Iranian – German Cooperation Project

Energy Scenarios for Iran

Executive Summary

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IRAN ENERGY ASSOCIATION

Wuppertal Institute for Climate, Environment and Energy

UNIVERSITÄT OSNABRÜCK

This project was conducted as part of the initiative ***"Climate Policy and Sustainable Development: Opportunities for Iranian – German Co – Operation"***. Up to now, one internship has taken place in Wuppertal on 12 – 20 Jan. 2007.

Moreover the following workshops and seminars have held:

1. Workshop in Wuppertal on 20 – 21 Nov., 2006
2. Workshop in Wuppertal on 21 – 24 Nov., 2007
3. Workshop in Wuppertal on 14 – 17 May, 2008
4. Workshop in Berlin on 17 – 21 Nov., 2008
5. Seminar in Tehran on June 15, 2008
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Table of Contents

List of Figures

List of Tables

Introduction

Iran plays an important role in world energy supply and hence in the global economy. However, the country has faced serious challenges in capitalizing on its vast resources. 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. Iran has also difficulties in meeting the increasing trend in energy demand across the sectors of the economy. The heavily subsidized energy prices have led to a high and inefficient use of energy and lack of foreign investment has slowed down the production and development of new projects. Iran also needs to find a way on how to make optimal use of the oil revenues and to invest in energy efficiency and its ample renewable energy sources.

This study intends to tackle some of these challenges and to explore alternative scenarios for the utilization of energy resources in Iran in the long run. Specifically, 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 under a Business As Usual (BAU) scenario taking into account the past trends, future policies, and developments in the economy and the energy sector. The study also identifies potentials for efficiency and renewable energy resources in four scenarios: High-efficiency, high-renewable, Combined efficiency and renewable, and Constrained scenario.

Methodology

The main method of the study is the bottom-up approach in which demand side dynamics are modeled using a computational model and detailed data from different sectors of the economy. In some cases, where 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, based on differentiated estimates of the existing potentials 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.

An Overview of the Economy and the Energy Sector

Iran is considered as a low-mid income country with a GDP equal to $158.6 billion and a per capita GDP $2,280[1]. Agriculture accounts for 11.2 percent of the GDP, industry 41.7 percent and service 47.1 percent. 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 have been relatively high, thanks to the high oil prices until the mid of 2008, they are lower than the government targets under the third and the fourth five-year development plans. Iran's population is 70 million (the largest in the Middle East), one third of which is less than 14. The average life expectancy is 70 and the literacy rate is 87 percent.

[1] GDP and GDP per capital with the Purchasing Power Parity (PPP) method are $599.2 billion and $8,700, respectively (Central Bank of Iran, 2006)

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 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 per year 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. In Figure 1, the energy intensity in Iran is compared to that in the rest of the world. The energy intensity in Iran is as high as the whole Middle East region, but twice as high as the world average. Figure (2) shows the primary energy supply and final consumption, and table (1) summarizes the major energy production and consumption measures in Iran in

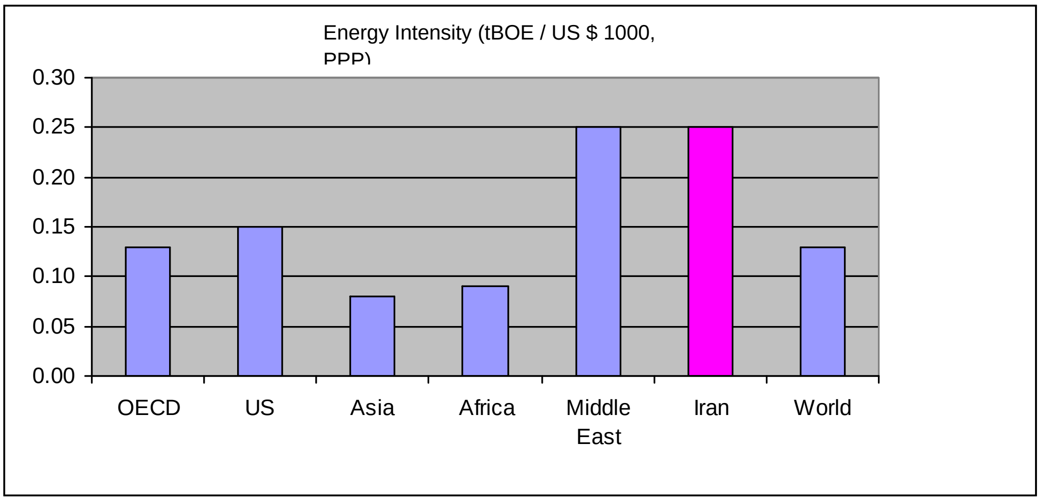


Figure 1. Energy Intensity, Iran and the World

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. 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, is also very high in Iran compared to the world: 1.27 compared to 0.41 for the period 1990-2003, respectively.

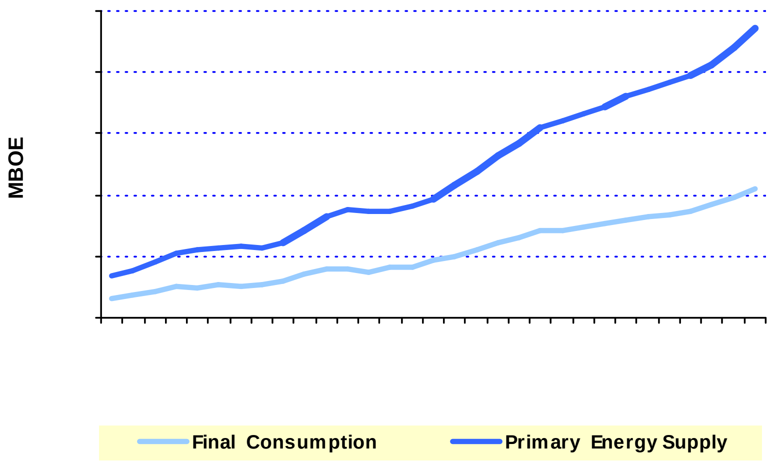


Figure 2. Primary Energy Supply and Final Consumption, MBOE (1974 – 2004)

Source: Energy Balance, Ministry of Energy, 2005

Table 1. Energy Production and Use in Iran

	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		
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, tcm: trillion cubic meter, bcm: billion cubic meter, bkWh: billion kilo watt hour, GW: Giga Watt

**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)

Business as Usual (BAU) Scenario

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. GDP and population are two main factors affecting energy demand in different sectors. Our assumptions about the growth of these variables are summarized in the following table.

