



Review Article

**Sustainable development and the trend of changing energy consumption pattern
in Iran**

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Abstract

Sustainable development means providing solutions to the transient patterns of physical, social and economic development that could prevent some Problems such as destruction of natural resources, destruction of biological systems, global climate change, pollution, uncontrolled population increase, injustice and low quality of human life and the next stop. Energy consumption is one of major problem in Iran that causes unstable environment. Energy consumption in transportation sector accounts for the most share of consumption after household and commercial consumption and has the first grade of financial value among other sectors. On the other hand, the sector of transportation plays a positive and necessary role in economic and social development and certainly, transportation requirements will increase in future. However, since the sector of transportation is one of the sources of air pollution, it is necessary to revise the current transportation systems and the effective management and design of transportation systems. In this paper, we have tried to review the trend of energy consumption in sector of transportation of Iran in a 5 year period. Then, the energy consumption in the sector was compared with the Middle East region and the whole world. The reviews show that Iran is the only country in the Middle East that uses natural gas in its transportation sector. Also, the share of natural gas consumption in sector of transportation of the country was 0.35% of the whole world in 2005. The average growth of final consumption of petroleum products in sector of transportation of the country (6.3%) in the examined 5 year period was more than the average growth of consumption of these products in the whole world (4.6%). For example, in 2005, the share of the final consumption of petroleum products in transportation sector of Iran in the world and in the Middle East is 1.7 and 32.6%, respectively. In recent years, the consumption of gasoline has reached 74 million liters per day with a growth about 10% in 2006. Finally, management procedures are presented for optimizing consumption of energy carriers in transportation sector.

Keywords: *transportation sector, consumption pattern, energy carriers,*

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INTRODUCTION

The issue of energy in developing and energy producing countries is important in the aspects of the amount of producing it as the basis of the country's revenue, also the way of consumption and adopting the most suitable mechanism and strategy for suitable utilization. Therefore, energy is the basis of industrial and economic development of these counties and the danger of its reduction and

also the destructive outcomes due to unsuitable consumption pattern and energy loss are the most important concerns of these countries.

It is for more than three decades that the main consumers of energy carries have followed the activities of reducing losses due to consumption of energy carriers and policies of optimizing consumption of fuel seriously and by plans. In this way, not only they have reached considerable economies, but they have also prevented from the

increasing development of the process of destruction of the environment effectively. Promoting the level of technology of manufacture and production, increasing revenues of the government in controlled taxes of fuel consumption and the similar cases are other results of enforcing policies of energy consumption [Hashemi, Mahdi, 2002].

Transportation accounts for 30% of the consumed commercial energy of the world and about 60% of the whole liquefied petroleum of the world. In developing countries, the quick development of motor vehicles and insufficient investment in planning urban transportation and the foundations and management of transportation create increasing problems in aspects of accidents and injuries, hygiene, noise, crowd, jumble and losing producing force that is the same as what occurs for many developed countries. All of these problems have negative effects on urban population, especially low income or no income people.

Iran is located in the Middle East with about 1.6 million and with a population for more than 70 million people which connects Europe to the Far East and is the partition between independent countries around the Persian Gulf having common benefits. The average fuel consumption of Iran has increased as one of the energy producing countries compared with the average global consumption. A main part of this consumption is for transportation sector with a 30% share in the energy consumption basket of the country.

Energy consumption in the world

Energy is a necessity of living and advancement, economic and social development of societies depends on having a permanent and certain access to energy resources. Currently, 1.1 billion people consume about 60% of the energy of the whole world in industrial countries and the share of 5.5 billion people is for developing countries and those countries with a low development use 40% of this energy.

Based on predictions stated in International Energy Outlook book, it is predicted that global energy demand during 2004-2030 amounts to 702 quadrillion BTU in 2030 from 447 quadrillion BTU in 2004 with a growth rate about 1.8 %. The most amount of growth in energy demand is for non-OECD countries.

In developing countries, consumption of petroleum and other non-renewable fuels is increasing. In some of these countries, non-commercial fuels (such as wood for providing food and heating houses) are used extensively.

Today, diesel generators (distributing generators such as photovoltaic systems) are used to prevent from destruction of forests and plants by rural population. This is seen mainly in Africa and South and Central America and south of Asia [International Energy Outlook, 2004].

Because of the necessity of substructure for development, using natural gas in developing countries does not depend on the extension of using this fuel in industrial countries. Therefore, it is not expected that using natural gas in developing countries is as high as demands for other energies. Iran is one of the wealthy countries of the world. It is the third grade of the world in the volume of petroleum stores and the second grade in the volume of gas stores. This country uses a high part of its produced gas and petroleum domestically. This is not only common in Iran, but also in other petroleum producing countries of the Middle East. Studies show that in most petroleum producing countries of the world, petroleum is the main energy resource and this can have a high effect on the volume of consuming this energy resource.

