in Figure (4.7).





**Figure 4.7. The Energy Demand In The Agriculture Sector, BAU Scenario (2005-2030)-**

**mboe**

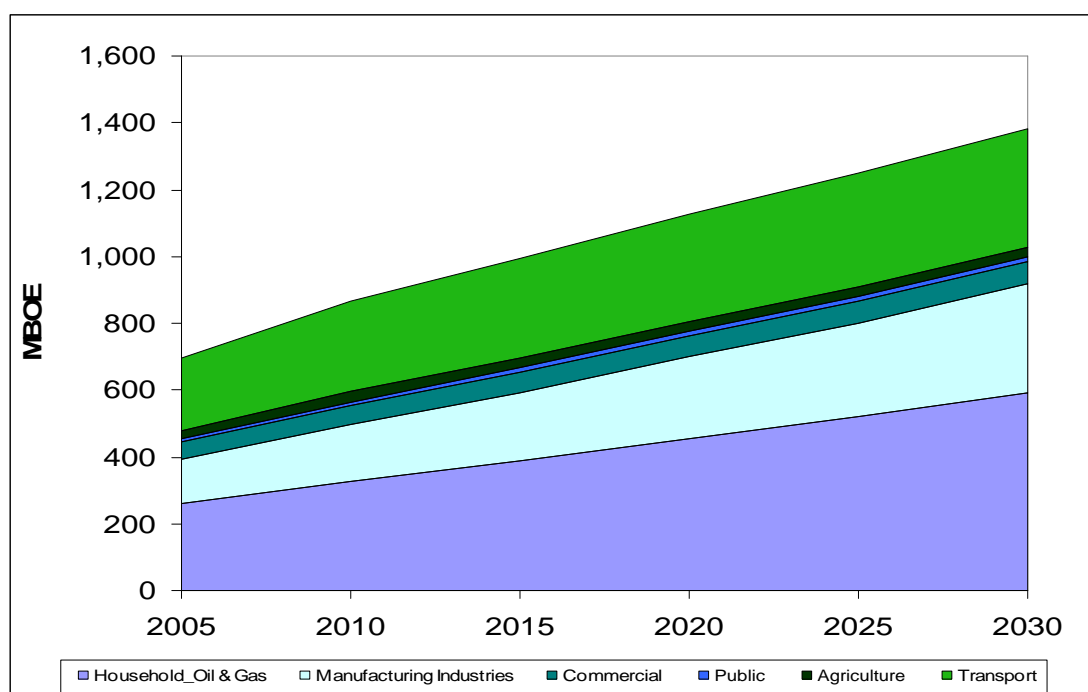
## 5. Total Energy Demand

### 5.1. Sectors

Total demand for primary energy will increase on average by 2.5 percent per year reaching from 970 mboe in 2005 to 1821 mboe in 2030 in the BAU scenario. The manufacturing industries will have the highest growth in demand for energy with an average growth of 3.6 percent per year followed by the residential and transport sectors with 3.4 and 2 percent annual growth, respectively. The demand for energy in the commercial sector will grow on average by 1.3 percent annually, public sector by 1 percent, and agriculture sector by 0.3 percent. Table (5.1) and Figure (5.1) show the BAU Scenario results for energy demand in different sectors for the period 2005-2030.

**Table 5.1– Total Primary Energy Demand in Iran by Sectors, BAU Scenario (2005-2030),**

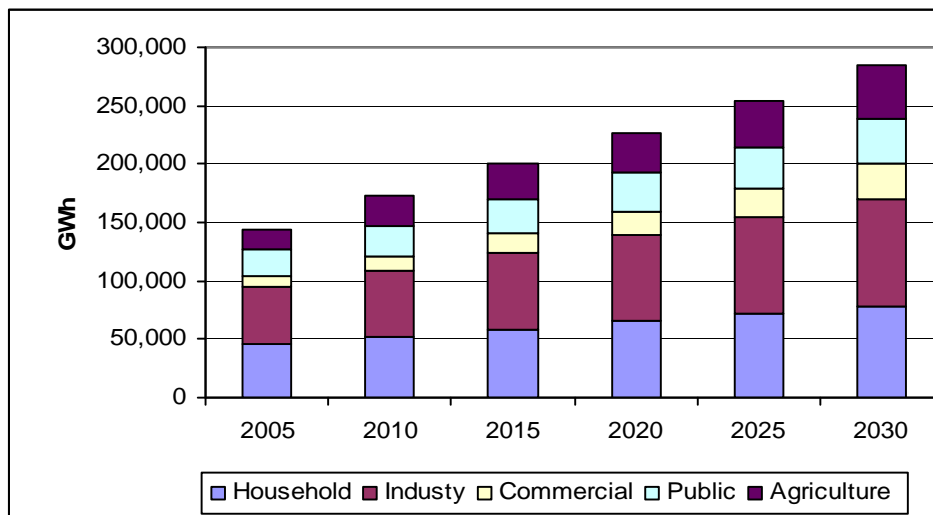
	2005	Share	2030	Share	Growth
	(mboe)	(%)	(mboe)	(%)	(%/year)
Households	259	37.2	592	42.8	3.4
Manufacturing Industries	135.6	19.4	326	23.6	3.6
Transport	218	31.5	356	25.8	2
Public	11	1.6	14	1.0	1
Commercial	49.5	7.1	68	4.9	1.3
Agriculture	24.5	3.5	26.2	1.9	0.3
Total	698	100	1,382	100	2.8
Electricity	272		440		1.9
Total (including electricity)	970		1,822		2.6



**Figure 5.1- Total Primary Energy Demand by Sectors, BAU Scenario (2005-2030)**

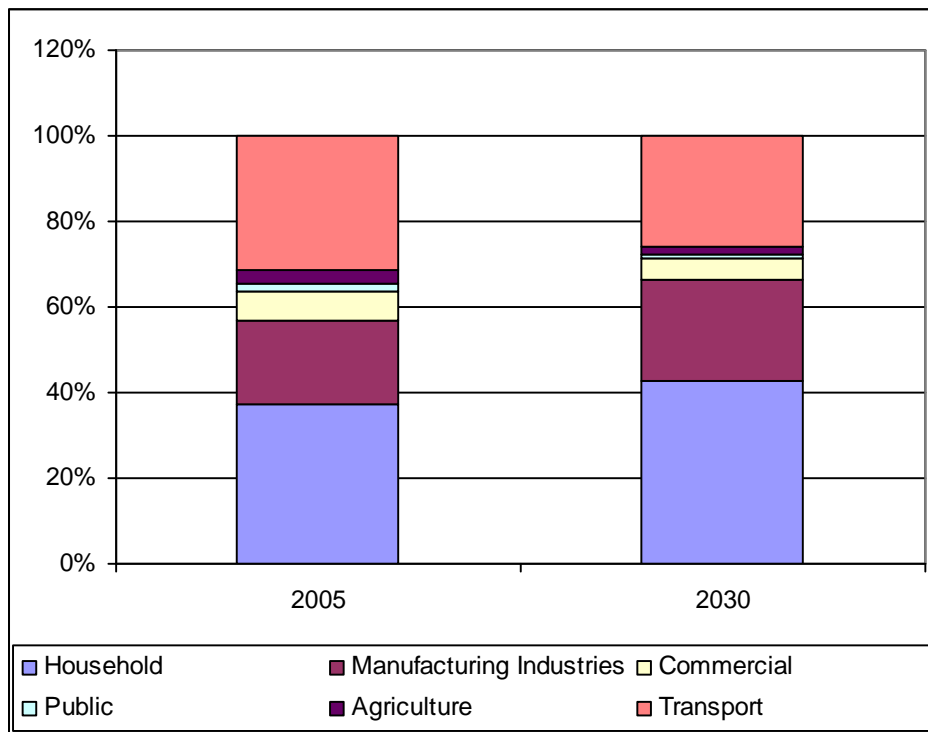
The demand for electricity by all sectors will increase on average by 2.7 percent annually reaching from 144 GWh in 2005 to 384 TWh in 2030. The commercial and agriculture sectors' demand for electricity will grow at higher rates than the average growth rate for the economy, and therefore, their shares of electricity demand will increase from 15 and 7 percent in 2005 to 16 and 10 percent in 2030, respectively. The other sectors' demand for electricity will grow at a rate lower than the average growth in the economy, and as a result their shares will reduce slightly in 2030. Figure (5.2) shows the demand for electricity by different sectors in the BAU scenario for the period 2005-2030.

In 2030, 96 percent of electricity produced will be based on fossil fuel power generating plants. The remaining 4 percent will be produced by the renewable and nuclear plants. Natural gas will be the main source (79 percent) of fuel for the power generating plants by 2030. The renewable sources in power generating plants will grow on average by 3.6 percent per year reaching from 2.8 mboe in 2005 to 6.7 mboe in 2030,. It is also assumed that the nuclear energy will contribute to the power generation by producing 11 mboe starting in 2010.



**Figure 5.2- Demand for Electricity by Sectors in BAU Scenario (2005-2030)**

The structure of the energy demand will change according to the policies and the technological changes in the next 25 years. Specifically, the shares of households and manufacturing industries of total energy consumption will increase from 37 and 19 percent to 43 and 24 percent, respectively. However, the shares of transport, commercial, public, and agriculture sectors will decrease from 31, 7, 1.6, and 3.5 percent in 2005 to 26, 5, 1, and 2 percent in 2030, respectively. The increasing shares of household and manufacturing industries in total demand for energy are mainly due to the increase in population and economic activities in those sectors and decreasing energy demand shares of transport and other sectors are due to technological improvement and government policies. Table (5.1) and Figure 5.3 show the changes in total energy demand by all sectors and their shares for the period 2005-2030.



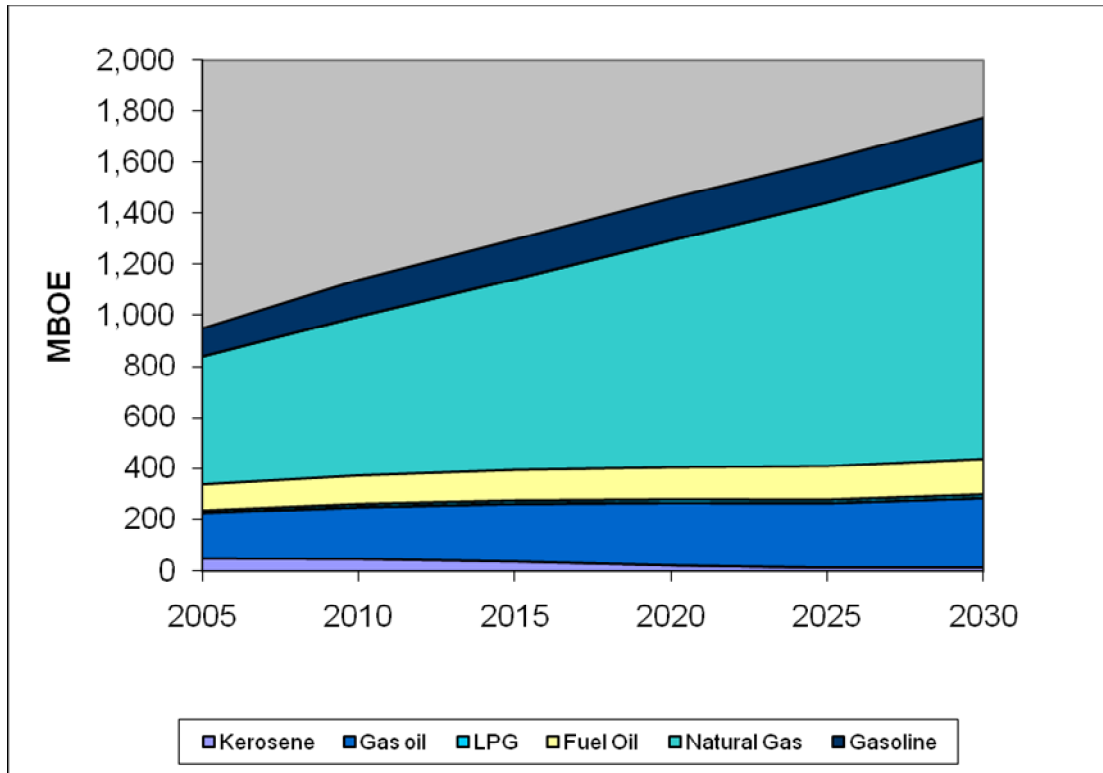
**Figure 5.3- The Shares of Demand for Energy by Sectors in BAU Scenario (2005-2030)**

## 5.2. Energy Type

In the BAU scenario, natural gas demand will have the highest growth rate with 3.5 percent growth per year on average, reaching from 501 mboe in 2005 to 1,171 mboe in 2030. The demand for oil products (fuel oil, gas oil, and gasoline) will grow on average between 1 to 2 percent. Demand for kerosene, however, will decrease on average by 4.6 percent per year in this period. Renewable energies will grow on average by 3.6 percent per year for the next 25 years. Table 5.2 and figure 5.4 show the total energy demand by type of energy in 2005 and 2030.

**Table 5.2- Total Energy Demand by Type of Energy , BAU Scenario (2005-2030), mboe**

	Growth				
	2005	Share(%)	2030	Share(%)	(%)/year
Gasoline	110	11	164	10	1.62
Kerosene	50	5	15	1	-4.6
Gas oil	175	18	271	15	1.8
Fuel Oil	104	8	140	7	1.2
Natural Gas	501	52	1,171	63	3.5
LPG	11	2	13	1	0.9
CNG	6	1	8	1	0.99
Jet Fuel	10	1	20	1	
Total Energy Demand	970	100	1,779	100	2.8

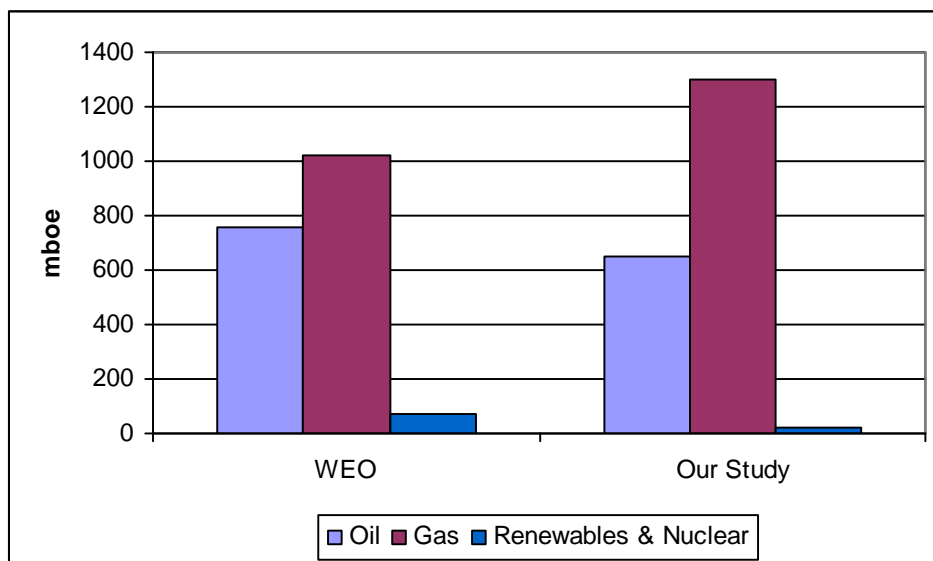


**Figure 5.4 – Total Primary Energy Demand by Energy Type, BAU Scenario (2005-2030)**

### 5.3 Comparison with WEO

The World Energy Outlook (WEO) published by IEA projects scenarios for energy demand in different countries and regions in the world. In its 2006 report, the demand for energy in Iran has been estimated based on the two “reference” and “deferred investment” scenarios for the period 2003-2030. The main determinants of the energy demand in the WEO model are GDP and population. The GDP growth rates are assumed 4.5 percent in 2003-2010 and 3 percent in 2020-2030. The population is assumed to grow at 1.3 percent in 2003-2010 and 0.9 percent in 2020-2030. Although the assumptions, methodology, coverage of the sectors, and the objectives of the WEO study are not exactly the same as those of our study, the comparison of the results may

prove helpful. For instance, WEO seems to have used aggregate data, whereas our study uses micro level data, particularly in household sector, to model the energy demand. Furthermore, our GDP growth assumption is higher by 1 percentage point than WEO assumption for the period ending 2010. There are also differences in classification of the sectors, but we rearrange the results to make them comparable. Figure 5.5 shows a comparison between the primary energy demand in our BAU scenario results and the WEO's reference scenario results for the year 2030.



**Figure 5.5 – Total Primary Energy Demand in WEO and Our Study, BAU Scenario (2030)**

Overall, the estimates for the total final energy consumption by the two studies are rather close, but WEO's total calculations are lower than our calculations by 133 MOBE in 2030. In our study, the total primary energy demand will grow on average by 2.8 percent, but in WEO study by 2.6 percent. The main source of difference is the lower demand for natural gas and higher demand for oil by WEO. Demand for oil products and natural gas in our study will increase on average by 1.4 and 3.6 percent per year, but in

WEO by 1.9 and 2.9 percent, respectively. The use of renewable and nuclear energy is also projected higher in the WEO than our study. However, renewable energy will have a higher growth rate in our High-Renewable scenario, which is presented in the Scenario Analysis in part II. The other source of difference in the two studies is the projection of total electricity generation, which will increase on average by 3.2 percent per year in WEO , but 2.8 percent in our study.