Table 2. 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

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's consumption of oil products has increased on average by about half a percent per year, but the consumption of natural gas and electricity have increased by 19 percent and 6 percent per year for the past 15 years, respectively. The household energy consumption pattern has changed markedly since 1990 because of government's policy of substituting natural gas for oil products.

Oil Products and Natural Gas

We use a regression equation to estimate the relationship between the demand for oil and gas in the household sector. The estimation results of the regression equation show that GDP and population are significant factors in explaining the changes in demand for oil and gas by households. We predict the future demand for oil and gas by households using the regression equation results and the assumptions on the future values of GDP and population. We then break down the future demand for energy into kerosene, gas oil, LPG, and natural gas 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. One of the key factors in estimating the future shares of energy types in households demand for oil and natural gas is the government policy to increase the share of natural gas in the households 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, 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. Figure (3) shows the trend of the future demand for oil, natural gas, and solar energy by households for the period 2005-2030. Overall, households 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 households will grow by 3.4 percent per year on average, increasing from 259 MBOE in 2005 to 592 MBOE in 2030.

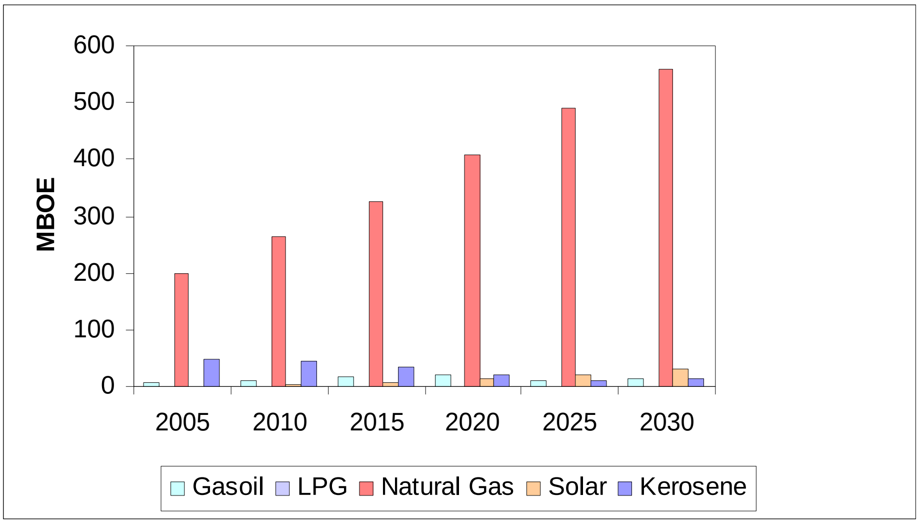


Figure 3. Household Demand for Oil Products, Natural Gas, and Solar Energy - The BAU Scenario (2005-2030)

Electricity

Household demand for electricity is estimated using a bottom-up approach. This approach uses micro data that allows for analyzing various scenarios regarding the changes in technology, penetration rates, and other determinants of demand. Table (3) shows the general information about the residential electricity use in Iran. In 2005, about 16.4 million customers used electricity, from which 73 percent were urban.

Table 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

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 the 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 and its ratio to population, the total electricity use by households and appliances are calculated.

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 households electricity consumption, 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. Figure (4) shows the future trend of the residential demand for electricity in the BAU scenario. The number of residential customers 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.

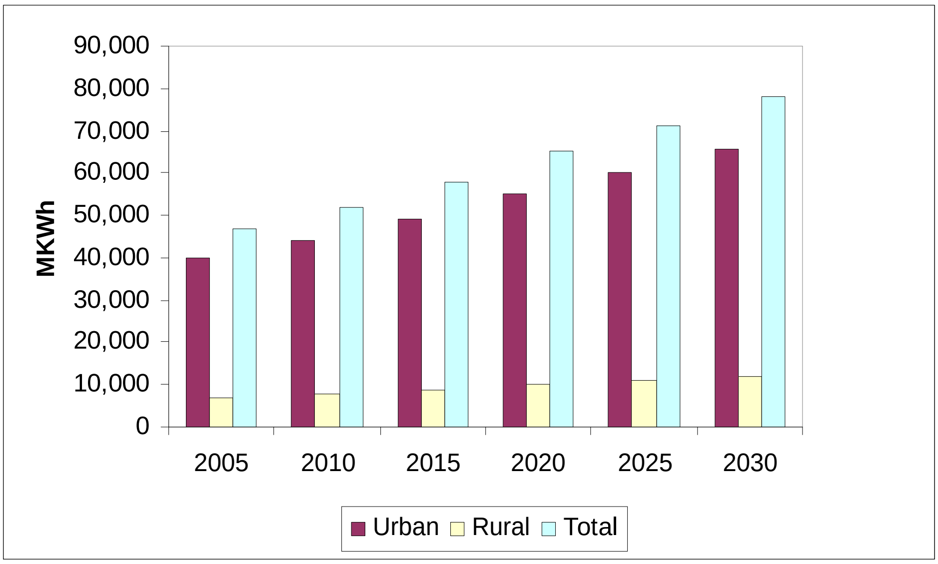


Figure 4. Residential Demand for Electricity- MkWh (2005-2030)

Industry

Industry accounts for about 42 percent of the Iranian GDP, and uses 164.5 mboe or 17 percent of the total final 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 policy of substituting natural gas for oil products.

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 the data at the two digit ISIC[2] level by which the manufacturing industries are classified into nine main industry groups.

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 obtained 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 per year at the beginning of the period and at 4 to 6 percent per year at the end of the study period. Third, using the energy intensity in each manufacturing group, the value added and the future energy demand for manufacturing industry groups is estimated for the next 25 years. 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. It is also assumed that 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 will continue. The BAU results are shown in Figure (5). 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.