## **5.4. Energy and Environment**

Fossil fuels produce greenhouse gases such as NO<sub>x</sub>, SO<sub>2</sub>, CO<sub>2</sub>, CO, and SPM. In 2005, the energy users in the economy produced in total 1 million tones (mt) of NO<sub>x</sub>, 0.8 mt of SO<sub>2</sub>, 382 mt of CO<sub>2</sub>, 87 mt of CO, 2 mt of CH, and 0.3 mt of SPM. The transport sector is by far the most pollutant sector in the economy, followed by household, industry, and power generating plants. The amount of CO<sub>2</sub> emissions by different sectors in 2005 are as follows: Transport 105 mt (27.5 percent), residential, commercial, and public 112 (29.3 percent), power generating plants 95 mt (25.1 percent), industry 59 mt (15.4 percent), and agriculture 10 mt (2.6 percent). Although the substitution of natural gas for oil products and the development of renewable resources in the power generating plants will mitigate CO<sub>2</sub> emissions problems, an increase in energy demand especially by manufacturing industries and households will raise the aggregate pollution level significantly. Table (5.3) shows a summary of the CO<sub>2</sub>-emissions from primary energy use for the period 2005-2030. CO<sub>2</sub> emissions from oil will grow on average by 1.4 percent and from gas by 3.5 percent per year for the next 25 years. The total CO<sub>2</sub> emissions will grow on average by 2.5 percent per year reaching from 360 Mt in 2005 to 667 Mt in 2030.



**Table 5.3 - CO<sub>2</sub> emissions From Primary Energy Consumption (2005-2030), Mt**

	2005	2010	2020	2030	Growth (%)/year
Oil	205	241	271	290	1.4
Gas	155	196	287	377	3.5
Total	360	437	558	667	2.5

## **Part II**

### **Demand for Energy: Scenario Analysis**

## Part II: Scenario Analysis

In this part, we develop alternative scenarios for the energy demand in Iran using the results of the BAU scenario presented in part I as a reference. Specifically, we consider four scenarios as follows:

1. High Efficiency scenario
2. High Renewables scenario
3. Combined Efficiency and Renewable scenario
4. Constrained scenario

In the High Efficiency scenario, we draw on the efficiency parameters in energy use in each sector of the economy leaving the renewable resources at the BAU levels. In the High Renewable scenario, we assume that the potentials of the renewable resources will be highly utilized keeping the efficiency parameters constant as in the BAU level. In the Combined Efficiency and Renewable scenario, we assume that the country will utilize both the efficiency and the renewable potentials in the future. Finally, in the Constrained scenario, we assume that some of the assumptions in the High Efficiency and High Renewables scenarios may not be realized and therefore impose a number of restrictions on both scenarios.

An underlying assumption in all four scenarios is that the policies regarding energy prices will change in a way to reflect the real cost of energy to consumers. This will encourage higher efficiency in energy use and will allow for investment in the renewable resources in different sectors of the economy. One of the most important reasons why the Iranian energy system is quite inefficient, is the fact that oil, gas, and electricity prices are extremely low compared to the international average and the world

market price of crude oil. The huge amount of subsidies for the energy sector, which account for more than 10 percent of GDP, has led to government budget imbalances as well as increasing demand for gasoline, electricity, and natural gas in different sectors. As long as the domestic energy prices are so low, there is less incentive to invest in technologies that are more efficient and to change energy wasting behavior in different sectors of the economy.

The energy market in Iran is controlled by the state. This means that the government mostly undertakes investment, production and even distribution in the energy sector. The government also sets the production quantities (domestic, exports, and imports) and prices on different energy carriers and products. Therefore, there is no competition in production and distribution and political factors, rather than economic and market conditions, affect the energy prices. This may well be one additional reason why energy efficiency is on a low level and why there is no incentive to invest in renewable energy resources. Although the fourth FYDP (2004-2009) called for a price reform in the energy market, the new parliament and government did not implement it. However, there are indications that the past policies cannot not continue and price reform is inevitable. If the domestic energy consumption continues to grow as projected in the BAU scenario, Iran's ability to export oil will be diminished largely. This is obviously a warning to the government whose budget is heavily dependent on the oil export revenues.

For the analysis of the four alternative scenarios, some principal assumptions have been made as follows:

- The price of oil will continuously approach the boarder prices for crude oil. The electricity price will rise and reflect the true cost of electricity production and distribution. A rise in relative energy prices will change people's behavior in

energy demand and their investment into efficient appliances, buildings, cars, and power plants.

- Any cost-related decision concerning energy efficiency at the individual level is based, more or less, on a trade-off between the up-front investment cost and the expected future energy expenses. As the energy price increases, energy efficient solutions with typically higher up-front costs become more attractive. Making a “good” investment decision, for domestic appliances or industrial devices, from the energy efficiency viewpoint, certainly relies on a sound economic calculation. Good or adequate (and not subsidized) price signals are necessary to make a correct calculation.
- To gain efficiency, government may change its past policy of full provision to allow for private sector investment in the energy sector. Government would still be able to regulate the market to protect consumers from monopolies exercising market power. Efficient regulation will lead to energy prices that reflect the cost of energy supply, i.e. the long-term marginal cost for electricity and the long-term price of oil products in international markets for fossil fuels.
- In addition to price and market reform, there are other measures, which would help to remove the existing barriers to energy efficiency as follows.
  - The availability of efficient appliances and production devices
  - The availability of good information for consumers about such equipment and devices
  - Public awareness on energy efficiency, in particular awareness of the final consumers about the individual and national benefits of energy efficiency and climate protection

- Removal of other hampering factors such as legal and administrative barriers
- The availability of technical, commercial and financial services

These policy measures are necessary in market economies to reinforce the role of energy prices, and to create a framework that provides cost effective solutions for the consumers. Any efficiency improvements in oil consuming sectors like the transport sector will result in direct benefits to the balance of oil trading, because Iran would have to import less gasoline from other countries. Instead of subsidising the consumed energy through the national fund, the saved resources could be sold in the world market. Improving energy efficiency through highly efficient electric appliances or efficient lights will have two major benefits. First, the electricity demand growth will slow down, which reduces the expansion of investment needs in the electricity sector. Second, the costs for the saved kilowatt-hours are usually lower than the costs of electricity production.

## **6. Scenario I: High Efficiency**

High Efficiency is the first scenario we propose for the future energy demand in Iran. In this scenario, we will focus only on the efficiency parameters in the energy demand in different sectors keeping all other things, including renewable potentials, constant. The most important efficiency parameter is energy intensity, which changes with advancement in technology and a change in the structure of the economy. Other things being constant, more efficient technology will decrease the energy intensity. A change in the structure of the economy in favour of less energy intensive production will also reduce the energy intensity. Our primary concern in this scenario will be a change in energy intensity due to a change in technology. For instance, in the household sector,

we assume that light bulbs and other appliances that are more efficient will substitute the traditional inefficient devices. Likewise, in the transport sector, we assume that cars with more efficient engines will drive away the cars with low efficient engines. In addition to the technological effect, we assume that price reform will induce higher level of consciences in the consumers, household and industry, so that they will be more vigilant in their use of energy.

## **6.1. Households**

We analyze the High Efficiency scenario in the residential sector in two sections: Electricity and Heat.

### **A) Electricity**

The most important use of the electricity in household is lighting (33 percent), refrigerator and freezer (26 percent), and air conditioning (about 10 percent). TV and computer's share of electricity use is 8 percent, but it will double by 2030 in the BAU scenario.

#### **Lighting**

Compact fluorescent light bulbs (CFL) use 60 to 80 percent less energy compared to the traditional light bulbs, producing the same level of lighting. It is assumed that compact fluorescent bulbs will substitute 50 percent of the incandescent lamps that households are using today by the year 2020. In the year 2030, households will substitute 80 percent of the incandescent lamps. It is also assumed that through substituting old T12 lamps by T8 and T5 with electronic starters, electricity consumption of fluorescent lamps will be 40 percent less while keeping the same brightness. Overall, the electricity use by lights in

the residential sector in 2030 will be about 40 percent less in the efficiency scenario compared to the BAU scenario.

### **Refrigerators and Freezers**

It is assumed that in the year 2020, the average consumption of an Iranian refrigerator would be 20 percent higher than the consumption of an average refrigerator bought in Central Europe today. For the year 2030, the average consumption could be 20 percent higher than that of the most efficient refrigerators, which are sold in Europe today. The same relation is assumed for freezers and combined appliances (refrigerator and freezer in one appliance). The overall electricity consumption by refrigerators and freezers in the residential sector in 2030 will be 67 percent less in the efficiency scenario compared to the BAU scenario.

### **Iron**

Using irons equipped with thermostat-regulation would lead to a 50 percent reduction in electricity use for ironing. The electricity consumption of this appliance would still be five times higher than the consumption for ironing in Germany.

### **Air Conditioner**

It is assumed that there will not be a significant change in the water-cooler system, but there will be an efficiency improvement in the new air conditioning system. Although the need for cooling may decrease, the amount of equipment and comfort demands and as a result cooling loads will increase. Overall, the electricity consumption for the cooling systems in the residential sector will be reduced by 30 percent in 2030 under the High Efficiency scenario compared to BAU.

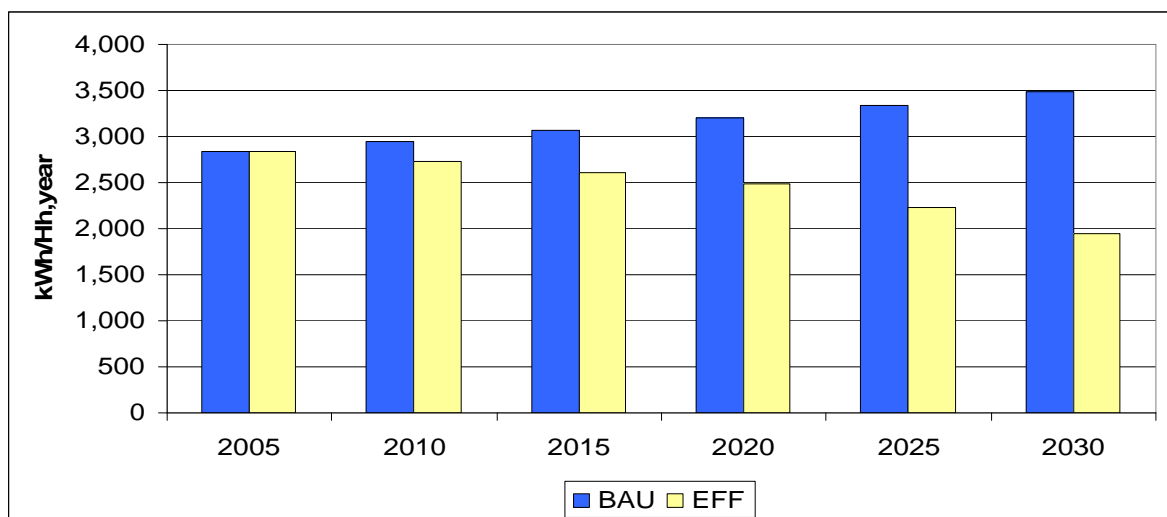


## TV and Computer

It is assumed that there will not be a significant change in the electricity consumption by computers, but through change from CRT-monitor to LCD-monitor TV, the electricity consumption of TV-devices will go down 25 percent until the year 2030.

## Others

For the other appliances no changes in efficiency are assumed.



**Figure 6.1 - Average Electricity Demand in BAU and Efficiency (EFF)  
Scenarios (2005 – 2030) – kWh/Hh, year**

To achieve the high-efficiency parameters in the household sector, the following policies are required.

- Minimum standards for appliances
- Market oriented electricity prices
- Consumer information about electricity consumption of appliances and about efficient products

- Efficiency labeling
- Special marketing measures for highly efficient appliances
- Building standards for efficient cooling system

Figure 6.1 shows the average electricity consumption by households in the efficiency and BAU scenarios. According to our results, the average electricity consumption by households in the efficiency scenario will be 42 percent lower than that in the BAU scenario and thus more than 25% below the current level despite higher penetration rates and higher comfort levels per household.

## **B) Heat**

For the heating sector, the following assumptions have been made:

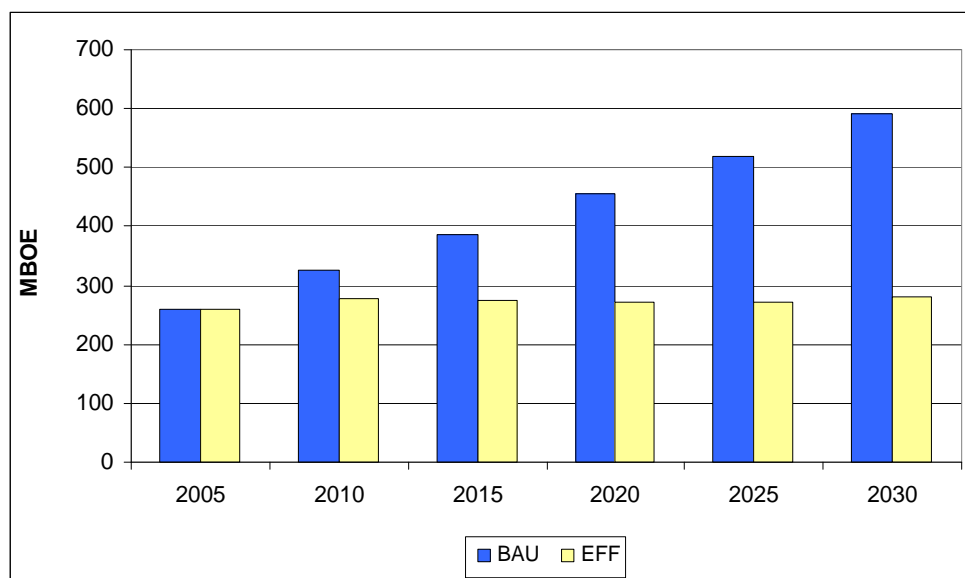
- For existing buildings a renovation rate of 2 percent has been assumed. This means that during a period of 50 years, all buildings will be renovated to a better standard. The energy saving per building is assumed to be 50 percent on average, a value that has already been shown to be feasible in several case studies for Iran. The technical potential to make a building more efficient is about 90 percent. These are the results of many projects and studies in Germany.
- For new buildings in the year 2010 and later, we assume a standard that is about 80 percent better than the average consumption of today's buildings.
- We also assume that by the year 2030, 10 percent of the houses will be demolished and replaced by new and better buildings and that there will be a 10 percent increase in the size of the living-area per person in Iran.

- For the supply of warm water, we assume a higher efficiency through better boilers and better insulation of storage and taps.

To achieve the efficiency scenario targets, the following policies are required.

- Implementing standards for new buildings and for building-renovations
- Financial help for home-owners to bear the investment
- Education for builders and architects
- Control system for monitoring the building standard

The total energy demand for heat by households in the efficiency scenario will be 52 percent less than that in the BAU scenario in 2030. Figure 6.2 shows the heat energy consumption of households in the two BAU and efficiency scenarios.



**Figure 6.2 - Household Energy Demand (Heat) in BAU and Efficiency (EFF) Scenarios (2005-2030), mboe**

## 6.2. Industry

The energy savings in the industry can be achieved by taking the following measures (ECOFYS, 2007).

- Efficient motor system to reduce electricity consumption of electric motor systems, which accounts for 65 percent of the electricity consumption use by industry
- Improved monitoring and process control, which can lead to higher efficient use of energy in industry. This includes monitoring and targeting, computer integrated manufacturing and process (temperature, airflow, moisture, oxygen, etc.) control. These measures can account for 2 to 18 percent of energy savings.
- Process optimization and integration (pinch analysis). This is especially important when there are multiple heating and cooling demands in a production plant. Process integration saves energy by matching components of the system in terms of size, function, and capability. The potential saving by process optimization and integration is 10 to 25 percent.
- Recycling, especially in the aluminium and steel production. Producing aluminium by recycled scrap will use only 5 to 10 percent of the energy used to produce aluminium, because it involves re-melting of the metal instead of the electrochemical reduction process.

The industry in Iran has seen immense growth rates of almost 15 percent per year over the last 15 years, which has led to significant increases in energy consumption. In spite of decreases of energy intensity of about 7 percent per year

between 1990 and 2005, the energy intensity of many industrial installations is still significantly above (about 36 percent) world average. This is mainly due to the low energy prices, lack of capital for investment in new and/or more efficient machinery, and poor public management of the majority of industrial plants.

Between 2000 and 2007, The Iran Energy Efficiency Organization (SAABA), a subsidiary of the Tavanir, and the Iran Fuel Conservation Company (IFCO), a subsidiary of National Iranian Oil Company, have conducted several studies and audited many manufacturing industries to estimate the energy saving potentials. Table 6.1 shows the auditing results for the four major aluminium plants by SAABA in 1999. The metallic manufacturing industry consumes 25 percent of the energy used in the total manufacturing industries and aluminium plants consume 17 percent of the total energy consumed by the metallic industries. Improved monitoring and process control have been identified as the most important sources of energy savings in the audited plants.

**Table 6.1 – Energy Savings in Aluminium Manufacturing Industry**

Unit	Product	Electricity Consumption (MWh/year)	Fuel Consumption (GJ/year)	Electricity Saving Potential (MWh/year)	Fuel Saving Potential (GJ/year)	Total Energy Saving Potential(B OE/year)	Electricity saving (%)	Fuel saving (%)
1	Aluminium Profile	5117	82988	1463.2	37509.5		29	45
2	Aluminium Profile	6408	71513	2290.7	27461	8531	36	38
3	Aluminium Profile	3397	166174	1222.8	53175	10848	36	32
4	Cable	3654	47520	438.4	20433.7	4113	12	43

Source: Tavanir, SAABA, 1999

Tables 6.2 and 6.3 summarize the auditing results by IFCO. They show the current energy consumption and the specific energy index for the selected industries as well as the energy saving potentials in those industrial groups. Both demonstrate that using best practice technology would lead to high energy savings of more than 40 percent on average and also to great savings of energy costs.