[2] International Standard of Industry Codes

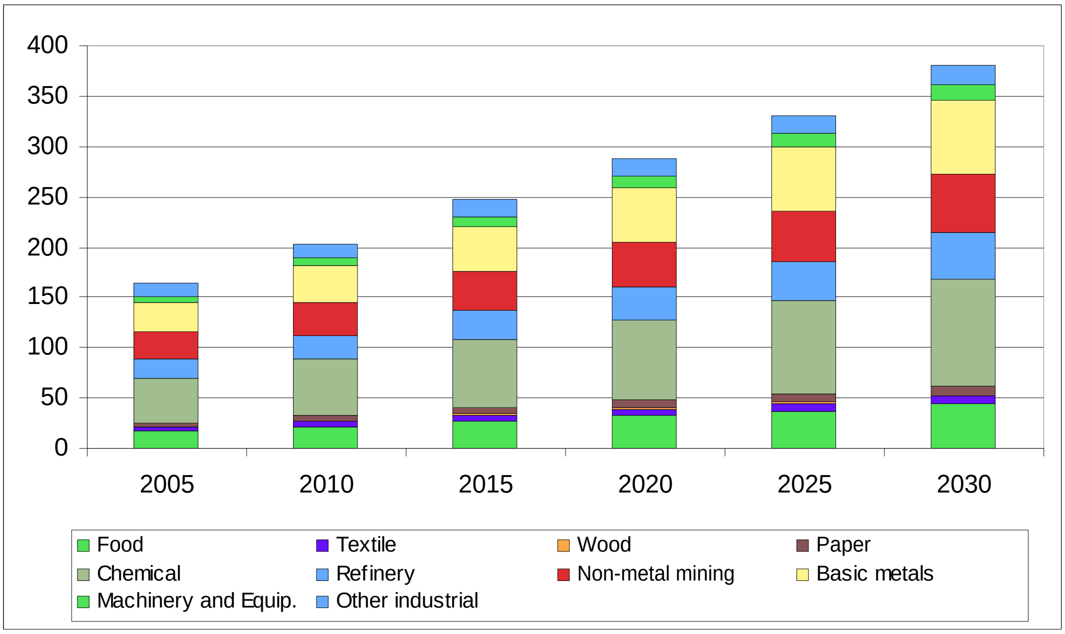


Figure 5. Total Energy Demand by Manufacturing Industries, BAU (2005-2030), mboe

Power Generating Plants

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. In this year, the total installed capacity was 37.3 GW, which was contributed by steam (38%), natural gas (30%), combined cycle (17%), and hydro (15%) power plants.

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 per year based on the Ministry of Energy's 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.

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). The total fuel demand by the power generating plants will grow on average by 1.81 percent per year for the period 2005-2030.

Table 4. 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	

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 billon 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.

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.

Table (5) shows the total final energy demand in transport sector, which will grow on average by 2 percent per year reaching from 217 mboe in 2005 to 354 MBOE in 2030.

Table 5. 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

Others

The other sectors include 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. Similar to the industry sector, we use the energy intensity and the value added data to estimate the future demand for energy in these sectors. Table (6) summarizes the energy demand for these sectors in 2005-2030.

Table 6. Energy Demand in Other Sectors, BAU Scenario (2005-2030), MBOE

``	Public			Commercial			Agriculture		
	2005	2030	Growth	2005	2030	Growth	2005	2030	Growth
Gasoline	0.85	0.66	-1	0.06	0.03	-3	0.09	0.12	0.91
Kerosene	1.83	0.95	-2.6	0.47	0.21	-3	0.5	0.17	-4.06
Gas Oil	5.88	7.52	1	4.45	4.74	0	24	25.9	0.31
Fuel Oil	2.1	0.03	-15	10.34	5.24	-3	0.03	0.01	-4.87
Electricity	13.42	22.84	2	5.27	17.51	5	10	26.6	3.66
Natural Gas	0.16	4.68	14	34.17	57.84	2			
Total	24	37	1.67	54.77	85.57	2	35	52.8	1.6

Total Energy Demand

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 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 (7) shows the BAU Scenario results for energy demand in different sectors for the period 2005-2030.

Table 7. Total Primary Energy Demand in Iran by Sectors, BAU Scenario (2005-2030)

	2005 (mboe)	Share (%)	2030 (mboe)	Share (%)	Growth (%/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

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, theirs 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 (6) shows the demand for electricity by different sectors in the BAU scenario for the period 2005-2030.

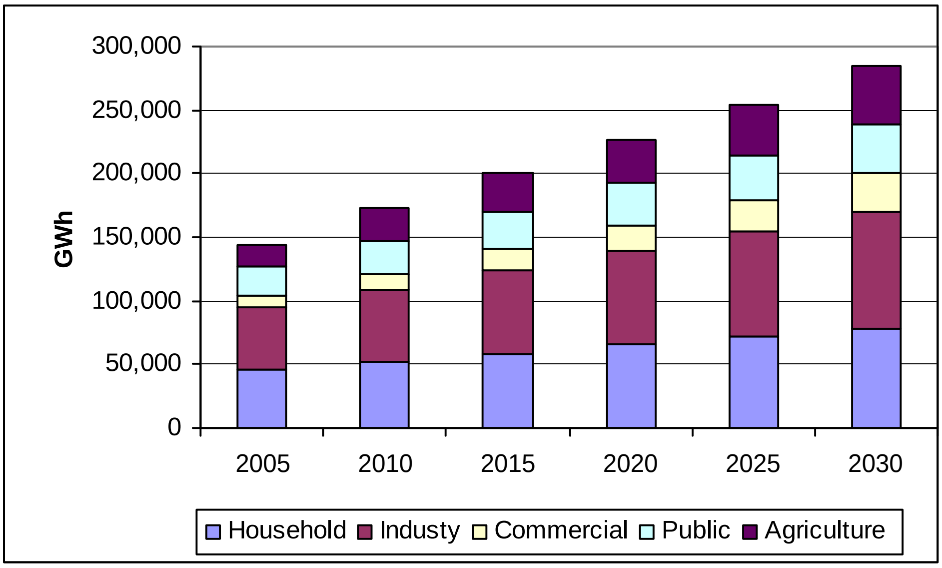


Figure 6. Demand for Electricity by Sectors in BAU Scenario (2005-2030)

Scenario Analysis

In this part, we develop alternative scenarios for energy demand in Iran using the results of the BAU scenario as a reference. Specifically, we consider four scenarios as follows: High Efficiency, High Renewable, Combined efficiency and renewable, and Constrained scenarios.

High Efficiency Scenario

In the High Efficiency scenario, we focus only on the efficiency parameters in the energy demand in different sectors keeping all other factors, 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 favor 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 appliances that are more efficient will substitute the traditional inefficient devices. In the industry sector, we assume the energy intensity will continue to decline, and in 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.

Households

In the households sector, the major changes in electricity consumption will occur in the use of light bulbs, refrigerators and freezers, iron, and TV and computer, and air conditioner. We assume that households will substitute 80 percent of the incandescent lamps and therefore will use about 40 percent less electricity by 2030. We also assume that in the year 2020, the average consumption of a refrigerator in Iran would be 20 percent higher than the consumption of an average refrigerator in Central Europe today, but 20 percent higher than the highly efficient refrigerators in Europe today. 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. Due to the use of the better technologies by 2030, the electricity consumption by iron, air conditioner, TV and computer will be 50, 30, and 25 percent less, respectively. Furthermore, households will consume 11 percent less energy for heating by 2030. This will be achieved by assuming a 2 percent of renovation rate, 50 percent energy saving per building, 10 percent replacement rate, and a 10 percent increase in the size of the living-area per person. Overall, the total energy demand by households in the efficiency scenario will be about 50 percent less than the BAU scenario in 2030.

Industry

The industry in Iran has experienced 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. We use the detailed energy auditing results by various organizations to estimate the energy savings potentials in the manufacturing industries.

We assume that real monetary growth and physical production will be decoupled by a rate of 1 percent per year in the future, 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 by about 1 percent per year. The residual production will come from completely new producing sites. By 2030, 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, we assume that the current best available technology (BAT), as described by the study of SABA (a subsidiary of TAVANIR), 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 (2006).

We furthermore assume 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 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. Overall, the total energy consumption in industry in the efficiency scenario will be 41 percent less than the BAU scenario in 2030.

Transport

Fuel efficiency in transport sector can be achieved in two ways: Change in the number of cars and travel distance, and 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[3]. 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 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.

We assume that the average specific energy consumption for Iranian private cars in the BAU scenario will decrease from 14 litres/km to 10 litre/100km by 2030. We further assume that in 2020, the average consumption of private cars in Iran will be the same as Germany in the year 2006, which was 7.8 litres/100km. For the year 2030, the private cars in Iran will consume gasoline on average in the same amount of a good 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. Overall, the total energy used in the transport sector in the efficiency scenario will be 35 percent lower than that in the BAU scenario.

Others

We use the energy auditing results for public buildings to estimate the savings potentials in the public sector. For existing buildings, an average savings potential of 35 percent over the next 25 years has been assumed to be feasible by a

[3] This is still significantly less than most OECD countries, which levy high taxes on transport fuels.

systematic upgrading. 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 the BAU scenario levels by 2030. 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. In agriculture sector, savings in electricity and fuels will be 40 percent and 30 percent less than the BAU scenario, respectively.

Total Final Demand

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 7 shows the total final energy demand under the high-efficiency and the BAU scenarios. In general, the high-efficiency scenario will lead to more than 40 percent energy savings 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 energy compared with BAU. The savings in the industry, transport, public, and commercial sectors will be in the range of 30 to 40 percent. Even though the saving rates in the commercial and public sectors are higher than those in industry and transport sectors, the amounts of energy saved in the latter are much higher due to the their higher levels of energy consumption.

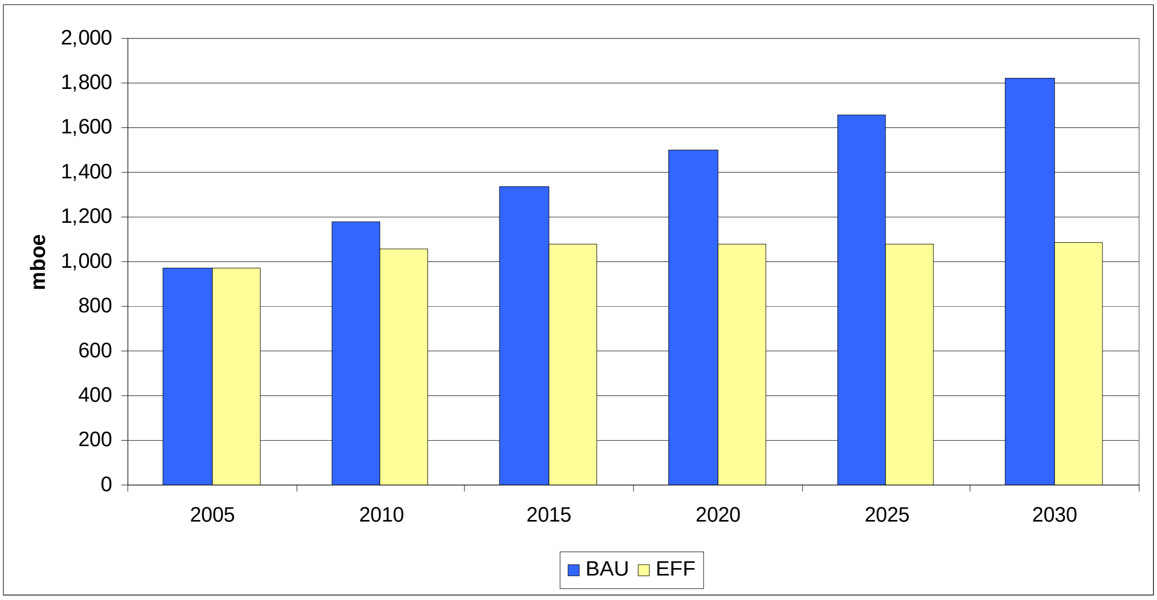


Figure 7. Total Final Energy Demand in BAU and Efficiency Scenarios (2005-2030), mboe

High Renewable Scenario

In the High Renewable scenario, we concentrate on the renewable energy potentials in Iran and keep the efficiency parameters at the BAU scenario level. We review various national and international studies conducted on renewable energy resources in Iran and examine all the potential resources like wind, hydro, biomass, geothermal, and solar irradiation. Overall, the share of renewable energies in this scenario will reach 16 percent in 2030. A summary of the utilization of the renewable energy sources in each sector of the economy is presented below.

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. Also 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.

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 that will be realised to large extent in the longer time frame.

Transport

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

Others

In the public and commercial sectors, the renewable energies will make up to 10 and 16 percent of fuel use by 2030, respectively, mainly contributed by solar thermal devices. In agriculture sector, the renewable energies will contribute 12.7 percent to the fuel use. 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.

Total Final Demand

Figure 8 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 most important source of the savings will almost exclusively be achieved by the higher efficiency of the renewable power generation technology.