**Table 6.2 – Energy Consumption in Selected Manufacturing Industries**

	Current Energy		Specific Energy Index (GJ/ton)				
	mboe	PJ	Country	Best	World	Current	New
	/Year		Average	Practice	Average	Condition	Plants
Glass	3.6	22.2	14.77	7.5	7.95	13.63	9.4
Sugar	8.4	51	36	12	19.7	27.6	13.8
Cooking Oil	1.8	11.4	10	5	6	7.5	6.4
Tire	0.83	5	31.1	17	19	22.7	17.44
Brick	1.7	104	4.8	1.73	2.2	3.9	2.5
Ceramic	3.7	22.7	0.13	0.06	0.07	0.12	0.09
Cement	18	112	3.5	2.6	2.72	3.45	3
Stucco	2.4	14.8	1.69	0.98	0.9	1.3	0.98
Lime	0.6	3.5	6.21	3.8	3.6	4.32	3.78
Iron and Steel	29.9	182.2	15	11	11	12.3	11.3

Source: Optimizing Energy Consumption in Industry Sector in the Next 20 Years, IFCO, 2007

**Table 6.3 – Energy Savings in Selected Manufacturing Industries**

	Saving Potential			Saving Potential (%)		
	Million GJ	Million m <sup>3</sup>	Value (bn. Rials)	Best Practice	Current Condition	New Plants
Glass	8	214.5	408	49	8	36
Sugar	31	836.2	1589	67	23	62
Cooking Oil	4	109.9	209	50	25	36
Tire	2.2	59	112	45	27	44
Brick	49.8	132.2	2512	64	19	48
Ceramic	6.9	185.3	352	54	8	31
Cement	16	424.8	807	26	1	14
Stucco	0.62	165.4	314	42	23	42
Lime	1.3	36.6	70	39	30	39
Iron and Steel	44.9	1,193	2267	27	18	25

Source: Optimizing Energy Consumption in Industry Sector in the Next 20 Years, IFCO, 2007

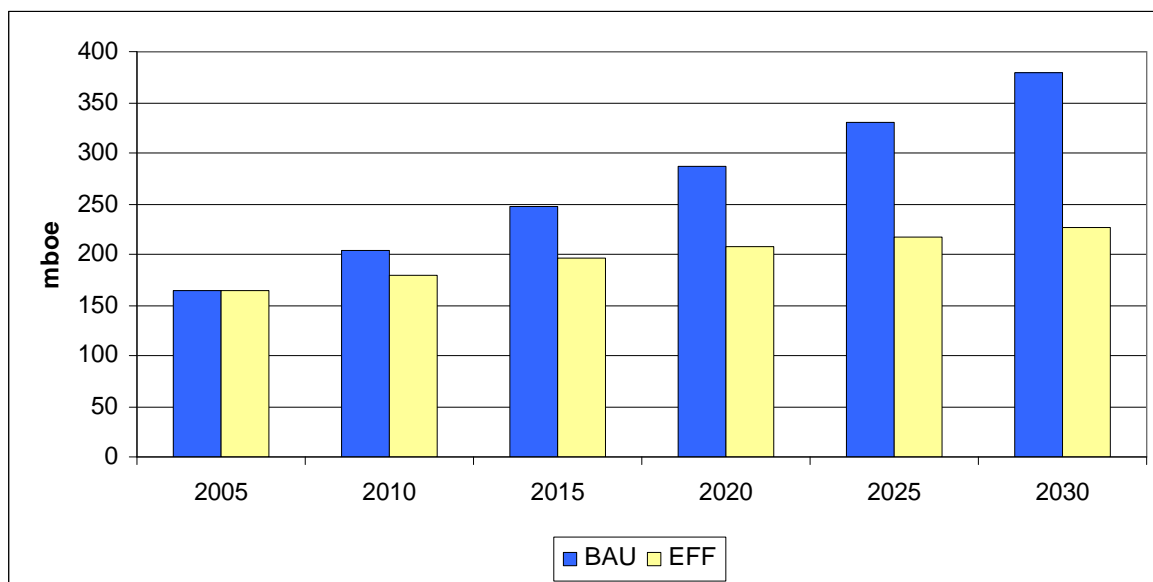
Based on the auditing results above, the following assumptions for the efficiency scenario in industry are made.

- It is assumed that real monetary growth and physical production will be decoupled by a rate of 1 percent per year in the future (as in the BAU scenario), as it is typical in more advanced economies. It is also assumed that existing plants will increase their production levels through a higher capacity utilization and expansions by about 1 percent per year. The residual production will come from completely new producing sites. By 2030 thus the number of plants will almost double and new installations will account for about 50 percent of physical production.

- For the technical standard of refurbished and new power plants it is assumed that the current best available technology (BAT) as described in the tables 6.2 and 6.3 will be utilized. This standard will further improve in the future by about 1 percent per year. For sectors not covered by the analyses of SABA, an average savings factor of 50 percent by using BAT versus currently installed technology has been assumed based on detailed study results from Ecofys (2007).
- It is furthermore assumed that existing plants will be almost completely (83 percent) reinvested by 2030. This would enable most existing plants to produce with BAT by 2030.

The overall energy intensity of the Iranian industry declined by more than 50 percent or by an average of 7 percent per year for the period 1990-2005. In the efficiency scenario, a further decline by more than half, or an annual rate of 3.1 percent, will be achieved by 2030. Although this decrease in energy intensity in industry is a continuation of the past trend, its realization requires strong policies to promote efficiency. The 3.1 percent annual decline in energy intensity in industry under the efficiency scenario is in the same range as the German national target of doubling energy productivity, which would need about 3 percent energy intensity decrease by 2020. Figure 6.3 shows the total energy consumption in the industry sector under the BAU and the High Efficiency scenarios. The total energy consumption in industry in the efficiency scenario will be 41 percent less than that in BAU scenario in 2030.





**Figure 6.3 - The Final Energy Demand in Industry in the BAU and Efficiency (EFF) Scenarios (2005-2030), mboe**

### 6.3. Transport

Fuel efficiency in transport sector can be achieved in two ways:

- Change in the number of cars and travel distance
- Change in technology

The basic assumption in the transport sector is that the price of gasoline and gas oil will eventually increase to the border prices<sup>1</sup>. In this case, the number of private vehicles will be lower and the average yearly travel distance will be shorter compared to the BAU scenario. Furthermore, the share of public transport will increase, mainly because of the higher cost of private cars. We assume that the number of private cars will almost double from 244'800 in 2005 to 433'800 in 2030 (instead of 602'400 in BAU-scenario). The average travel distance per private car will go down from 24'000 km/year

<sup>1</sup>This is still significantly less than in most OECD countries, which levy high taxes on transport fuels.

to 17'600 km/year (a twenty percent decrease compared to the BAU scenario). This is still about 60 percent more than the average travel distance per car in developed countries like Germany today.

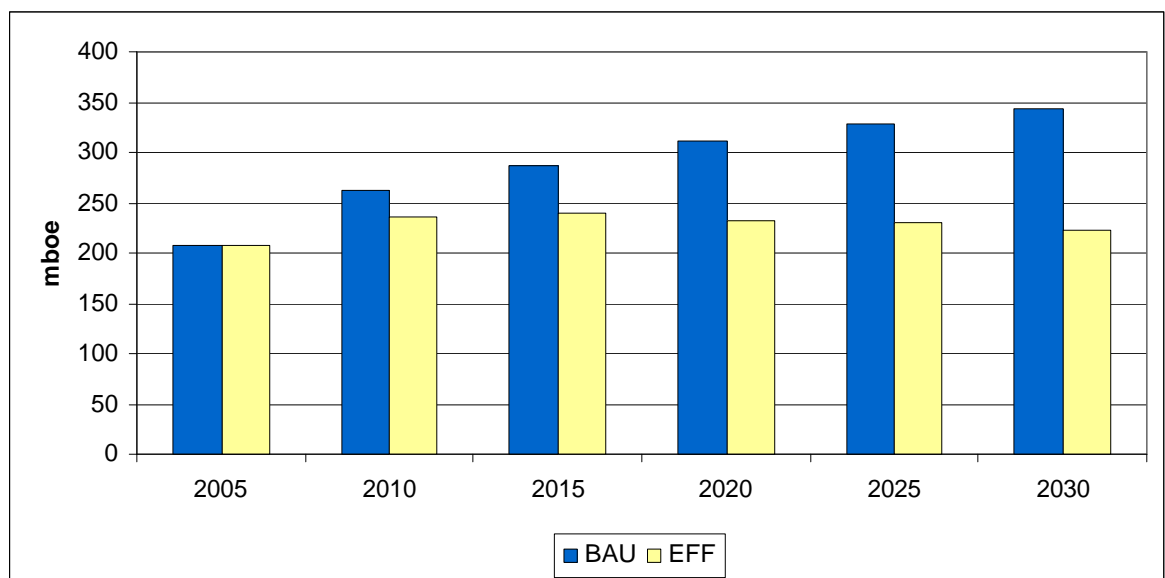
Passenger cars can be more fuel efficient if they have better engines, reduced weights, friction, and drag. The hybrid cars, which combine a conventional engine with an electric engine, are now consuming about 4.3 liter ge/100 Km. It is suggested that this rate can further decline to 1 liter ge/100 Km, when new light materials and new propulsion technologies are used. The average specific energy consumption for Iranian private cars in the BAU scenario will decrease from 14 litre/km to 10.litre/100km by 2030. For the efficiency-scenario, we assume that in 2020, the average consumption of private cars in Iran will be the same as in Germany in the year 2006, which was 7.8 litres/100km. For the year 2030, we assume that private cars in Iran will consume gasoline on average in the same amount of a fairly efficient middle-class car today, that is 6 litres/100 km. The efficiency of busses and trains will rise by 20 percent, the efficiency of aviation will rise by 45 percent through newer and bigger planes.

To achieve the targets above, the following policies are required.

- Stepwise increase of gasoline price to border price
- More investment in bus and train-system
- Consumer awareness on the efficiency of cars and environment
- Labelling for cars and trucks
- Introduction of car fleet efficiency-standards for car importers
- Education courses for efficient driving
- An improvement in road conditions

- Efficiency Improvement in domestic refineries

Figure 6.4 shows the total energy consumption in the transport sector under the BAU and the High Efficiency scenarios in 2005-2030. The total energy used in the transport sector in the efficiency scenario will be 35 percent lower than that in the BAU scenario.



**Figure 6.4 - Final Energy Demand in the Transport Sector under the BAU and High-Efficiency (EFF) Scenarios (2005-2030), mboe**

## 6.4. Other Sectors

Other sectors include public buildings, the commercial sector and the agricultural sector. As the results of surveys show (see table 6.4 below), public buildings and in particular hospitals have extremely high energy intensities. Nevertheless, high saving potentials of between 30 percent and 50 percent have been proven even with current low energy

prices. For existing buildings in the public sector, an average savings potential of 35 percent over the next 25 years has been assumed to be feasible by a systematic upgrading. While savings of 35 percent and more seem to be easily achievable from a technical point of view, the crucial factor will be the possible speed of refurbishment. For new buildings, savings potentials of up to 80 percent compared to the current average are feasible. The average energy intensity of the sector will be 45 percent below BAU-levels by 2030.

**Table 6.4 - Energy Savings in Selected Buildings**

Project	Energy Use Before the Plan		Energy Use After the Plan		Savings
	GJ	MJ/SqM	GJ	MJ/SqM	(%)
Hospital(600 bed)-Tehran	169'999	4'404	111'171	2'880	35
Hospital(400 bed)-Tehran	109'216	3'248	68'530	2'038	37
Hotel (5 Storey, 60 Rooms)- Tehran	62'311	1'648	4'040	1'068	35
Public Building (13 Storey)-Tehran	22'041	2'388	11'057	1'198	50
Public Building –Fars	12'678	1'822	8'319	1'195	34
Public Building – East Azerbayejan	13'369	1'774	7'552	1'002	44
Public Building -Khorasan	10'843	1'807	6'220	1'037	43
Residential Building (12 storey)-Tehran	81'447	1'616	48'485	962	40
Residential Building (4 storey)-Tehran	3'376	2'153	1'624	1'036	52
Residential Building (20 cases)-Tehran	22'638	1'417	12'123	759	46
Educational Building	75'594	2'645	54'426	1'904	28
Total	583'512		333'548		
Subtotal public	413'740		267'276		35

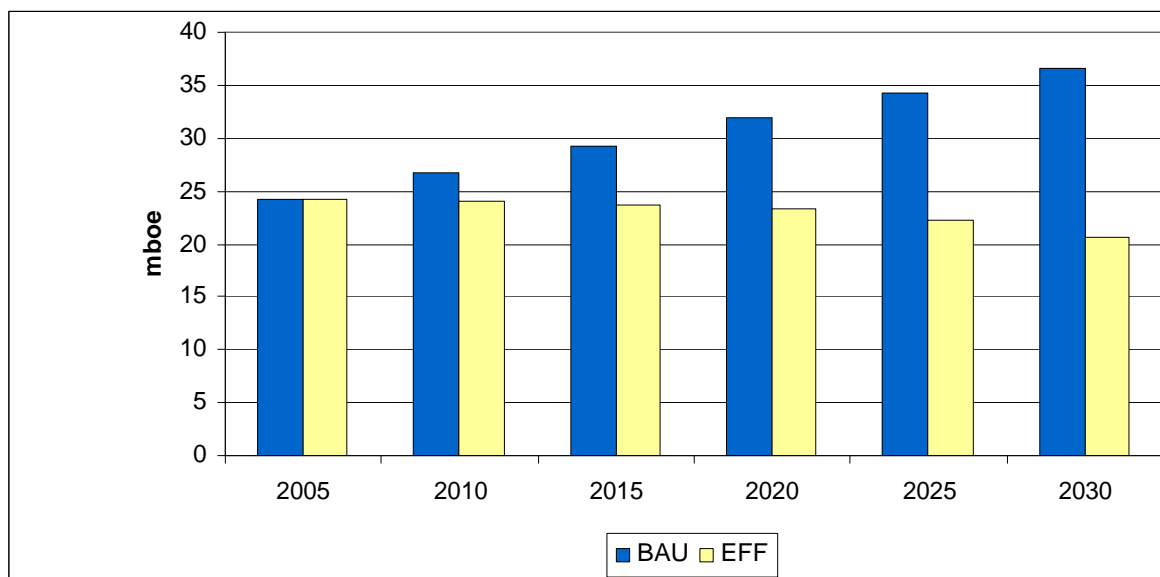
Source: Energy Statistics in Iran and the World, Ministry of Power, Department of Planning, 2004

In order to achieve the efficiency targets above, government should take the following measures.

- Implementing standards for new buildings and for building-renovations

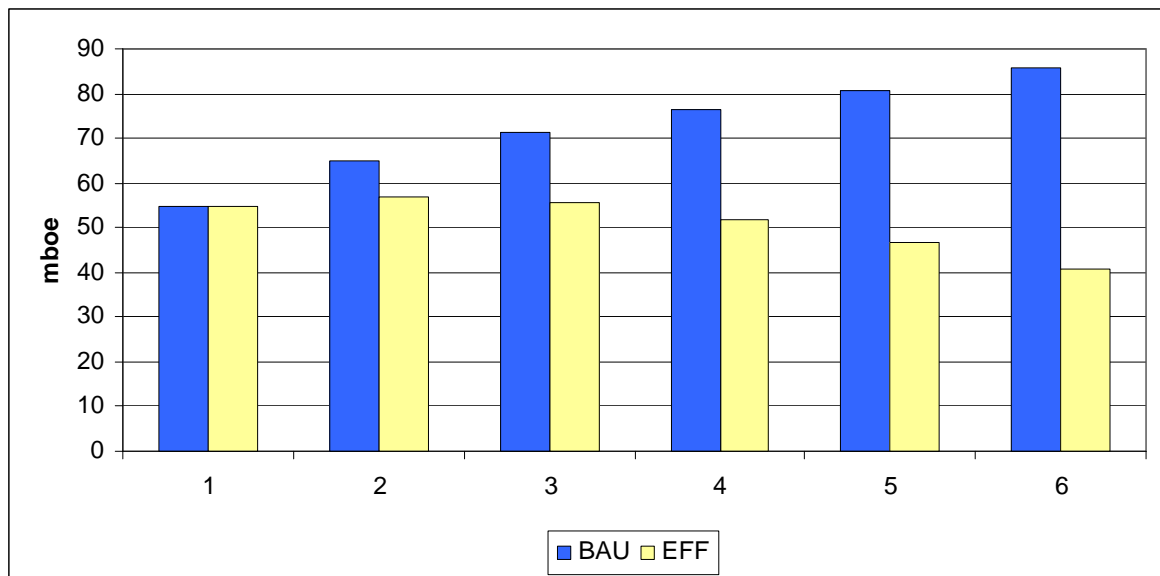
- Regulating energy use in public buildings such as monitoring use of lamps during the out-of-office and holiday hours
- Ban of inefficient lights and appliances in public buildings
- Implementing minimum requirements for the public procurement of energy using goods
- Control system for monitoring the building standard
- Financial support for public institutions to invest in energy efficiency
- Implementing article 44 of the constitution with increasing role of private sector in the economy

Figure 6.5 shows the energy consumption in the public sector under the BAU and the high-efficiency scenarios. The total energy consumption in the public sector in the efficiency scenario will be 44 percent less than that in the BAU scenario in 2030.



**Figure 6.5 - Final Energy Demand in the Public Sector in BAU and High-Efficiency (EFF) Scenarios (2005-2030), mboe**

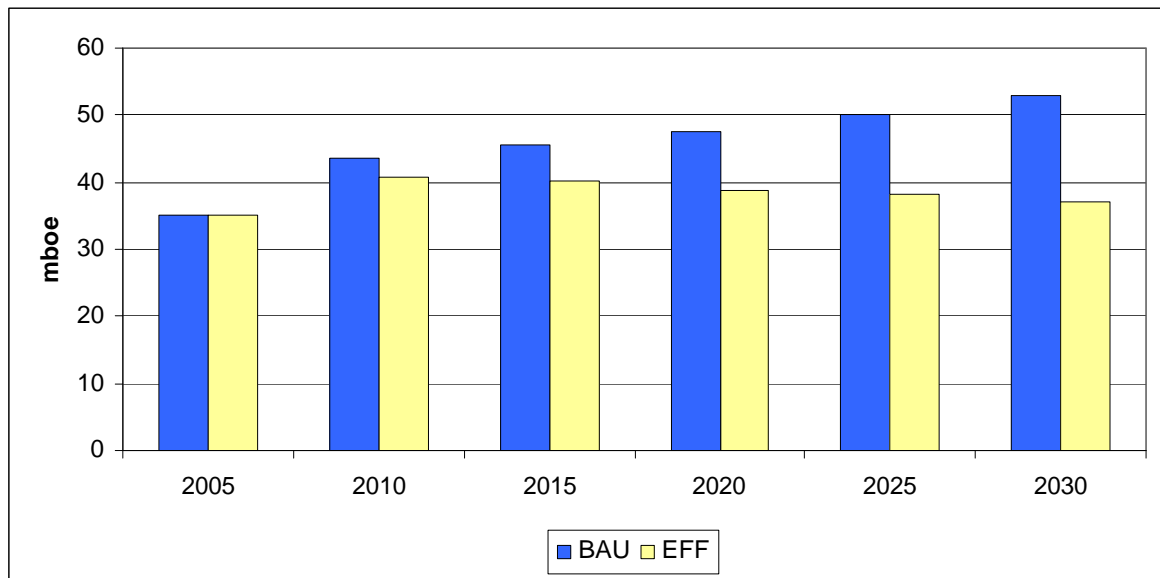
In commercial buildings, energy consumption and potential savings are similar to those in public buildings. However, due to a more dynamic development in the commercial sector, higher refurbishment rates and new building rates are assumed. This leads to overall savings of about 55 percent versus BAU by 2030. The results are presented in Figure 6.6. Also for this sector, several policies and measures are available to improve energy efficiency such as minimum standards for building design and electric appliances including air conditioning, information and financial support for energy efficiency investment.



**Figure 6.6 – Final Energy Demand in the Commercial Sector in BAU and High Efficiency (EFF) Scenarios (2005-2030), mboe**

In the agricultural, sector the achievable savings are probably lower than those in the public and commercial sectors. The core reason is the more diverse use of energy, and often limited availability of capital and knowledge about technology due to remote location and socioeconomic situation. Savings are assumed to be 40 percent versus BAU for electricity and 30 percent for fuels. The results are shown in Figure 6.7. In the

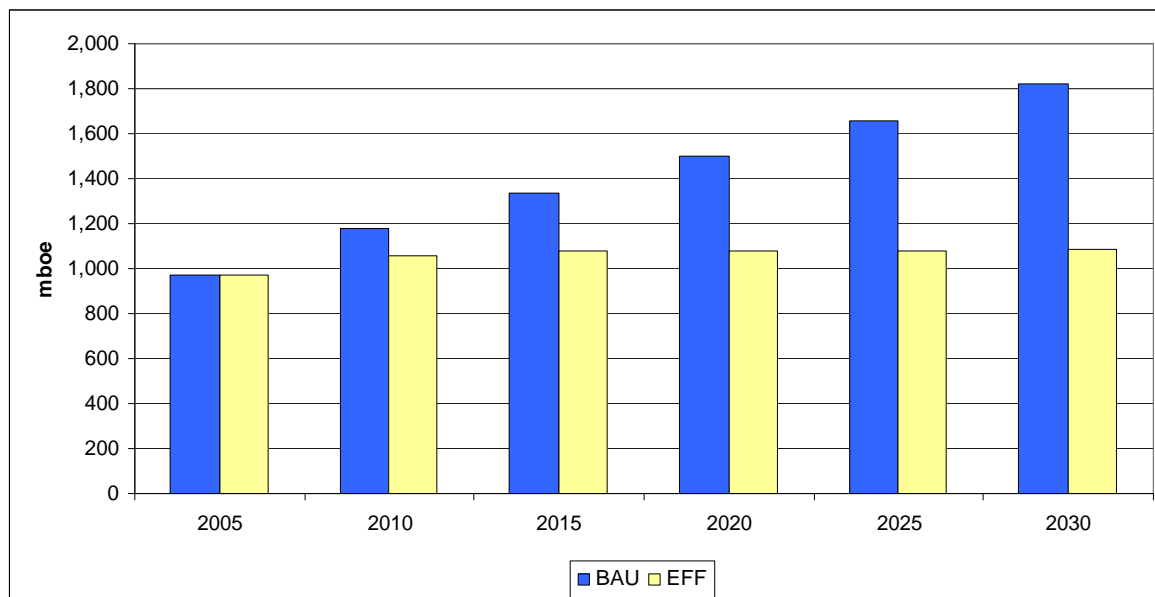
agricultural sector, further to other measures applied in other sectors, it is particularly important to start targeted information campaigns and to provide financial support in order to be able to invest in energy efficient and thus more economical technology.



**Figure 6.7- Final Energy Demand in the Agriculture Sector in BAU and High Efficiency (EFF) Scenarios (2005-2030), mboe**

## 6.5. Total Energy Savings in High Efficiency Scenario

The total final demand for energy under the high-efficiency scenario will grow on average by 0.4 percent per year reaching from 970 mboe in 2005 to 1,084 mboe in 2030. This means that the energy demand growth will slow down on average by 2.2 percent per year compared to the BAU scenario. Figure 6.8 shows the total final energy demand under the high-efficiency and the BAU scenarios.



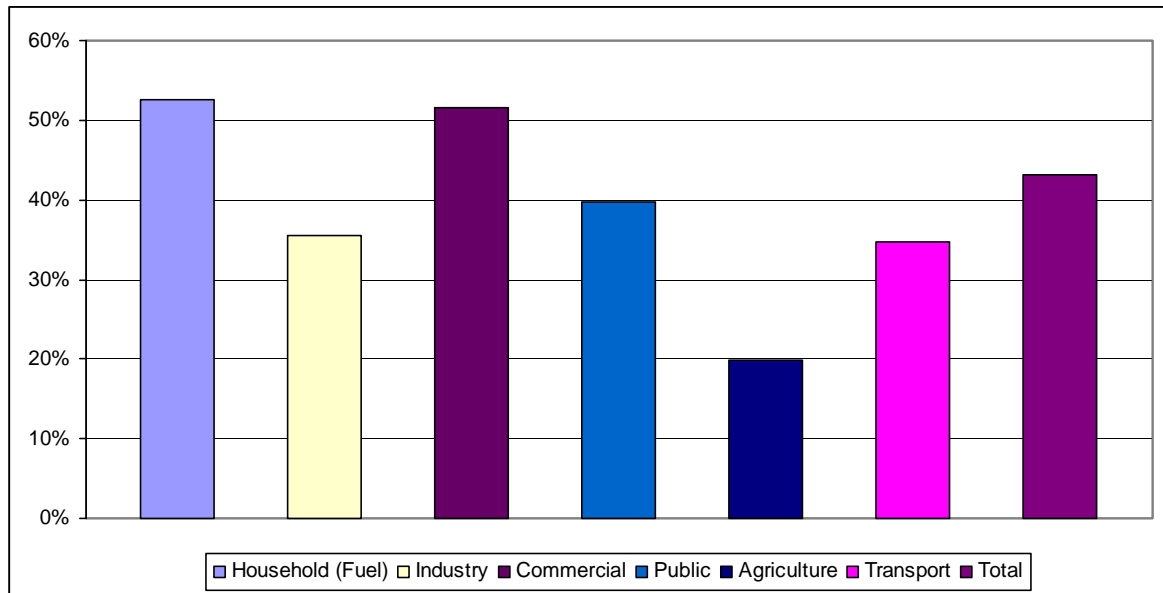
**Figure 6.8 - Total Final Energy Demand in BAU and Efficiency Scenarios (2005-2030), mboe**

In general, the High Efficiency scenario will lead to more than 40 percent energy savings in the country by the year 2030. The lion share of the savings in the efficiency scenario will be in the household sector with more than 50 percent lower consumption of fuel compared with BAU. The savings in the industry, transport, public, and commercial sectors will be between 30 to 40 percent. It should be noted that even though the saving rates in the commercial and public sectors are higher than those in industry and transport sectors, the amount of energy saved in the latter are much higher due to their higher level of energy consumption.

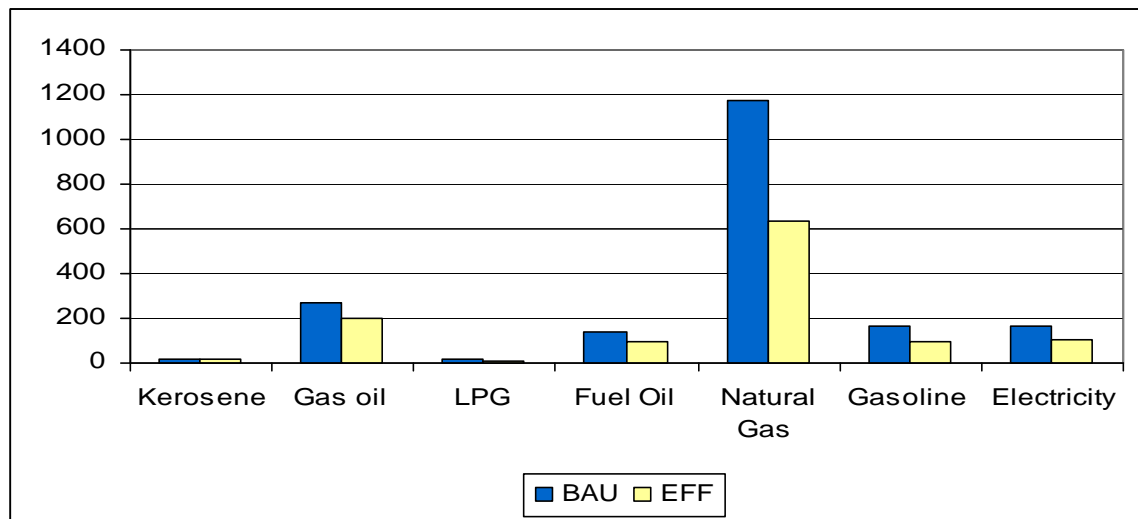
The total energy demand by energy types under the BAU and high-efficiency scenarios in 2030 are shown in Figure 6.9. Demand for all energy carriers will decline in the high-efficiency scenario relative to the BAU scenario. The most significant decline will be in the natural gas consumption, which will decrease by almost 50 percent.



Gasoline will also decrease considerably by about 42 percent. The consumption of electricity will decrease by 35 percent, and gas oil, fuel oil and LPG by about one third.



**Figure 6.9- Savings in Efficiency Scenario Compared with the BAU Scenario, 2030, (%)**



**Figure 6.10 - The Energy Demand by Energy Types in BAU and High-Efficiency Scenarios in 2030, mboe**

## **7. Scenario II: High Renewables**

In this section, we concentrate on the renewable energy potentials in Iran. We first review all the potential resources and then present the estimation of the energy demand under the High Renewables scenario for the period 2005-2030. Different national and international studies were used as data base. We will mainly concentrate on electricity generation, but will also discuss heat generation at the end of this section.

### **7.1. Wind power**

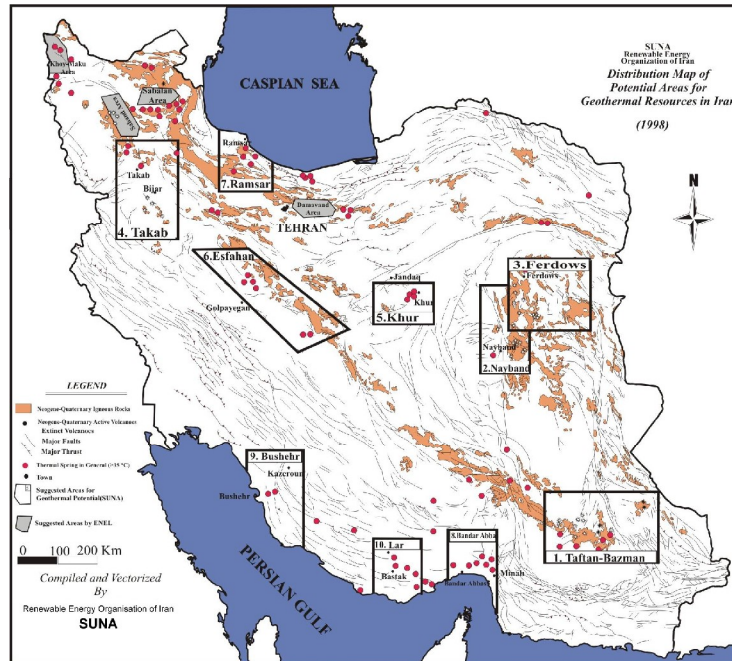
There exist very different estimates of wind power potential in Iran. This starts from 6500 MW by World Bank, and rises to 12000-16000 MW potential by SUNA (CEERS et al. 2006). Assuming 2000 full load hours, the latter estimate leads to a potential generation of 32 TWh/a of electricity. The forthcoming wind atlas will provide more detailed data. In Khusistan, a German company made province-wide measurements, but the data were not published. Some preliminary results of the study, however, were published in an article in a German energy journal. According to this article there are some exceptionally good wind power sites in N-E-Iran with high wind velocities (Hagenkort 2004, Kipke 2004). The German Aerospace Center generated a wind map with satellite imaging, showing only a small wind power potential of 8 TWh/a. However, the author argues that this is probably significantly underestimated. We assume that wind power will be able to generate 22 TWh/a electricity by 2030, which is about 8 times higher than the electricity generation by renewable sources in the BAU scenario.

## **7.2. Biomass**

The DLR (2005) lists a biomass potential of 24 TWh/a electricity, but this figure includes municipal waste . Since the data sources regarding biomass are not reliable, we ignore biomass as an electricity option almost totally and use only a very low figure, i.e. 0.018 TWh/a in all scenarios by 2030.

## **7.3. Geothermal**

Geothermal primary energy sources are relatively well investigated in Iran, but there is still a lack of knowledge on economic and technical potentials. Talebi (2004) from SUNA estimates the country-wide geothermal electricity potential in the range of 5000 MW to 6000 MW<sub>el</sub>. As geothermal energy can be used for base load on 24/7 basis, full load hours (FLH) are high. Assuming 7500 FLH, about 37 – 45 TWh/a electricity could be produced. However, since geothermal hot spots are far from inhabited areas, heat could not be used. Therefore only the electrical option remains for geothermal energy utilisation.



**Figure 7.1- Geothermal Resources in Iran, SUNA (1998)**

As figure 7.1 shows, there are 14 geothermally promising regions in Iran. They can be divided in three categories (Talebi 2004, Fotouhi 1994):

Category 1: Sabalan/Meshkin-Shahr, which is explored in detail, its potential is investigated in-depth, and the temperatures are well known. The first geothermal power plant is being built in this area.

Category 2: Khoy-Maku, Sahand, Damavand. These regions were identified as potential geothermal sites in the 1970s. They are explored relatively well and the details of their energy contents are estimated.

Category 3: Takab, Ramsar, Isfahan, Khur, Ferdows, Nayband, Bushehr, Lar, Bandar Abbas, Taftan-Bazman. These are identified as potential geothermal regions, but detailed assessments are needed.

The data sources in Table 7.1 give details on the energy contents of Iran's geothermal regions.

**Table 7.1 – Geothermal Potentials in Iran**

Location	Energy Potential	
Sabalan*	$32 \cdot 10^{18}$ J - $48 \cdot 10^{18}$ J	
Meshkin-Shahr project	250 MWe	Project budget: 250 million US\$
Khoy-Maku**	$30 \cdot 10^{18}$ – $40 \cdot 10^{18}$ J	Surface temperatures between 25 and 63 °C

\*Fotouhi 1995, 1994, Fotouhi/Noorollahi 2000

\*\*Noorollahi 2004

We assume that by 2030, geothermal sources will be able to produce 5.25 TWh/a electricity, which is about 17 times more than electricity produced by geothermal in the BAU scenario. The utilised potential remains far behind the maximum potential, due to the short timeframe to 2030.

## 7.4. Solar irradiation

Solar irradiation is very high in Iran. DLR (2005) assesses a direct normal irradiance of 2200 kWh/m<sup>2</sup>/a. This study estimates the total *economic* potential for the use of concentrating solar power plant (CSP) via satellite imaging. It analyzes the relevant topographic aspects of different areas in the country including water surfaces, and high inclinations. One can also estimate the total area that could be used for the erection of other solar power solutions such as photovoltaic power. In general, utilisable surfaces in Iran are so large that they will not be a limiting factor for solar energy utilisation.

Samimi (1994) in his country-wide analysis of irradiation concludes that on 80 percent of Iran's territory solar irradiation would be between 1640 and 1970 kWh/m<sup>2</sup>/a. The highest values are reached in the central-Iranian region. Geyer (1997) provides detailed measurements of solar intensities in selected sites. He presents a maximum

direct normal insolation in Shiraz of about 2580 kWh/m<sup>2</sup>/a. Data for Yazd are of particular interest, as tender documents for a solar thermal power plant in the area were prepared. According to IPDC (2001) solar insolation in Yazd is in the range of 2500 kWh/m<sup>2</sup>/a. In our scenario analysis, based on the assumptions on the capacity installation rate and the full load hours, we estimate that 94 TWh/a electricity will be produced by CSP and 0.007 TWh/a by photovoltaic generation. The CSP generation is assumed 0.004 TWh/a in the BAU scenario.

## **7.5. Hydropower**

Hydropower produces less than 10 TWh/a electricity and therefore its contribution to energy production is not significant in Iran. However, there are plans to increase hydropower's share in the electricity mix. World Energy Council (WEC) and DLR estimate Iran's hydropower potential as 48 TWh/a (DLR 2005, WEC 2001). In our study, we estimate that large hydropower will contribute to electricity generation by producing 17.3 TWh/a.

Table 7.2 summarizes the renewable electricity performance indicators estimated by DLR (2005). They define the representative average renewable electricity yield of a typical facility in Iran. Table 7.3 shows the economical renewable electricity supply side potentials, which are estimated by DLR (2005) for Iran.