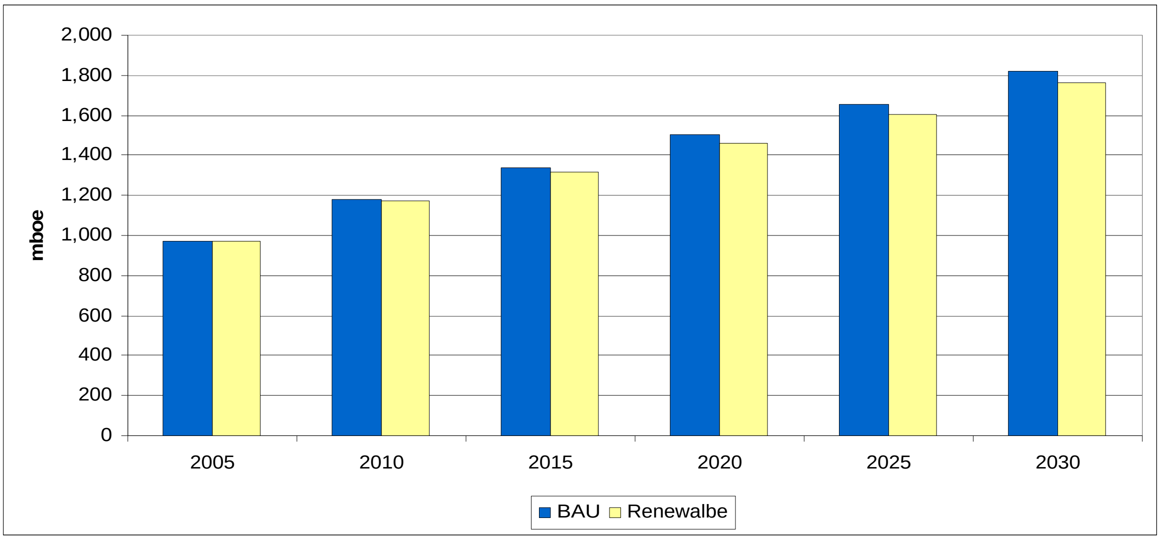


Figure 8. Total Primary Energy Demand in BAU and High-Renewable Scenarios, 205-2030, mboe

Combined Scenario

In the Combined scenario, we combine high-efficiency and high-potential scenarios. Therefore, the energy saving under this scenario is expected to be higher than that in each individual scenario. Figure 2.18 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 energy demand growth in BAU which is 2.6 percent. The total energy demand in 2030 under this scenario will be 1030 MBOE which translates into 43 percent energy saving compared to the BAU scenario.

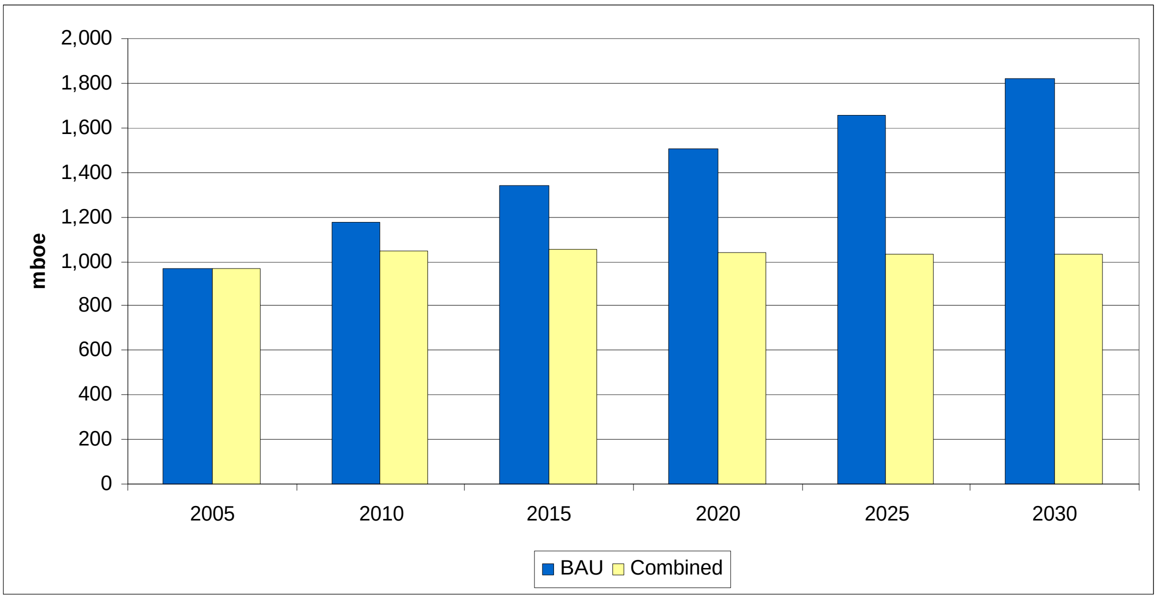


Figure 9. Total Primary Energy Demand in Combined and BAU Scenarios (2005-2030), mboe

Constrained Scenario

In the high-efficiency and high-renewable scenarios, we assume that the efficiency factors and the renewable resources will be fully 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 reason for the failure of the assumptions is uncertainty in policymaking, economic conditions, and technological changes. To acknowledge those restrictions, we thus construct an additional scenario, which is called “Constrained scenario.” The Constrained scenario will take into account those uncertainties in the context of high-efficiency and high- renewable 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-renewable scenarios.

Sector	Constrained Scenario By 2030	Original Scenario By 2030	Constraint
Electricity generation by wind power	15 TWh	22 TWh by wind power	Uncertainty in investment by private sector
Electricity generation by geothermal plants	3 TWh	5.25 TWh by geothermal power plants	uncertainties regarding the plant factor and the hours of operation
Transport – Number of cars	18,26 million cars	6.26 million cars	Lower use of public transport
Transport – Fuel use by cars	7 liter/100 km	6 liter per 100 km	The effect of other factors (infrastructure, driving habit, traffic condition, …)
Residential - heat	30 percent saving per building	50 percent saving per building	uncertainties in the policies and their successful implementation

Figure 10 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.