**Table 7.2 - Basic data on renewable energy potentials in Iran**

	Hydro	Geo	Bio	CSP	Wind	PV
	Full Load	Temperature	Full Load	Direct	Full Load	Global
	Hours per	at 5000m	Hours Per	Normal	Hours Per	Horizontal
	year (h/y)	Depth	Year (h/y)	Irradiance	Year (h/y)	Irradiance
		(Celcius)		(kWh/m2/y)		(kWh/m2/y)
						Per
						Year
						(h/y)
	1351	295	3500	2200	1176	2010
	4000					
Remarks	Well	From 5000m	Agricultural	From DNI	From wind	
	documented	temperature	(bagasse)	and CSP	speed and	
	resource	map	and	site mapping	site	
	taken from	considering	municipal	taking sites	mapping	
	literature	areas with	waste and	with	taking sites	
		T>180 C as	renewable	DNI>2000	with a	
		economic	solid	kWh/m2/y as	yeld>14	
			biomass	economic	GWh/y and	
					from	
					literature	
					(EU)	

Source: DLR (2005)

**Table 7.3- Summary of Economic Renewable Electricity Supply Potentials in Iran, TWh/y**

	Hydro	Geo	Bio	CSP	Wind	PV
Electricity Supply	48	11.3	23.7	20000	8	16

Source: DLR (2005)

## 7.6. Economic and Infrastructural Analysis

### 7.6.1. Technical Data for MENA Region

The detailed data on renewable energy potentials in the MENA region are given by DLR. In the TRANS-CSP report, basic data are also given for conventionally fuelled power plant as a standard for comparison (see Table 7.4).

**Table 7.4 - Basic Parameters of Conventionally Fuelled And of Renewable Energy Power Plants**

Plants	Economic Life Years	Efficiency (%)	Fuel Price Escalation (%)	Operation & Maintenance (% of Inv./y)	Annual Full Load Hours (hours/year)
Steam Coal	40	40	1	3.5	5000
Steam Oil	30	40	1	2.5	5000
Combined Cycle	30	48	1	2.5	5000
Wind Power	15			1.5	2000
Solar Thermal	40	37	1	3	8000
Hydro	50	75		3	2600
Photovoltaics	20	10		1.5	1800
Geothermal	30	13.5		4	7500
Biomass	30	35		3.5	3700

Source: DLR (2005)

### 7.6.2. Full Load Hours (FLH)

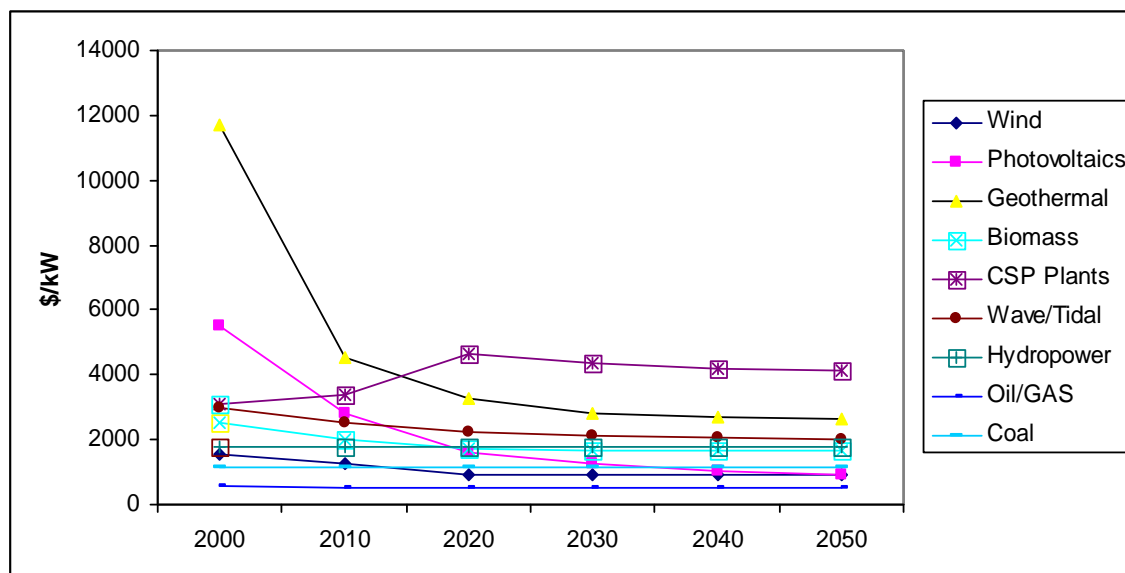
Annual load hours of hydropower plant are relatively low in Iran. Historical data are in the range of less than 3000 FLH. DLR assumes high investment costs for hybrid



CSP with combined feed of natural gas and solar radiation. The share of natural gas decrease strongly through time, and expensive storage technologies would become necessary. FLH of hybrid CSP are 8000/a, which is exceptionally high. As CSP fulfil peak load production in later decades, FLH decrease over time. This is one option of calculating basic characteristics of CSP, but there are also other assumptions possible. For instance, the share of natural gas can decrease at slower rate and therefore the need for expensive storage systems for solar radiation can be postponed. This leads to lower investment costs compared to DLR.

### **7.6.3. Investment Costs**

DLR has the investment costs of renewable energy technologies in different stages of their development. According to these calculations, the investment costs will be reduced dramatically mainly because of the learning curve as well as the economies of scale. The only exception is the investment cost of CSP plants, which will increase because of increasing solar shares (increased collector fields and storage) and increasing annual solar operating hours. The electricity cost, however, will continue to decline in time. Figure 7.2 shows the specific investment cost trend for the regions of North Africa and Persian Gulf.



**Figure 7.2 - Investment Costs of Renewable Power Plants**  
**Source: DLR (2005)**

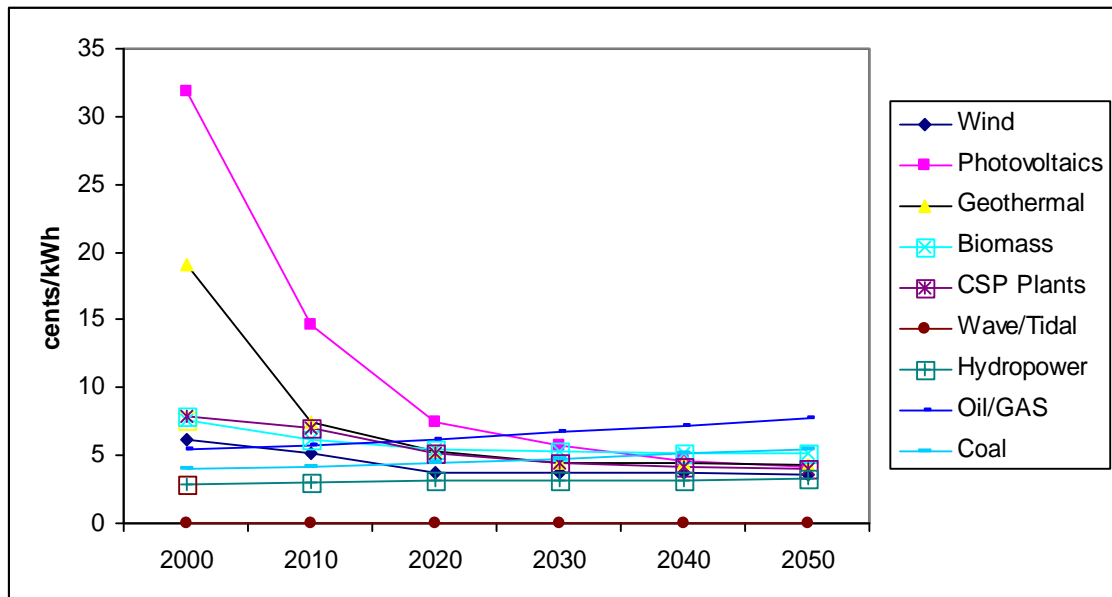
World Bank (2006) has also estimated the investment costs of renewable energy plants, which are different from the DLR's estimates. These data were processed by Supersberger (2007). The results are presented in Table 7.5.

**Table 7.5 - Investment Costs of Renewable Energy Resources in US\$/kW**

	2000	2010	2020	2030	2040	2050
Geothermal	2500	2300	2150	2050	2000	2000
(hydrothermal)						
CSP	2500	2250	2100	2000	2000	2000
Hydropower	1800	1800	1800	1800	1800	1800

Source: DLR (2005), Supersberger (2007), Worldbank (2006)

The costs of electricity generation by renewable energy technologies have been estimated by DLR (2005). According to this estimation, in the year 2000, none of the renewable technologies, except for hydropower, could compete with fossil fuels. However, by the year 2030, they will cost either the same or slightly less than the fossil fuels, and 20 years later, they will all become cheaper. Figure 7.3 shows the electricity cost estimation by different renewable energy technologies.



**Figure 7.3 - Electricity Costs by Renewable Energy Technologies**  
**Source: DLR (2005)**

#### 7.6.4. Time Scale and Dynamics

As the different technology options show different market readiness and temporal flexibility, the establishment of a certain chronology of renewables introduction is necessary. Renewables contributions vary strongly depending on the specific scenarios. In the Business as Usual scenario, only hydropower plays a somewhat important role

with about 7 TWh/a in 2030. Wind power is the second largest contributor with less than 3 TWh/a. This is different in the High Renewables scenario, in which the renewable energy sources make a more or less vivid mix. In the High Renewable scenario, hydropower will supply 17.6 TWh/a. Geothermal electricity generation is utilised by 2030 to about 20 percent of the total possible potential, contributing 5.25 TWh/a electricity to the system. The first concentrating solar power (CSP) plants enter the system mainly as retrofitted natural gas fuelled combined cycle power plants, which are initially built as natural gas fuelled plants. The solar devices are retrofitted later when costs will come down significantly. CSP will make the largest contribution to electricity production among the renewable energy sources in the High Renewable scenario, amounting to 94 TWh/a by 2030.

Concentrating solar power plants (CSP) are often planned as hybrid plants, using natural gas during night-time and solar irradiation during day-time. In general, it is possible to build natural gas power plants “CSP ready”: Starting with 100 percent natural gas share, and adding solar devices later. The major additional requirement is space to retrofit the solar panels. This arrangement of the hybrid CSP has a cost advantage of using inexpensive natural gas plants in the beginning and the solar devices in some years when costs will come down.

## **7.7. Final Energy Demand in the High Renewables Scenario**

In the time frame to 2030, the final energy demand includes only small shares of renewable energies. They vary between 0 percent and 16 percent. A summary of the utilization of the renewable energy sources in each sector of the economy is provided below.

### **7.7.1. Households**

Over the coming decades, solar thermal water heating will become a standard in Iranian homes as it already is in many households in the Mediterranean region. It is assumed that by 2030 about two thirds of sanitary hot water will be generated by solar thermal heat. In addition, solar devices will be used for cooking, mainly in rural areas, supplying about 10% of the energy demand for this use. Overall, this leads to a share of about 10% of direct renewable energy use.

### **7.7.2. Industry**

The share of renewable energy use in the sector is expected to increase to 6 percent. This is relatively low mainly because of the limited potentials for residuals from production, biomass, geothermal, and solar radiation. Biomass is in general very low and geothermal is not practical because of large distance between supply and consumption locations. There are, however, large potentials for solar heat generation for industrial processes they will be realised to large extent in the longer time frame.

### **7.7.3. Transport**

We assume no introduction of biofuels in the transport sector, as the supply chain would be too expensive regarding the low biomass potentials.

### **7.7.4. Others**

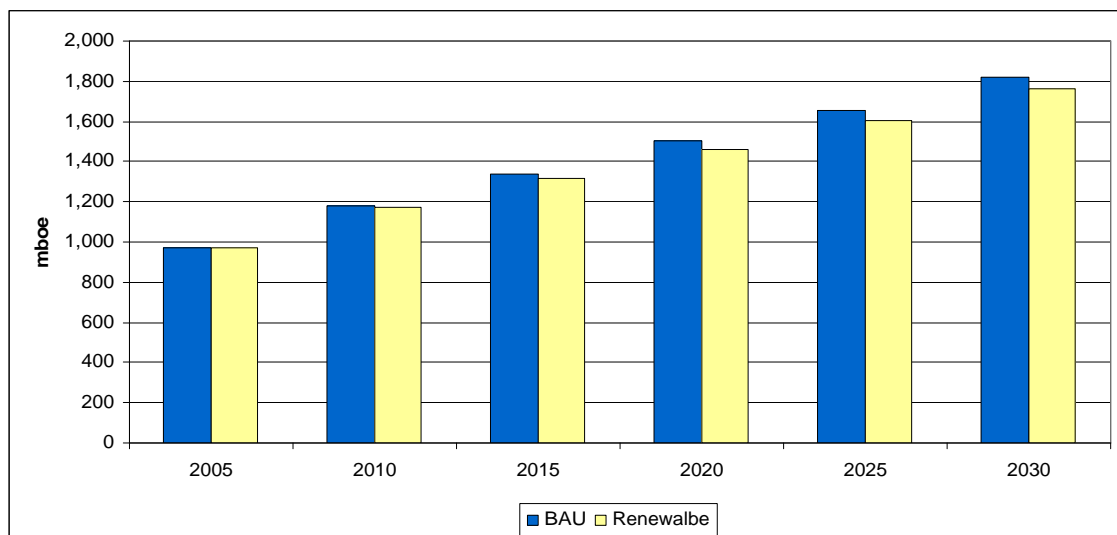
**Agriculture:** Renewable energies contribute 12.7 percent to the fuel use in this sector. Biomass and solar irradiation are two important renewable energy sources as agricultural residues and local oil seeds can be converted to liquid fuels and heat, and

solar heat generation is a viable option. The share of renewables is assumed to remain relatively low due to two reasons: Short timeframe and restricted biomass potentials.

**Commercial:** The renewable energy share in the commercial sector is 16 percent, contributed mainly by solar thermal devices. The share is relatively high due to the simple applicability of solar thermal systems together with the availability of efficiency potentials.

**Public:** Renewable energies make up to 10 percent of fuel use by 2030, mainly contributed by solar thermal devices.

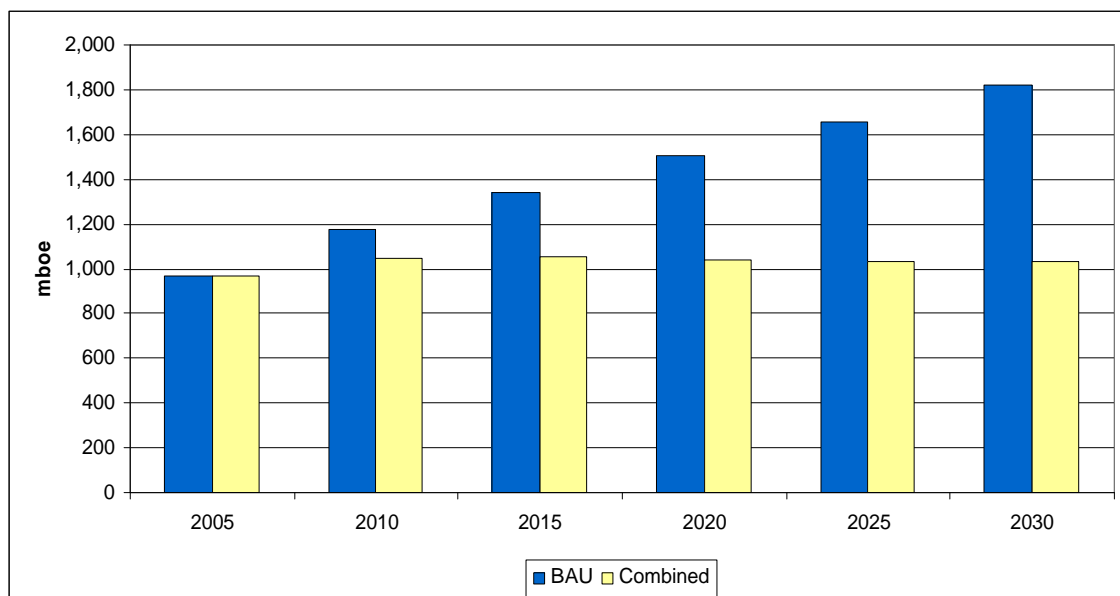
Figure 7.4 shows the total energy demand under the High Renewable scenario in comparison with the BAU scenario. In 2030, the total demand for energy will increase from 970 mboe in 2005 to 1,080 MBOE, which means an average growth rate of 2 percent per year. The energy saving rate in 2030 under the High Renewable scenario will be 3 percent compared to BAU. The savings will almost exclusively be achieved by the higher efficiency of the renewable power generation technology.



**Figure 7.4 - Total Primary Energy Demand in BAU and High Renewables Scenarios, 2005-2030, mboe**

## 8. Scenario III: Combined Scenario

In the Combined scenario, we combine high-efficiency and High Renewables scenarios. Therefore, the energy saving under this scenario is expected to be higher than that in each individual scenario. Since we have already discussed about the details of each scenarios and their implications in each sector of the economy, we only present the final result of this scenario. Figure 8.1 shows the total energy demand under the Combined scenario compared with the BAU scenario. The total energy demand under the Combined scenario will grow on average by 0.2 percent per year for the period 2005-2030. This is much lower than the 2.6 percent growth in energy demand in the BAU scenario. The total energy demand in 2030 under this scenario will be 1030 mboe, which implies a saving rate of 43 percent compared to the BAU scenario.



**Figure 8.1- Total Primary Energy Demand in Combined and BAU Scenarios (2005-2030), mboe**

## 9. Scenario IV: Constrained Scenario

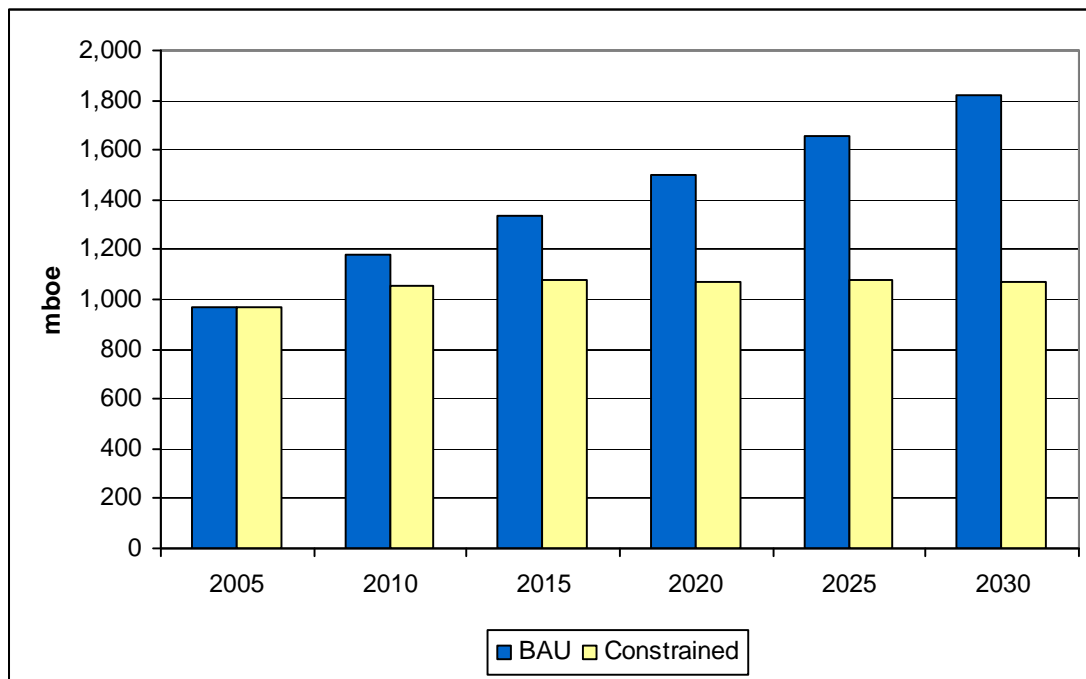
In the high-efficiency and the High Renewables scenarios, we assume that the efficiency potentials and the renewable resources will be utilized by 2030. Although the assumptions in those scenarios are supported by the case studies conducted by SABA, IFCO, and other international organizations such as IEA, they may not necessarily be realized. The main reasons for the failure of the assumptions are the uncertainties in policymaking, economic conditions, and technological changes. To acknowledge those restrictions, we thus construct a “Constrained scenario.” The Constrained scenario will take into account those uncertainties in the context of high-efficiency and High Renewables scenarios, and will therefore be a rather conservative scenario with regard to both energy saving and utilization of renewable resources. In the following, we list the assumptions for the Constrained scenario. We only include those assumptions that are different from the high-efficiency and High Renewables scenarios.

1. In High Renewables scenario, we assume electricity generation of 22 TWh by wind power by 2030. Given the uncertainties in investments by private sector and in the policy changes, the more conservative assumption will be 15 TWh by 2030.
2. In High Renewables scenario, we assume electricity generation of 5.25 TWh by geothermal power plants by 2030. This corresponds to 700 MW capacities given 90 percent plant factor. The more conservative assumption is the electricity production of 3 TWh by 2030. The lower electricity generation by geothermal power plants takes into account uncertainties regarding the plant factor and the hours of operation.



3. In high-efficiency scenario, we assume number of cars will increase from about 6 million cars in 2005 to 16.26 million cars in 2030. This projection is lower than the BAU projection by 2 million cars. The lower growth rate of number of cars projection in the high-efficiency scenario is based on the assumptions that people will use public transport as a main transport means and that gasoline price will rise up to a level that will not provide an incentive to own a car. In the Constrained scenario, we assume that the number of cars in 2030 will remain the same as the BAU scenario, that is, 18,26 million cars.
4. The fuel consumption by passenger cars is assumed to decline to as low as 6 litre per 100 km by 2030 in the high-efficiency scenario. This assumption is mainly based on the higher efficiency of new engines. However, there are other factors such as city infrastructure, road condition, driving habit, quality of fuel, and traffic condition, which affect the fuel consumption by passenger cars. Since there are some uncertainties regarding the other factors affecting the fuel consumption, the more conservative assumption for the average fuel consumption would be 7 litter per 100 km.
5. In the residential heat section of the high-efficiency scenario, we assume 50 percent saving per building and 90 percent saving as technical potential. These figures are based on the IFCO and the Ministry of Energy's auditing reports on sample buildings, but their realization would depend on building policies, government successful supervision in the construction sector, and a change in household behaviour. In the Constrained scenario, we assume 30 percent saving per building, because of uncertainties in the policies and their successful implementation.

Figure 9.1 shows the total energy demand under the Constrained scenario and the BAU scenario. The total demand for energy in the Constrained scenario will be 1070 mboe in 2030, which implies a saving rate of 41 percent compared to the BAU scenario.



**Figure 9.1 - Total Primary Energy Demand in Constrained and BAU Scenarios (2005-2030), mboe**

## 10. A Comparison among Scenarios

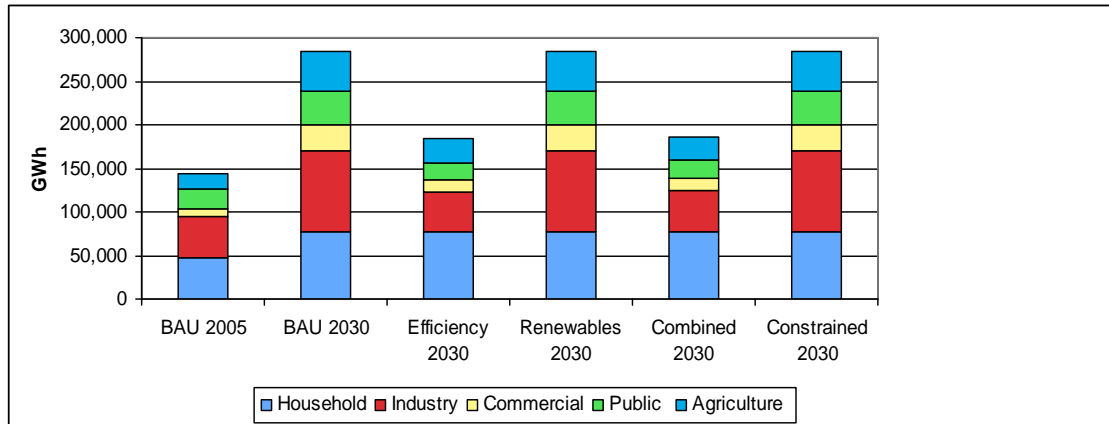
Table 10.1 shows a comparison of demand for energy among four scenarios. As it is evident from the table, the high-efficiency scenario will lead to about 40 percent saving in total energy consumption in the year 2030. This saving potential is very significant in the international scale. The energy saving under the High Renewables scenario will be about 3 percent in 2030. The saving rate in the High Renewables scenario only reflects the efficiency gains in electricity production by the use of renewable energies. The

Combined scenario, which is a combination of the high-efficiency and High Renewables scenarios, will lead to the highest energy saving in 2030. In total, the energy saving rate under this scenario will be 43 percent compared to the BAU. Finally, the Constrained scenario results show that total energy saving in 2030 will be 41 percent compared to the BAU scenario.

**Table 10.1 - A Summary of the Scenario Results (2005-2030)**

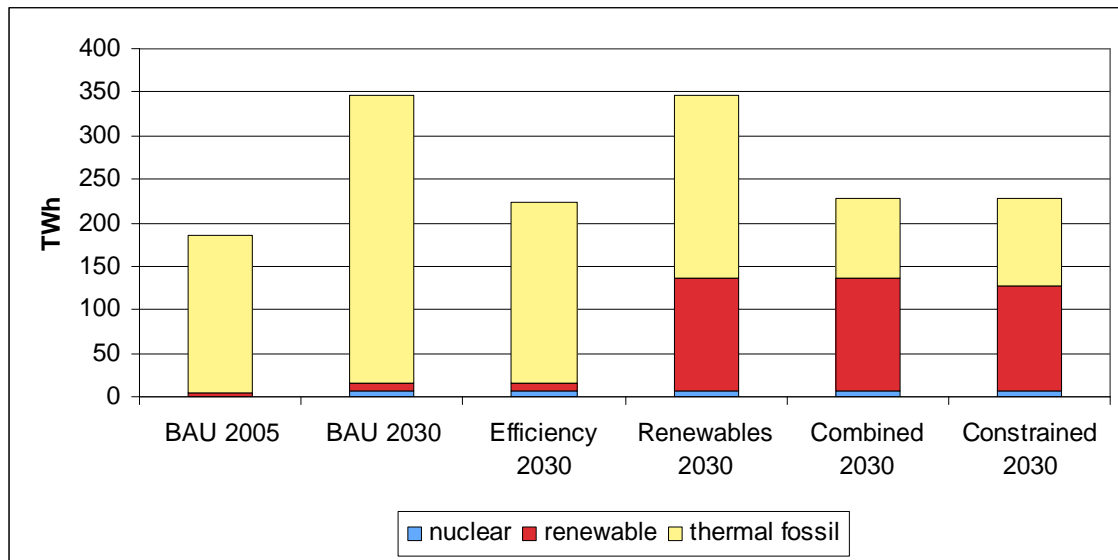
Scenario	Primary Energy Demand (mboe)		Growth per year (%)	Savings vs. BAU by 2030 (%)
	2005	2030		
BAU	970	1,822	2.6	-
High- Efficiency	970	1,084	0.4	40
High Renewables	970	1,760	2.4	3
Combined	970	1,030	0.2	43
Constrained	970	1,070	0.4	41

Total demand for electricity will almost double in BAU, High Renewables, and Constrained scenarios in 2030. The electricity demand in the efficiency and Combined scenario, however, will increase only by about 13 percent. The most significant reduction in electricity consumption is in the manufacturing industry under efficiency and Combined scenarios compared with the BAU scenario. Figure 10.1 shows the demand for electricity in different sectors and different scenarios.



**Figure 10.1 – Total Demand for Electricity by Sectors and Scenarios  
(2005 & 2030), GWh**

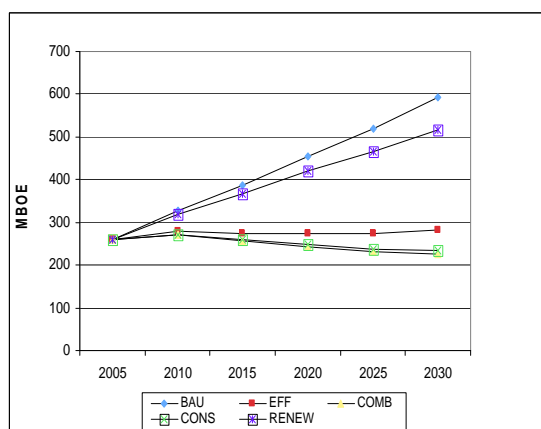
The sources of electricity generation vary with the scenarios and throughout the years. Overall, the share of renewable sources in electricity generation will be increasing in all scenarios throughout the years. Specifically, the share of renewable energy in producing electricity is 3 percent in BAU in 2005, and will remain the same in 2030, but it will increase to 5 percent in efficiency scenario, 38 percent in renewable scenario, 57 percent in Combined scenario, and 53 percent in Constrained scenario. The higher shares in the Combined and Constrained scenario are due to two effects: Employing more renewable resources under the High Renewables scenario, and the decreasing demand for electricity under the efficiency scenario. Figure 10.2 shows the share of three sources (fossil fuel, renewable, and nuclear) in producing electricity under alternative scenarios in 2030.



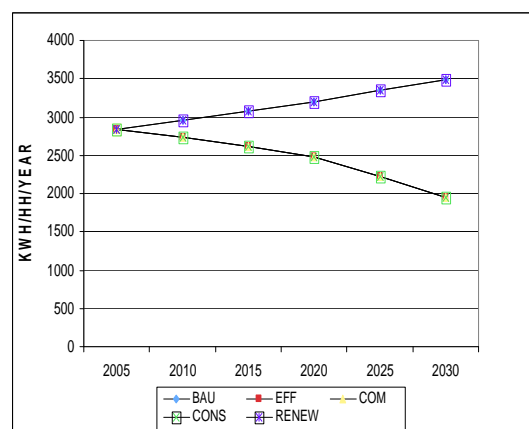
**Figure 10.2– Electricity Generation by Sources in Alternative Scenarios, TWh**

Figure 10.3 shows the final energy demand in alternative scenarios in different sectors of the economy. As it is evident, the highest potential in energy saving will be in household sector under the efficiency scenario. The industry and transport sectors also show a significant energy saving under the efficiency scenario. Although the energy savings in the public and commercial sectors are also relatively high, but in absolute term they are not comparable with those in household, industry, and transport sectors.

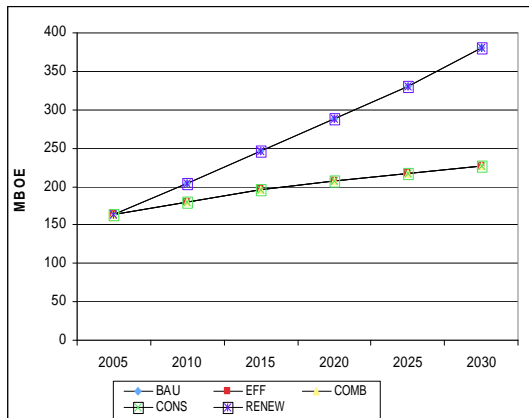
#### Household (Heat)



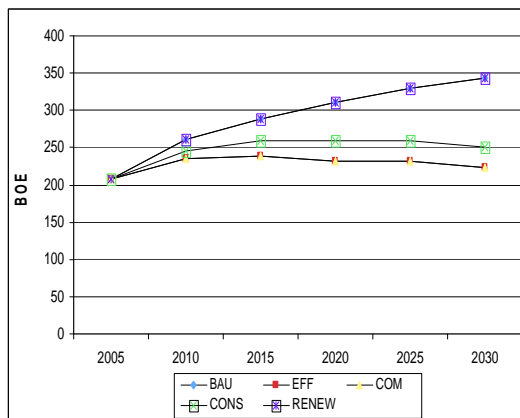
#### Household (Electricity)



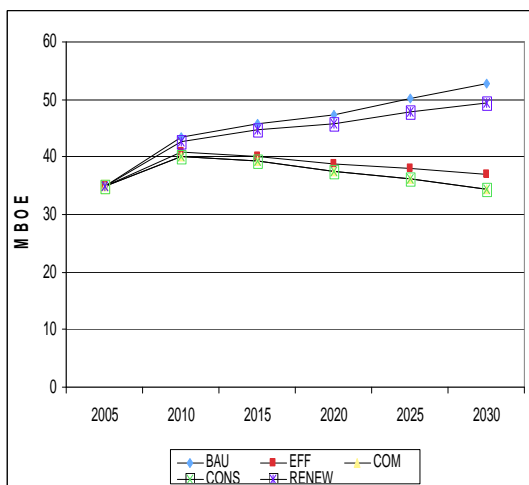
### Industry



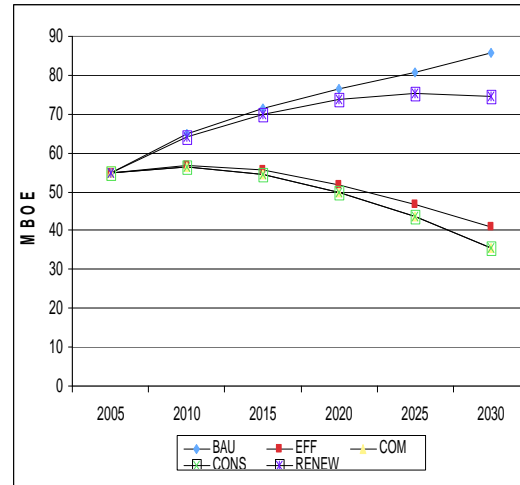
### Transport



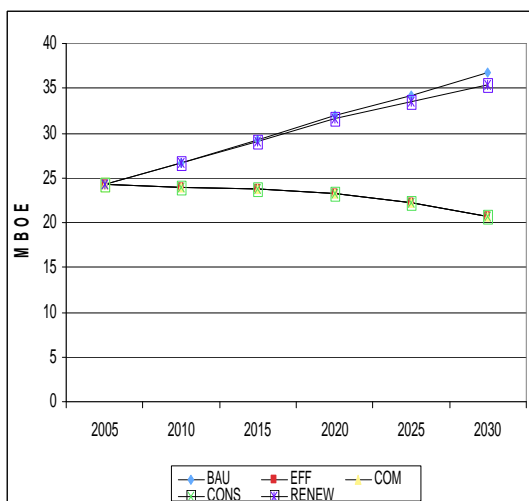
### Agriculture



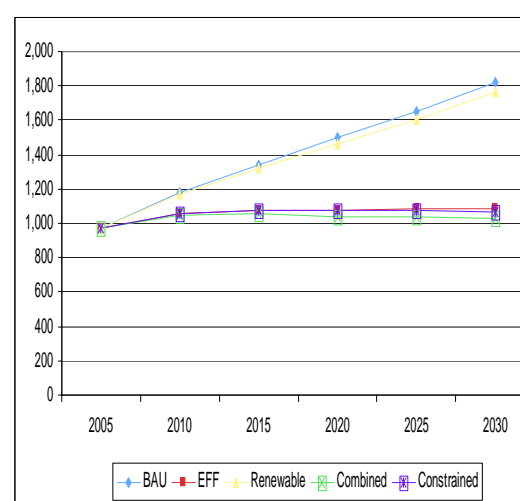
### Commercial



### Public



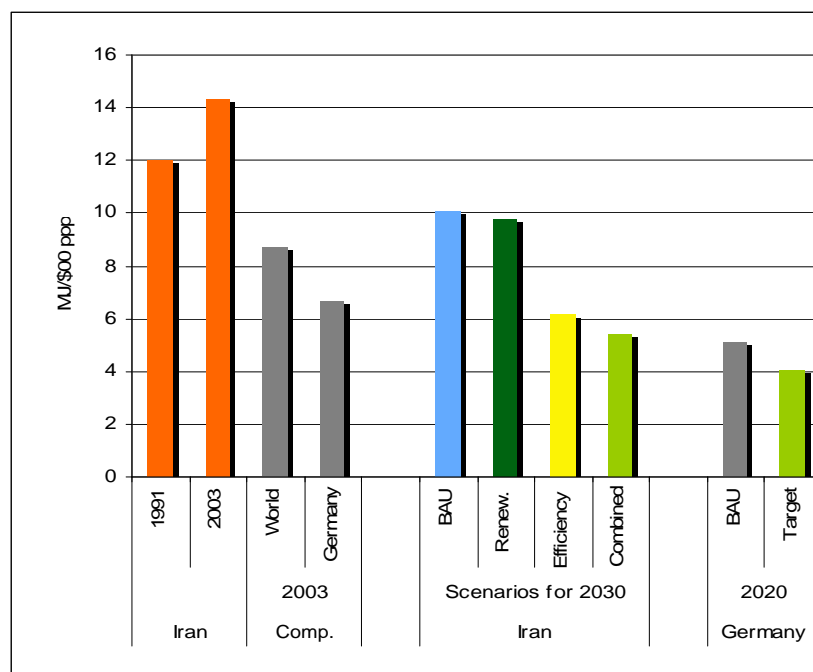
### Total



**Figure 10.3 - A Summary of the Scenario Results (2005-2030), mboe**

## 10.1. Energy Intensity

The energy intensity in Iran is one of the highest in the world. We compare the energy intensity in different scenarios in Iran with that in the world, and in an industrialized country with a low energy intensity such as Germany. In 2003, the energy intensity in Iran was more than 60 percent higher than the world average and more than twice in Germany. Although the energy intensity will be reduced by about 30 percent in the BAU scenario in 2030, it will still be higher than today's world average. In the efficiency scenario, however, the energy intensity in 2030 will be declined by about 60 percent making it lower than the world average and Germany today, but still higher than the 2020 energy intensity target in Germany. Figure 10.4 shows the energy intensity in Iran in comparison with the world and Germany in different scenarios.