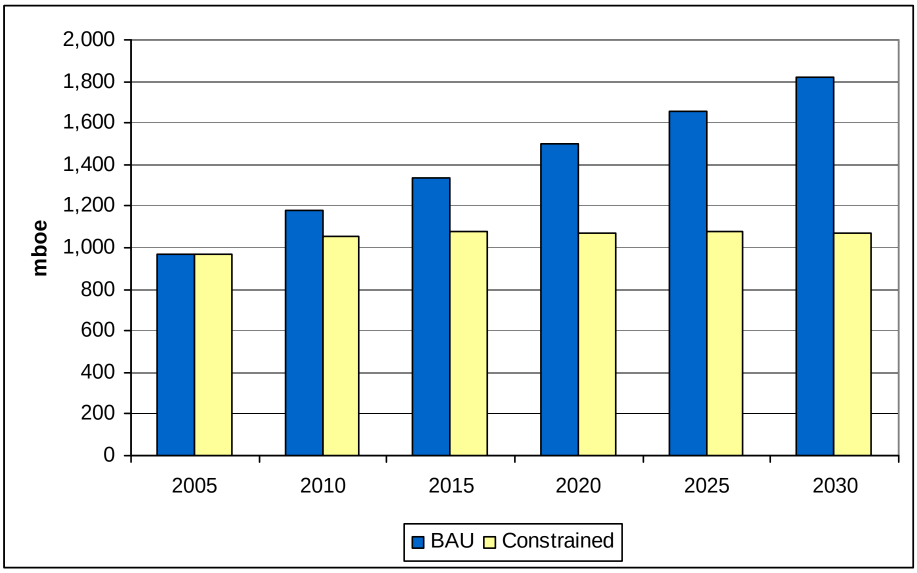


Figure 10. Total Primary Energy Demand in Constrained and BAU Scenarios (2005-2030), mboe

Comparison among Scenarios

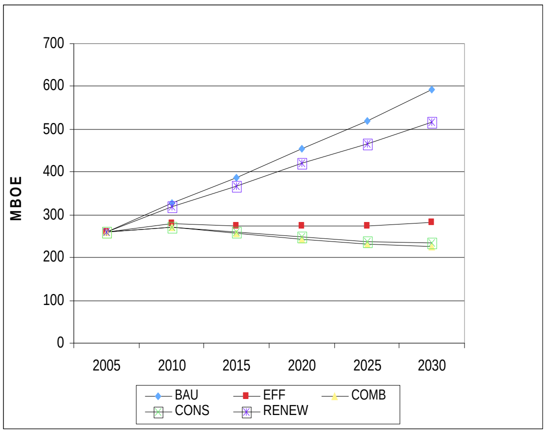
Table 8 shows a comparison among demand for energy in four different scenarios. As it is evident from the figures, the high-efficiency scenario will generate about 40 percent saving in total energy consumption in the year 2030. This saving potential is very high in the international scale. The energy saving under the high-renewable scenario will be about 3 percent in in 2030. The lower saving rate in the high-renewable scenario is due to the fact that utilization of new technologies and implementing appropriate policies towards the renewable energy would take much longer time than our study's time frame. The Combined scenario, which is a combination of the high-efficiency and high-renewable 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 8. A Summary of the Scenario Results (2005-2030)

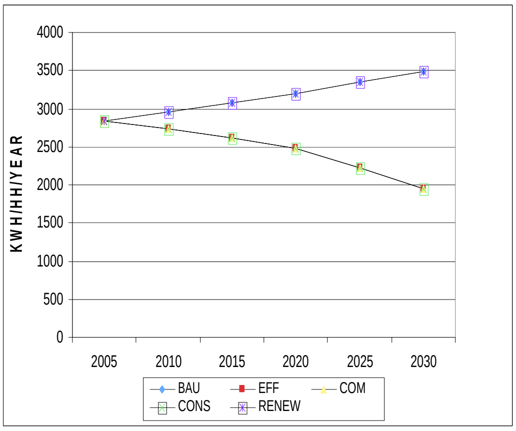
Scenario	Total Energy Demand (MBOE)		Saving in 2030 (%)	Growth per year
	2005	2030		
BAU	970	1,822	-	2.6
High- Efficiency	970	1,084	40	0.4
High- Renewable	970	1,760	3	2.4
Combined	970	1,030	43	0.2
Constrained	970	1,070	41	0.4

Figure 11 shows the energy demand by different sectors in each scenario. The amount of energy saving will be highest in the household sector followed by industry, transport, and others sectors, respectively.

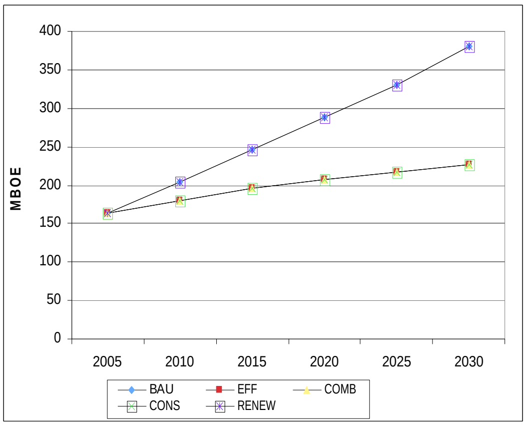
Household (Heat)



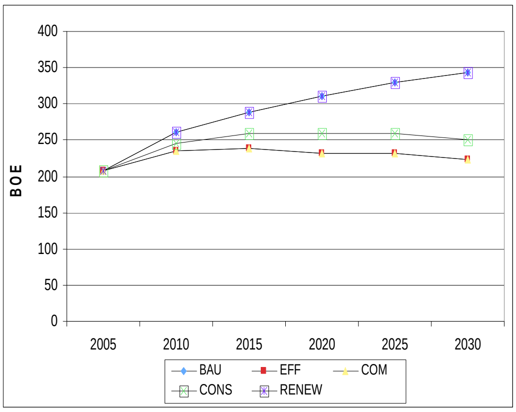
Household (Electricity)



Industry



Transport



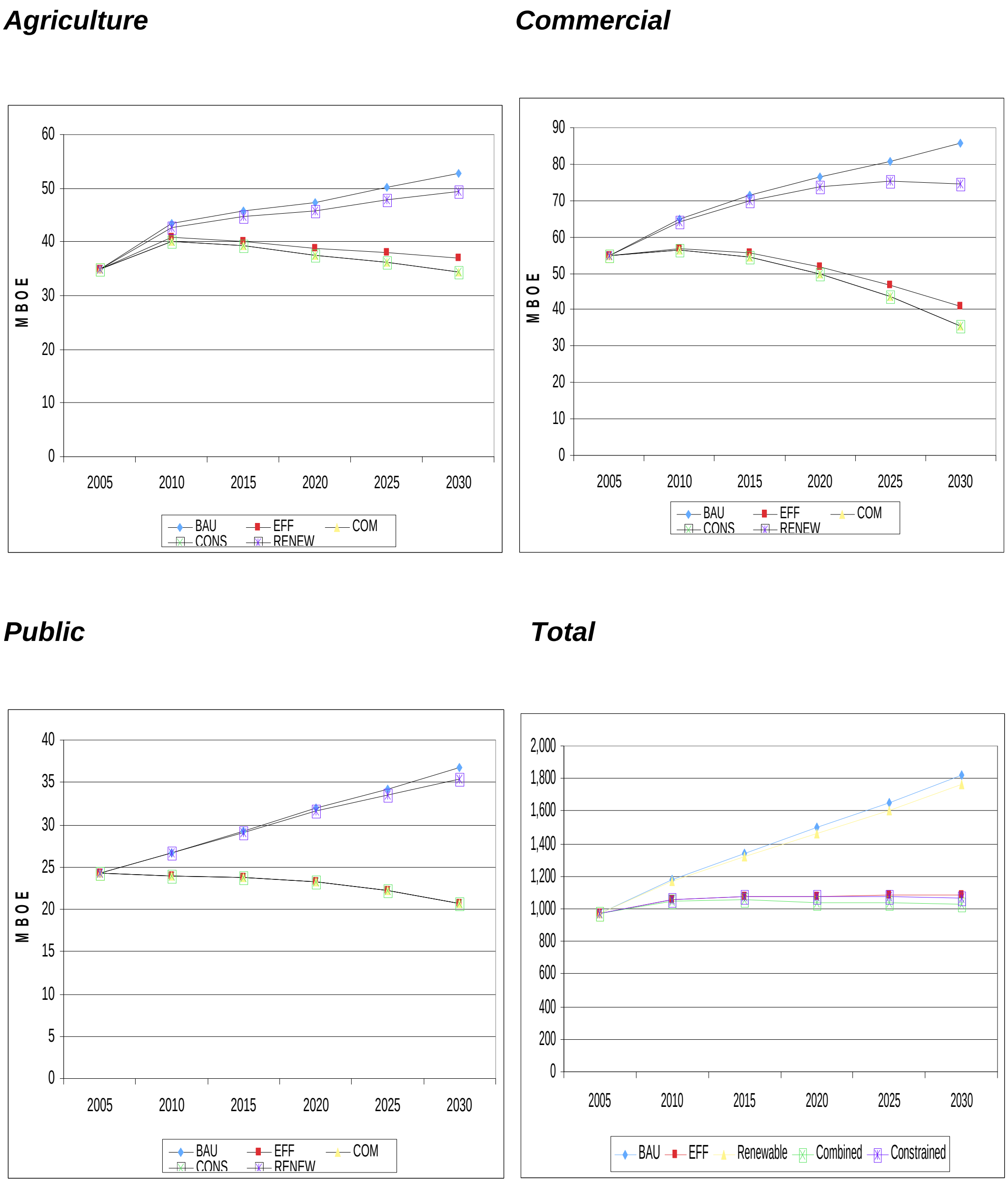


Figure 11. A Summary of the Scenario Results (2005-2030), mboe

In the BAU scenario, the energy intensity will be reduced by about 30 percent by 2030, which will still be higher than today's world average. In the efficiency scenario, however, the energy intensity will be declined by about 60 percent in 2030 making it lower than the world average and Germany today, but still higher than Germany's target for 2020. Figure 12 shows the energy intensity in Iran in comparison with the world and Germany in different scenarios.

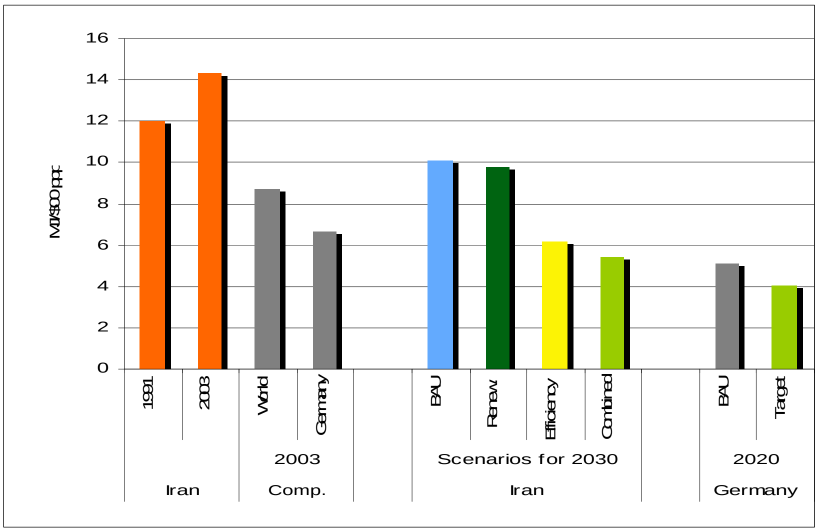


Figure 12. Energy Intensity in Iran and World _Under Different Scenarios

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

Economic and Ecological Impacts of Scenarios

We assume that the oil and gas saved under different scenarios can be exported to the international market, generating additional revenues for the country. Using the oil price prediction by WEO (2008), we estimate that the total revenues as a result of energy savings in the efficiency scenario will rise to about US $68 billion in 2030. This revenue will be more than US $19 billion in the renewable scenario, more than US $82 billion in the Combined scenario, and more than US $77 billion in the Constrained scenario. Over 25 years, the total revenues add up to an amount between US $240 billion in renewable scenario and more than US $1000 billion in Combined scenario. Figure 13 shows the potential revenues due to energy savings in different scenarios.