**Figure 10.4 – Energy Intensity in Iran and World under Different Scenarios**

Source: EEA, IEA (2007), and the authors' calculation

## **11. Economic and Ecological Impacts of Scenarios**

The different impacts of the examined scenarios are of great importance for policy makers facing the socio economical challenges. For instance, in the BAU-scenario, the export capacity of crude oil and natural gas will continually decrease, because of an increasing domestic consumption. With the current trend, it is probable that Iran might not be able to export any oil in the mid-2030s. Later, this might also happen with natural gas. In the other scenarios, the Iranian export capacities of oil and gas would decrease more slowly keeping up the country's export capacity at least until the middle of the century.

The BAU scenario will also have a negative impact on climate change. The CO<sub>2</sub> emissions will increase proportionally to the oil and gas consumption and thus will almost double by 2030. This also applies to other pollutants; such as nitrogen oxides, sulphur dioxide, dust and heavy metals; with considerable economic follow-up costs and risks for the public, especially in areas of high population density. In all the other scenarios, CO<sub>2</sub> emissions and contamination with other pollutants would decrease considerably. For the Combined scenario this means that energy related CO<sub>2</sub> emissions in Iran can be stabilised slightly above 400 Mt of CO<sub>2</sub> and slightly above current values, that is, a reduction of 45% by 2030 in comparison to the BAU scenario.

### **11.1. Economic Impacts**

Although the detailed economic evaluation of the scenario analysis is not in the scope of our study, it is important to assess generally the economic costs and benefits of the scenarios. In this section, we examine the overall economic impacts of the scenarios



focusing on export revenues and change in technology. Since our assessment of the scenarios will directly depend on the world oil prices, we will have to make an assumption about its long-term trend. The oil prices are one of the most volatile prices in the world making its short-term prediction very difficult, or even impossible, but the overall trend of the prices can be projected taking into account the fundamental forces in the energy market. Among the fundamental factors, we can point to the increasing demand for crude oil especially by emerging economies, limited supply, technological changes and substitution of alternative energy sources. The first two factors would push oil prices up, but the last two factors would have a downward pressure on oil prices. Furthermore, changes in the political and market structure towards growing autonomy of oil producing countries and increasing competition among the consumers might have an increasing impact on oil prices. Since the development of new technologies and substitution of new energy sources will take time, the upward pressure factors seem to have a dominant effect on oil prices in the next two or three decades. Therefore, we predict that the oil prices will grow due to increasing demand and supply limits until 2020 and then will start to stabilize due to competition by alternative sources. The projection of future oil prices by the International Energy Agency (IEA) in World Energy Outlook (2008) is consistent with our analysis and therefore provides a good basis for our calculations.

Tables 11.1 – 11.4 show saved amounts of oil and gas for the efficiency, High Renewables, Combined, and Constrained scenarios in comparison to BAU in 2005-2030. In the efficiency scenario, the total revenue as a result of energy savings will rise continually to about US \$68 billion in 2030. In the High Renewables scenario, the revenue will increase to more than US \$19 billion, in the Combined scenario to more than US \$82 billion, and in the Constrained scenario to more than US \$77 billion in 2030.

Over 25 years, the total revenue adds up to a number between US \$240 billion in High Renewables scenario and more than US \$1000 billion in Combined scenario.

**Table 11.1 – Additional Revenues in Efficiency Scenario, 2005-2030**

	2005	2010	2020	2030
<b>OIL</b>				
Demand - BAU	460	541	607	651
Demand – Efficiency	460	499	475	459
Saving	0	42	132	192
Price (US\$2007/b) *	---	100	110	122
Additional Revenues	0	4.20	14.52	23.42
<b>GAS</b>				
Demand – BAU	535	678	994	1.303
Demand - Efficiency	535	597	701	765
Saving	0	81	293	538
Price (US \$2007/b) *	---	64.60	73.64	82.21
Additional Revenues	0	5.23	21.58	44.23
<b>Total</b> <b>Addition Revenues</b>	<b>0</b>	<b>9.43</b>	<b>36.10</b>	<b>67.65</b>

The energy amounts are in mboe. The revenues are in US \$ billion. The prices are in real 2007 US\$ and obtained from WEO (2008).

**Table 11.2 – Additional Revenues in High Renewables Scenario, US 2007\$, 2005-**

**2030**

	2005	2010	2020	2030
<b>OIL</b>				
Demand - BAU	460	541	607	651
Demand – Renewables	460	538	587	603
Saving	0	3	20	48
Price (US\$/b) *	---	100	110	122
Additional Revenues	0	0.03	2.20	5.86
<b>GAS</b>				
Demand – BAU	535	678	994	1,303
Demand -Renewables	535	670	922	1,140
Saving	0	8	72	163
Price (US \$/boe) *	---	64.60	73.64	82.21
Additional Revenues	0	0.52	5.30	13.40
<b>Total</b>	<b>0</b>	<b>0.2</b>	<b>7.50</b>	<b>19.6</b>

The energy amounts are in mboe. The revenues are in US \$ billion. The prices are in real 2007 US\$ and obtained from WEO (2008).

**Table 11.3 – Additional Revenues in Combined Scenario, US 2007\$, 2005-2030**

	2005	2010	2020	2030
<b>OIL</b>				
Demand - BAU	460	541	607	651
Demand – Combined	460	497	456	402
Saving	0	44	151	249
Price (US\$/b) *	---	100	110	122
Additional Revenues	0	4.40	16.61	30.38
<b>GAS</b>				
Demand – BAU	535	678	994	1.303
Demand - Combined	535	590	646	664
Saving	0	81	293	538
Price (US \$/boe) *	---	64.60	73.64	82.21
Additional Revenues	0	5.68	30.63	51.79
<b>Total</b>	<b>0</b>	<b>10.08</b>	<b>47.24</b>	<b>82.9</b>

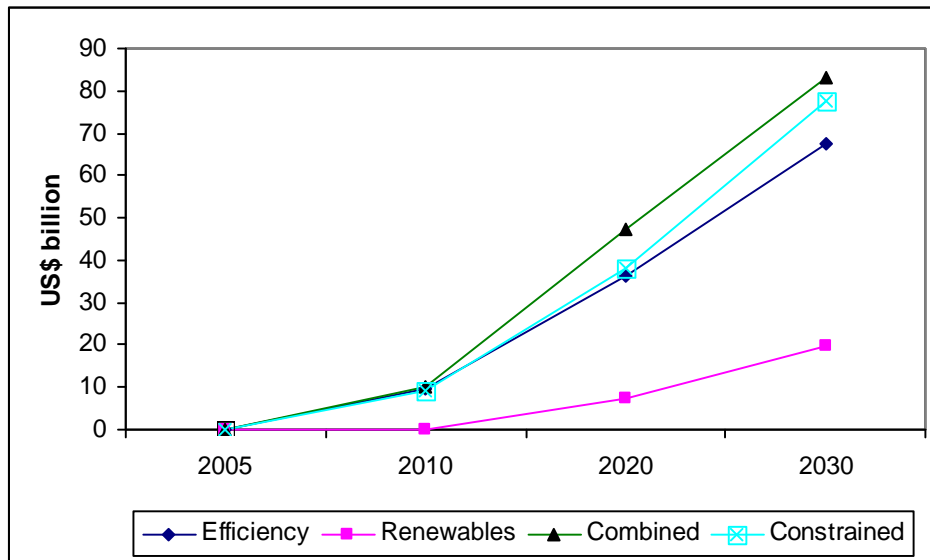
The energy amounts are in mboe. The revenues are in US \$ billion. The prices are in real 2007 US\$ and obtained from WEO (2008).

**Table 11.4 – Additional Revenues in Constrained Scenario, US 2007\$, 2005-2030**

	2005	2010	2020	2030
<b>OIL</b>				
Demand - BAU	460	541	607	651
Demand – Constrained	460	507	486	434
Saving	0	34	121	217
Price (US\$/b) *	---	100	110	122
Additional Revenues	0	3.38	13.33	26.62
<b>GAS</b>				
Demand – BAU	535	678	994	1.303
Demand - Constrained	535	591	658	684
Saving	0	87	336	619
Price (US \$/boe) *	---	64.60	73.64	82.21
Additional Revenues	0	5.61	24.72	50.90
<b>Total</b>	<b>0</b>	<b>8.99</b>	<b>38.05</b>	<b>77.42</b>

The energy amounts are in mboe. The revenues are in US \$ billion. The prices are in real 2007 US\$ and obtained from WEO (2008).

Figure 11.1 shows the trend of total revenues that Iran could generate with all four scenarios in comparison to BAU. The greatest revenues can be generated by realizing the Combined scenario where both efficiency and renewable potentials are considered. Compared to countries without own energy resources, Iran as a country with fossil energy resources is in a privileged position when it comes to changing its energy supply system. The saved resources of oil and natural gas can be transferred to more revenues through export.



**Figure 11.1 – The Potential Revenues Generated by Scenarios (2005-2030)**

Our economic impact evaluation of the scenarios shows that the potential revenues generated by different scenarios in Iran are remarkably high. To realize these additional revenues, there is a need for investment in new capital and training. Although the estimation of detailed investment costs requires further research, we present the results of some other studies, which can be used as references.

A thermal solar study for Tehran (CEERS, 2005) shows that taking over of that technology for the production of warm water would be beneficial to Iran's economy. This use of the thermal solar would be economical even if the State had to subsidize the full investment costs. The following simple calculation validates the claim. We can assume that the Iranian government is able to borrow loans at the international capital markets with an interest rate of 3 percent. This loan will be used to finance the solar installations projects that result in a reduction of fuel use for heating in households. If we further assume an oil price of US \$38 per barrel, which is a rather conservative assumption as the average oil price was about US \$50 per barrel in March 2005, and an annual

increase in oil prices of 2 percent, every solar thermal installation in a two-floor flat would yield a revenue of about US \$168 per year. Assuming a lifetime of 25 years, every solar thermal plant would yield economic net benefits (additional oil revenues minus capital and maintenance costs) of US \$4,200. Assuming that solar heating systems would be installed in about one quarter of all households in Tehran, the total net revenue would sum up to US \$1,800 million for the Iranian economy.

Supersberger (2007) has estimated the revenues and investment costs of increasing efficiency and renewable energy sources in Iran for the period 2005-2050. Given the assumption of oil price of US \$47 barrel in 2005 and the investment costs equal to \$47.2 billion, the net benefit of implementing the High Efficiency and High Renewables scenarios will be \$403 billion.

The international Studies for Germany, Europe and others confirm this economically profitable development. For instance, in a comprehensive study by the enquête commission of the German Federal Parliament about sustainable energy supply in Germany in 2002, one point of interest is the assessment of different energy scenarios and their costs until 2050. The results of the study show that the additional costs of alternative scenarios, without taking into account external costs, are only slightly higher in comparison to the baseline scenario at extremely low oil price levels. When taking into account external costs, all High Efficiency and High Renewables scenarios perform better than the baseline scenario economically.

Another recent study by the German Ministry for the Environment (Bundesministerium für Umwelt, 2008) shows that renewable energy technologies for power supply in Europe are already partly profitable and will be completely profitable in the medium term. Furthermore, the electricity generation in hydropower plants today is already cheaper than conventional electricity generation. Given a dynamic view and

further growth of world market prices for fossil fuel, geothermal energy and wind energy will reach their break-even point shortly after 2020. Only photovoltaics will need more than three decades to become profitable for electricity generation. The same study also shows that in Europe heat generation with biomass will be profitable in 2010, while heat generation using geothermal energy and solar collectors will become profitable between 2020 and 2025.

Most studies that are carried out mainly for developed countries indicate that a modernisation of energy system is an economical and viable option and therefore it does not have to depend on government subsidies. The McKinsey (2008) study evaluates the efficiency strategy with reference to CO<sub>2</sub> reduction as economically very positive. "Increasing energy productivity is the most cost-effective way globally to reduce GHG emissions, representing roughly 80 percent of the positive return opportunities identified in McKinsey's work on the global carbon-abatement cost curve."

## **11.2. Ecological Impacts**

Climate change is a global challenge. The concentration of CO<sub>2</sub>-emissions is the main cause for global warming. Based on the findings from IPCC (2007), to prevent a climate catastrophe, CO<sub>2</sub>-emissions have to be reduced by at least 50% of the 1990 level worldwide by 2050. The developed industrial countries are the main generators of climate change and should therefore make the most contribution to reducing CO<sub>2</sub>-emissions. Nevertheless, as expressed in the Bali Roadmap the less-developed industrial countries and developing countries like Iran should make their own contribution as well. The demand scenarios presented in this study can be used to assess the development of CO<sub>2</sub>-emissions in different scenarios. Since the total demand for primary energy in the High Efficiency, High Renewables and Combined scenarios are less than



that in the BAU scenario, the CO<sub>2</sub>-emissions are expected to be lower in those scenarios in comparison to the BAU scenario. In the following section, we assess the CO<sub>2</sub>-emissions for all scenarios.

Crude oil contains 466 kg CO<sub>2</sub> per barrel and natural gas contains about 289 kg CO<sub>2</sub> per barrel of oil equivalent. For reasons of simplicity, CO<sub>2</sub>-emissions resulting from conduction losses of gas and burning off during oil production are not taken into account. In addition, climate-relevant CO<sub>2</sub>-emissions from methane need to be examined separately. We use the results of energy savings under different scenarios, which were presented in Tables 11.1 -11.4, to calculate the CO<sub>2</sub>-emission levels for alternative scenarios in comparison to BAU. Table 11.5 shows the development of CO<sub>2</sub>-emissions for Business as Usual and Tables 11. 6 -11.8 show and the reduction of CO<sub>2</sub>-emissions in the alternative scenarios.

**Table 11.5 - CO<sub>2</sub>-Emissions in the BAU Scenario**

	2005	2010	2020	2030
<b>Oil</b>				
Demand - BAU	460	541	607	651
CO <sub>2</sub> - emission	205.2	241.3	270.7	290.3
<b>Gas</b>				
Demand – BAU	535	678	994	1,303
CO <sub>2</sub> - emission	154.6	195.9	287.3	376.6
<b>Total</b>	<b>359.8</b>	<b>437.2</b>	<b>558</b>	<b>667.1</b>

One barrel Oil contains 446 kg CO<sub>2</sub> , and one barrel oil equivalent gas contains 289 kg CO<sub>2</sub>

**Table 11.6 - CO<sub>2</sub>-Emissions Reduction the Efficiency scenario**

		2010	2020	2030
Oil				
	Saving	42	132	92
	CO <sub>2</sub> - emission Saving	19.6	61.5	89.5
Gas				
	Saving	81	293	538
	CO <sub>2</sub> - emission Reduction	23.4	84.7	155.5
Total	CO <sub>2</sub> -emiision Reduction	43.0	146.2	244.0

The BAU scenario is a basis for comparison.  
Savings are in MOBE and the CO<sub>2</sub>-emissions are in MT.

**Table 11.7- CO<sub>2</sub>-Emissions Reduction in High Renewables Scenario**

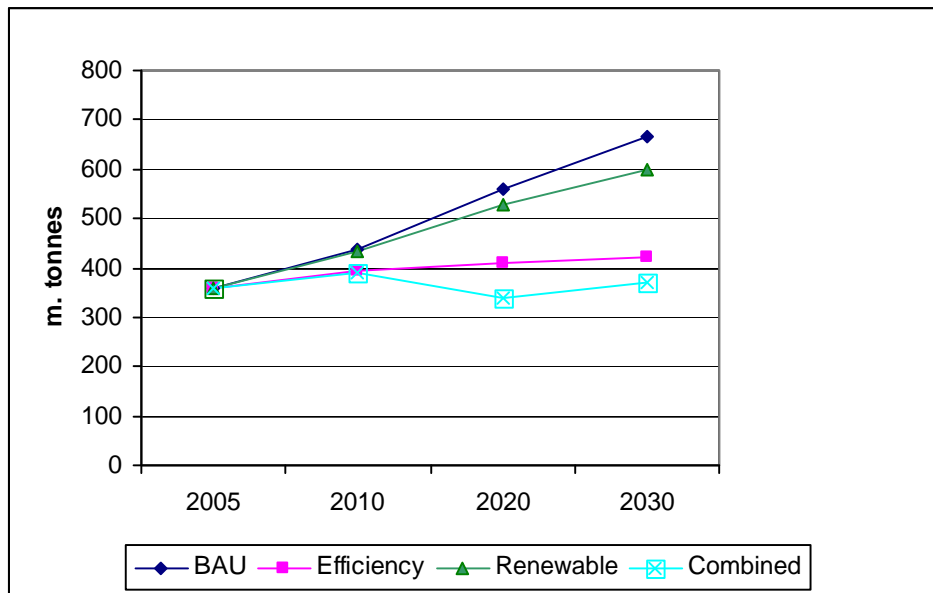
		2010	2020	2030
Oil				
	Saving	3	20	48
	CO <sub>2</sub> - emission Saving	11.4	9.3	22.4
Gas				
	Saving	8	72	163
	CO <sub>2</sub> - emission Reduction	2.3	20.8	47.1
Total	CO <sub>2</sub> -emiision Reduction	3.7	30.1	69.5

The BAU scenario is a basis for comparison.  
Savings are in MOBE and the CO<sub>2</sub>-emissions are in MT.

**Table 11.8 - CO<sub>2</sub>-Emissions Reduction in the Combined Scenario**

	2010	2020	2030
<b>Oil</b>			
Saving	4.4	151	249
CO2- emission Saving	20.5	117	116
<b>Gas</b>			
Saving	88	348	630
CO2- emission Reduction	25.4	100.6	183
<b>Total CO2-emission Reduction</b>	<b>45.9</b>	<b>217.6</b>	<b>298</b>

The BAU scenario is a basis for comparison.  
Savings are in MOBE and the CO<sub>2</sub>-emissions are in MT.



**Figure 11.2 - CO<sub>2</sub>- Emissions in Alternative Scenarios (2005-2030)**

As the figure 11.2 shows, the CO<sub>2</sub>-emissions are sinking to a considerable degree in all alternative scenarios in comparison to BAU. The strongest decrease may be observed in the Combined scenario in which the CO<sub>2</sub>-emission will be reduced by 10% in 2010, 39% in 2020 and 45% in 2030. The alternative scenarios will not only generate additional revenues for Iran's economy of up to \$1000 billion in 25 years, but also enable Iran to take the right path in reducing CO<sub>2</sub>-emissions according to IPCC guidelines and thereby acquiring an internationally leading position.

CO<sub>2</sub> is not the only pollutant that is generated by fossil fuel. Other pollutants such as SO<sub>2</sub>, NO<sub>x</sub>, dust, CO, and heavy metals like lead are also generated during the combustion of oil and gas. The main producers of SO<sub>2</sub> are industry and power plants. NO<sub>x</sub> is generated in the transport sector. These substances constitute a massive risk to humans and the environment. They induce numerous illnesses and soil and water pollution, which cause immense follow-up costs for the economy. For instance, bronchitis, skin diseases, and allergies are often caused by a concentration of the pollutants above that get into the human organism directly through the air or indirectly through the food chain. If these external costs imposed on health and environment are taken into account, the net benefits of the scenarios will be even higher than what are already shown in this study.

The estimation of the external costs is not in the scope of our study and requires a separate research, but to show the significance of those costs, we make a reference to a major study by the European Union. The European Commission predicts that as a result of air pollution with SO<sub>2</sub>, NO<sub>x</sub>, dust, and CO<sub>2</sub>, there will be the early death of many people with 2,800,000 life years of people aged over 30, 142,268 cases of chronic bronchitis, and 240,333,947 working days lost in the economy in 2020. However, if the fossil final energy consumption is reduced by 30%, those losses would decrease by

about 12 percent. The study estimates that the reduction of the illnesses would lower health care costs in the European Union by €19.9 billion (Low) to €76.9 billion (High).

The consequences of combusting fossil energy for health and economy in Iran will have to be assessed in a separate study. The above quoted study by the European Union nevertheless shows that human health problems and the resulting health care costs for the economy may be avoided largely by changing the current energy system.

## APPENDIX – Scenario Results Tables

**Table A1: Scenario Overview BAU-Scenario, 2005 - 2030**

	2005	2010	2020	2030	30/05 %/a	2005 shares	2010	2020	2030
in mboe									
<b>Total Final Energy Consumption</b>	783	969	1'262	1'549	2.8%	100%	100%	100%	100%
oil	382	453	511	550	1.5%	49%	47%	41%	36%
gas	316	415	617	830	3.9%	40%	43%	49%	54%
electricity	85	101	133	167	2.7%	11%	10%	11%	11%
coal	0	0	0	0		0%	0%	0%	0%
renewables	0	0	1	1		0%	0%	0%	0%
<b>Industry</b>	164	204	288	380	3.4%	100.0%	100.0%	100.0%	100.0%
oil	58	72	97	124	3.1%	35.6%	35.2%	33.9%	32.7%
gas	77	98	146	200	3.9%	47.2%	48.3%	50.7%	52.7%
electricity	28	33	44	54	2.6%	17.3%	16.3%	15.2%	14.3%
coal						0.0%	0.0%	0.0%	0.0%
renewables	0	0	1	1		0.0%	0.2%	0.2%	0.2%
<b>Transport</b>	218	273	325	356	2.0%	100.0%	100.0%	100.0%	100.0%
oil	211	265	316	348	2.0%	97.0%	97.1%	97.3%	97.7%
others (CNG)	6	8	9	8	1.0%	3.0%	2.9%	2.7%	2.3%
<b>Other sectors</b>	401	492	650	813	2.9%	100.0%	100.0%	100.0%	100.0%
oil	113	115	98	78	-1.5%	28.1%	23.5%	15.1%	9.6%
gas	232	308	462	622	4.0%	57.8%	62.7%	71.2%	76.5%
electricity	57	68	90	113	2.8%	14.1%	13.9%	13.8%	13.9%
coal									
renewables	0	0	0	0					
<b>Non-energy use</b>	21	21	27	34	0.0%				
<b>Electricity generation in TWh/a</b>	187	220	282	346	2.5%	100.0%	100.0%	100.0%	100.0%
fossil	182	209	267	330	2.4%	97.5%	94.7%	94.7%	95.3%
nuclear	0	6	6	6		0.0%	2.7%	2.1%	1.7%
renewables	5	6	9	10	3.1%	2.5%	2.6%	3.2%	2.9%
<b>Total Primary Energy Demand</b>	998	1'236	1'626	1'979	2.8%	100.0%	100.0%	100.0%	100.0%
Oil	460	541	607	651	1.4%	46.1%	43.8%	37.4%	32.9%
Gas	535	680	994	1'303	3.6%	53.6%	55.0%	61.2%	65.8%
Nuclear	0	11	11	11		0.0%	0.9%	0.7%	0.5%
Hydro & other REN elec.	3	4	6	7	3.6%	0.3%	0.3%	0.4%	0.3%
other renewables	0	0	1	1		0.0%	0.0%	0.0%	0.0%
Coal	0	0	7	7		0.0%	0.0%	0.4%	0.3%

Source: own calculations

**Table A2: Scenario Overview High Efficiency-Scenario, 2005 – 2030**

	2005	2010	2020	2030	30/05 %/a	2005 shares	2010	2020	2030
in mboe									
Total Final Energy Consumption	783	856	878	894	0.5%	100%	100%	100%	100%
oil	382	411	379	354	-0.3%	49%	48%	43%	40%
gas	316	351	394	431	1.3%	40%	41%	45%	48%
electricity	85	94	104	108	1.0%	11%	11%	12%	12%
coal	0	0	0	0		0%	0%	0%	0%
renewables	0	0	0	0		0%	0%	0%	0%
Industry	164	180	211	236	1.5%	100.0%	100.0%	100.0%	100.0%
oil	58	62	66	68	0.6%	35.6%	34.4%	31.3%	28.6%
gas	77	88	115	142	2.5%	47.2%	48.9%	54.6%	60.1%
net electricity*)	28	30	29	26	-0.3%	17.3%	16.5%	13.9%	11.1%
coal						0.0%	0.0%	0.0%	0.0%
renewables	0	0	0	0		0.0%	0.2%	0.2%	0.2%
Transport	218	246	242	232	0.3%	100.0%	100.0%	100.0%	100.0%
oil	211	239	236	227	0.3%	97.0%	97.1%	97.5%	97.9%
others (CNG)	6	7	6	5	-1.0%	3.0%	2.9%	2.5%	2.1%
Other sectors	401	431	425	426	0.2%	100.0%	100.0%	100.0%	100.0%
oil	112	110	77	59	-2.5%	28.0%	25.6%	18.2%	13.9%
gas	232	256	272	285	0.8%	57.8%	59.5%	64.1%	66.9%
electricity	57	64	75	82	1.5%	14.1%	15.0%	17.7%	19.3%
coal									
renewables	0	0	0	0					
Non-energy use	21	21	27	34	0.0%				
Electricity generation in TWh/a									
fossil	187	205	221	224	0.7%	100.0%	100.0%	100.0%	100.0%
nuclear	0	6	6	6	0.5%	97.5%	93.3%	93.2%	92.8%
renewables	5	8	9	10	3.1%	0.0%	2.9%	2.7%	2.7%
Total Primary Energy Demand	997	1,112	1,200	1,242	0.9%	100.0%	100.0%	100.0%	100.0%
Oil	460	499	475	455	0.0%	46.1%	44.9%	39.6%	36.6%
Gas	535	597	701	763	1.4%	53.6%	53.6%	58.4%	61.4%
Nuclear	0	11	11	11		0.0%	1.0%	0.9%	0.9%
Hydro & other REN elec.	3	6	6	7	3.6%	0.3%	0.5%	0.5%	0.5%
other renewables	0	0	0	0		0.0%	0.0%	0.0%	0.0%
Coal	0	0	7	7		0.0%	0.0%	0.6%	0.6%

Source: own calculations

**Table A3: Scenario Overview Renewables-Scenario, 2005 – 2030**

	2005	2010	2020	2030	30/05 %/a	2005 shares	2010	2020	2030
in mboe									
Total Final Energy Consumption	783	961	1,226	1,475	2.6%	100%	100%	100%	100%
oil	382	450	502	532	1.3%	49%	47%	41%	36%
gas	316	407	579	736	3.4%	40%	42%	47%	50%
electricity	85	101	133	167	2.7%	11%	11%	11%	11%
coal	0	0	0	0		0%	0%	0%	0%
renewables	0	2	12	39		0%	0%	1%	3%
Industry	164	204	288	380	3.4%	100.0%	100.0%	100.0%	100.0%
oil	58	71	95	116	2.8%	35.6%	35.1%	32.9%	30.4%
gas	77	98	142	185	3.6%	47.2%	48.2%	49.4%	48.8%
net electricity*)	28	33	44	54	2.6%	17.3%	16.3%	15.2%	14.3%
coal						0.0%	0.0%	0.0%	0.0%
renewables	0	1	7	25		0.0%	0.5%	2.6%	6.5%
Transport	218	273	325	356	2.0%	100.0%	100.0%	100.0%	100.0%
oil	211	265	316	348	2.0%	97.0%	97.1%	97.3%	97.7%
others (CNG)	6	8	9	8	1.0%	3.0%	2.9%	2.7%	2.3%
Other sectors	401	484	614	739	2.5%	100.0%	100.0%	100.0%	100.0%
oil	113	113	92	69	-1.9%	28.1%	23.4%	14.9%	9.4%
gas	232	301	429	542	3.5%	57.8%	62.2%	69.8%	73.4%
electricity	57	68	90	113	2.8%	14.1%	14.1%	14.6%	15.3%
coal									
renewables	0	1	4	14					
Non-energy use	21	21	27	34	0.0%				
Electricity generation in TWh/a									
fossil	187	220	282	346	2.5%	100.0%	100.0%	100.0%	100.0%
nuclear	0	6	6	6	0.6%	97.5%	93.5%	81.2%	60.5%
renewables	5	8	47	131	14.2%	0.0%	2.7%	2.1%	1.7%
renewables						2.5%	3.8%	16.7%	37.8%
Total Primary Energy Demand	998	1,228	1,584	1,917	2.6%	100.0%	100.0%	100.0%	100.0%
Oil	460	538	590	611	1.1%	46.1%	43.9%	37.2%	31.9%
Gas	535	670	933	1,166	3.2%	53.6%	54.6%	58.9%	60.8%
Nuclear	0	11	11	11		0.0%	0.9%	0.7%	0.6%
Hydro & other REN elec.	3	6	32	84	14.6%	0.3%	0.5%	2.0%	4.4%
other renewables	0	2	12	39		0.0%	0.2%	0.7%	2.0%
Coal	0	0	7	7		0.0%	0.0%	0.4%	0.4%

Source: own calculations



**Table A4: Scenario Overview Combined Scenario, 2005 – 2030**

	2005	2010	2020	2030	30/05 %/a	2005 shares	2010	2020	2030
in mboe									
Total Final Energy Consumption	783	849	848	841	0.3%	100%	100%	100%	100%
oil	382	408	372	346	-0.4%	49%	48%	44%	41%
gas	316	344	363	365	0.6%	40%	41%	43%	43%
electricity	85	94	105	110	1.0%	11%	11%	12%	13%
coal	0	0	0	0		0%	0%	0%	0%
renewables	0	2	8	21		0%	0%	1%	2%
Industry	164	180	211	234	1.4%	100.0%	100.0%	100.0%	100.0%
oil	58	62	64	63	0.3%	35.6%	34.3%	30.5%	26.9%
gas	77	88	112	131	2.1%	47.2%	48.8%	53.2%	55.8%
net electricity*)	28	30	30	28	-0.1%	17.3%	16.5%	14.1%	11.8%
coal						0.0%	0.0%	0.0%	0.0%
renewables	0	1	5	13		0.0%	0.5%	2.3%	5.4%
Transport	218	246	241	232	0.3%	100.0%	100.0%	100.0%	100.0%
oil	211	239	235	227	0.3%	97.0%	97.1%	97.5%	97.9%
others (CNG)	6	7	6	5	-1.0%	3.0%	2.9%	2.5%	2.1%
Other sectors	401	423	395	374	-0.3%	100.0%	100.0%	100.0%	100.0%
oil	112	108	72	55	-2.8%	28.0%	25.6%	18.2%	14.8%
gas	232	249	245	229	0.0%	57.8%	58.9%	62.0%	61.2%
electricity	57	64	75	82	1.5%	14.1%	15.2%	19.0%	21.9%
coal									
renewables	0	1	3	8					
Non-energy use	21	21	27	34	0.0%				
Electricity generation in TWh/a									
fossil	187	205	222	227	0.8%	100.0%	100.0%	100.0%	100.0%
nuclear	0	6	6	6	-2.7%	97.5%	93.0%	76.1%	40.3%
renewables	5	8	47	130	14.2%	0.0%	2.9%	2.7%	2.6%
renewables						2.5%	4.1%	21.2%	57.1%
Total Primary Energy Demand	997	1,106	1,160	1,187	0.7%	100.0%	100.0%	100.0%	100.0%
Oil	460	497	456	402	-0.5%	46.1%	45.0%	39.3%	33.9%
Gas	535	590	646	664	0.9%	53.6%	53.4%	55.7%	55.9%
Nuclear	0	11	11	11		0.0%	1.0%	0.9%	0.9%
Hydro & other REN elec.	3	6	32	83	14.6%	0.3%	0.5%	2.8%	7.0%
other renewables	0	2	8	21		0.0%	0.2%	0.7%	1.7%
Coal	0	0	7	7		0.0%	0.0%	0.6%	0.6%

Source: own calculations

**Table A5: Scenario Overview Constrained Scenario, 2005 – 2030**

	2005	2010	2020	2030	30/05 %/a		2005	2010	2020	2030
in mboe						shares				
Total Final Energy Consumption	783	859	882	879	0.5%		100%	100%	100%	100%
oil	382	418	400	374	-0.1%		49%	49%	45%	43%
gas	316	344	369	375	0.7%		40%	40%	42%	43%
electricity	85	94	105	110	1.0%		11%	11%	12%	12%
coal	0	0	0	0			0%	0%	0%	0%
renewables	0	2	8	21			0%	0%	1%	2%
Industry	164	180	211	234	1.4%		100.0%	100.0%	100.0%	100.0%
oil	58	62	64	63	0.3%		35.6%	34.3%	30.5%	26.9%
gas	77	88	112	131	2.1%		47.2%	48.8%	53.2%	55.8%
net electricity*)	28	30	30	28	-0.1%		17.3%	16.5%	14.1%	11.8%
coal							0.0%	0.0%	0.0%	0.0%
renewables	0	1	5	13			0.0%	0.5%	2.3%	5.4%
Transport	218	256	271	261	0.7%		100.0%	100.0%	100.0%	100.0%
oil	211	248	263	255	0.7%		97.0%	97.1%	97.3%	97.6%
others (CNG)	6	8	7	6	-0.1%		3.0%	2.9%	2.7%	2.4%
Other sectors	401	423	401	384	-0.2%		100.0%	100.0%	100.0%	100.0%
oil	112	108	72	57	-2.7%		28.0%	25.6%	18.1%	14.7%
gas	232	249	250	238	0.1%		57.8%	58.9%	62.4%	61.9%
electricity	57	64	75	82	1.5%		14.1%	15.2%	18.8%	21.3%
coal										
renewables	0	1	3	8						
Non-energy use	21	21	27	34	0.0%					
Electricity generation in TWh/a	187	205	222	227	0.8%		100.0%	100.0%	100.0%	100.0%
fossil	182	190	174	101	-2.3%		97.5%	93.1%	78.4%	44.4%
nuclear	0	6	6	6			0.0%	2.9%	2.7%	2.6%
renewables	5	8	42	120	13.8%		2.5%	3.9%	18.9%	53.0%
Total Primary Energy Demand	997	1,117	1,196	1,228	0.8%		100.0%	100.0%	100.0%	100.0%
Oil	460	507	486	434	-0.2%		46.1%	45.4%	40.6%	35.3%
Gas	535	591	658	684	1.0%		53.6%	52.9%	55.0%	55.7%
Nuclear	0	11	11	11			0.0%	0.9%	0.9%	0.9%
Hydro & other REN elec.	3	6	26	72	13.9%		0.3%	0.5%	2.2%	5.9%
other renewables	0	2	8	21			0.0%	0.2%	0.7%	1.7%
Coal	0	0	7	7			0.0%	0.0%	0.6%	0.6%

Source: own calculations

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