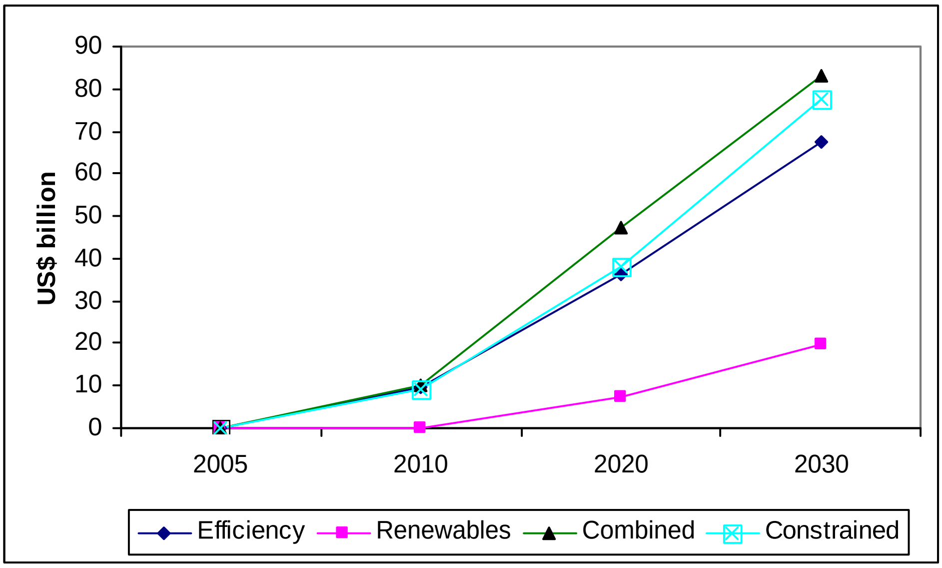


Figure 13. The Potential Revenues Generated by Alternative Scenarios (2005-2030)

The use of fossil fuel contributes to pollution and global warming. In this study, we restrict our estimation of ecological impacts of energy use in alternative scenarios to only CO2-emissions, and ignore the external costs imposed by the emissions on health care. Therefore, our estimation of the ecological damage of energy use should be regarded as a conservative estimation. As Figure 14 shows, the CO2-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 CO2-emissions 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 CO2-emissions and thereby acquiring an internationally leading position.

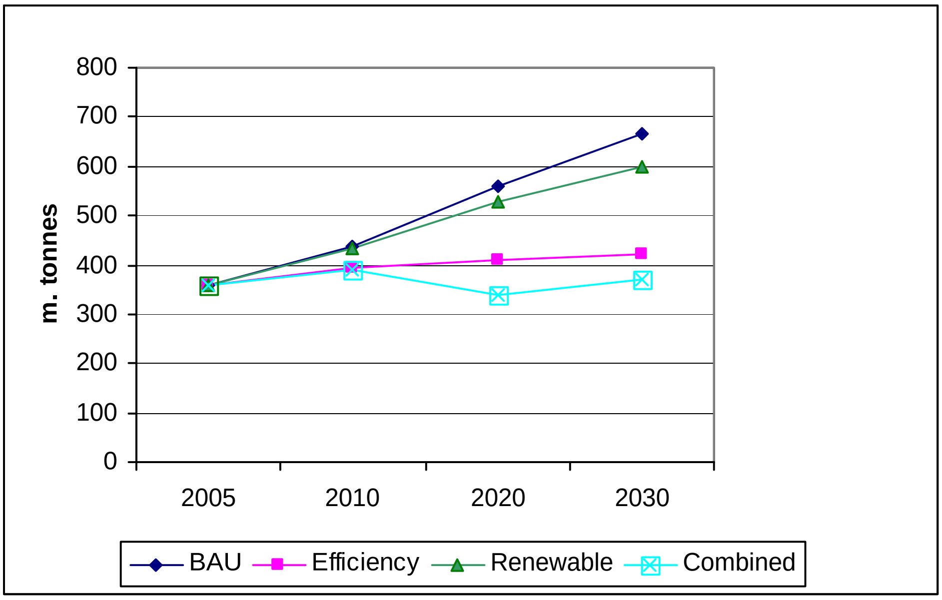


Figure 14. CO2- Emissions in Alternative Scenarios (2005-2030)

Conclusion

Iran with 11 percent of the global oil reserves and 15.3 percent of the global natural gas reserves plays an important role in world energy supply and in the global economy. However, it faces many challenges in optimal utilization of its vast resources. High economic growth, generous subsidies program in the energy sector, and poor resource management have contributed to growing energy consumption and high energy intensity in recent years. The continuing trend of energy consumption will bring about new challenges as it will shrink oil exports and revenues and restrict economic activities. This study intends to tackle some of the important challenge in the energy sector and to explore alternative scenarios for utilization of energy resources in Iran until 2030.

The study uses current and historical micro and macro data to model energy consumption in different sectors of the economy. The base model is the Business As Usual (BAU) scenario which takes into account the consumption trends and past and future policies. Four alternative scenarios are also developed as follows: High-Efficiency, High-Renewable, Combined, and Constrained. In the High Efficiency scenario, the study draws 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, it is assumed 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, it is assume that the country will utilize both the efficiency and the renewable potentials in the future. Finally, in the Constrained scenario, some of the assumptions in the High Efficiency and High Renewables scenarios are modified as they may not be realized.

The total final demand for energy under the BAU will grow on average by 2.6 percent per year reaching 1822 mboe in 2030, which is twice as much as the total energy consumption in 2005. However, the total final demand for energy in High-Efficiency scenario will grow on average by 0.4 percent per year reaching 1,084 mboe in 2030. The average growth of energy demand under the Renewable, Combined, and Constrained scenarios will be 2.4, 0.2 and 0.4 percent per year, respectively. In the BAU scenario, the energy intensity will be reduced by about 30 percent by 2030, which will still be higher than today's world average. In the High-Efficiency scenario, however, the energy intensity will be declined by about 60 percent in 2030 making it lower than the world average and Germany today, but still higher than Germany’s target for 2020.

Realization of the energy efficiency scenarios in Iran will lead to significant revenues as the saved oil can be exported to the international markets. Using the oil price prediction by WEO (2008), the study estimates that the total revenues as a result of energy savings in the High-Efficiency scenario will rise to about US $68 billion in 2030. This revenue will be more than US $19 billion in the High-Renewable scenario, more than US $82 billion in the Combined scenario, and more than US $77 billion in the Constrained scenario. Over 25 years, the total revenues would be in the range of $240 billion to $1000 billion depending on the scenarios. The efficiency scenarios will also lead to 45 percent reduction in CO2-emmissions by 2030.

The scenario analysis results show that developing energy efficiency and renewable energy policies will benefit Iran significantly. To achieve this objective, however, the current policy of providing subsidies to energy users, particularly in the residential and transport sectors need to be revised. Non price policies, such as education and public awareness, energy consumption regulation for producers of appliances and vehicles as well as consumers will also needed to take control of the consumption pace.