Consumption of energy carriers in Iran during 2002 to 2006

Consumption of main petroleum products (liquefied gas, gasoline, kerosene, gas oil and fuel oil) has grown about 4.6% per year on average during 2002-2006 in Iran. During this period, the highest growth of products was for motor gasoline with 9.8% and the lowest one was for kerosene with -4.4%. Development of electricity and gas networks in the country and more households having access to these carries have made consumption of kerosene decrease during recent years. Some regions of the country not having access to natural gas and using gas oil for fuel of their heater and heating water are the main reasons of increasing in gas oil consumption. Increases of vehicles in recent decade, the high average life of vehicles and as a result, their low efficiency and the high average fuel consumption of domestic vehicles due to low technology used in producing them are main reasons of increasing consumption of gasoline in transportation sector. In 2006, consumption of main petroleum products amounted to 86307 million liters with a growth of 7.7% compared to the previous year. In this year, the highest share of petroleum products belonged to gas oil and gasoline and the lowest share was for liquefied gas.

Consumption of energy carriers in transportation sector of the country during 2002 to 200

Gasoline

The main gasoline consuming part in the country is transportation sector that has a share more than 99.2%. Increasing in automobile production and demands in the recent decade, also the high average fuel consumption of domestic vehicles due to low technology used in producing them are the main reasons of increasing consumption of gasoline in transportation sector. Examination of gasoline consumption in various months of the recent years shows that the highest consumption of gasoline has been in August and February which is due to summer and the end year trips.

Gas oil

Gas oil is used in different sections. In transportation sector, it is used as the fuel of diesel motors. The main section using gas oil in the country is the transportation sector which accounts for 53.7%. In 2006, consumption of gas oil amounted to 31429 million liters with a growth of 9.6% compared to the previous year. Examining the trend of monthly consumption of gas oil, it is seen that consumption of gas oil increases in cold months of the year and one of the main reasons of this point is some regions of the country not having access to natural gas and using gas oil as the fuel of their water heating devices.

Fuel oil

The most important consumers of fuel oil are plants covered by ministry of energy. In transportation sector, fuel oil is used as the fuel of ships. During 2002 to 2006, consumption of fuel gas has decreased in this sector, so that the average annual reduction was -6.4% during this period.

Liquefied gas

Liquefied gas is mainly used in villages not being equipped with gas piping network or those cities not still having gas piping facilities. In 2006, consumption of liquefied gas amounted to 2830000 tons with 1.5% increase compared to the previous year. In this year, consumption of liquefied gas was 193000 tons in transportation sector that is 6.8% of the whole consumption.

Final consumption of energy carriers in transportation sector of Iran and comparing it with the world and the Middle East

The sector of transportation has the second grade in the amount of energy carriers' consumption after household-commercial sectors and has the first grade in the value of the consumed energy to prices of the Persian Gulf region and the international prices. This is due to consumption of the fuels gasoline, gas oil and LPG in transportation sector of the country.

As it is seen in table 11, the final consumption of natural gas in transportation sector in the world has increased from 2001 to 2005. The average growth of final consumption of natural gas was 7% in this period. In this period, Iran has had the growth of 42%. The whole consumption of natural gas in the Middle East region is for Iran. In 2005, the share of natural gas consumption in transportation sector of the country is 0.35% in the world.

According to table 12, it is seen that the final consumption of petroleum products in the world, in the Middle East and in Iran has grown 4.6, 9.9 and 6.3% on average, respectively during 2001 to 2005. It is also seen that in 2005, the share of final consumption of petroleum products is 1.7 and 32.6% respectively for transportation sector of the country and the world.

RESULTS & DISCUSSION

Results and presenting procedures and suggestions

The existing statistics and the relative growth of 6.3% in the annual energy consumption in transportation sector of the country show a specific importance and attention to management of energy consumption in this sector.

Energy consumption in this sector is after household and commercial sectors in the amount and has the highest share of consumption in financial value. A very high growth of high consuming vehicles produced in the late 1991 and 2001 has caused high amounts are expended for importing motor gasoline from financial resources of the country. Consumption of natural gas in transportation sector in two recent years has grown to 77%. During the six year interval studied, consumption of liquefied gas in the sector has decreased to 29% and consumption of the fuel oil has decreased to 27%. Consumption of gas oil in this sector has increased about 20% and consumption of motor gasoline has increased to 61% in the mentioned interval. The general trend of energy consumption in transportation sector shows that the growth of energy consumption has decreased from 8.24% in 2002 compared to 2001 to about 5.8% in 2006 compared to the previous year. This decrease can be the beginning point of

movement and the necessary interventions for optimizing energy consumption. In recent years (2002 to 2006), the growth of consuming these products varied between 9 to 11%. Therefore, importing motor gasoline is one of the necessities and as a result, the country is in intensive financial and operational limitation, so that after many years, partitioning and distributing gasoline through intellectual cards have been proposed to be able to help the economy of the country. The consumption of this product in 2006 has increased about 9.7% compared to 2005. Another considerable point is that despite the average life of gasoline vehicles in the country has decreased, technology of new produced vehicles is further than the current technology of the world and this has made the criteria of consumption in the vehicles produced by the country be much different from the average similar samples in European countries, so that some vehicles produced in the country have a double consumption than the similar class produced by other countries. It is necessary to consider the following procedures for reducing energy intensity in transportation sector according to high consumption of liquid fuels in this sector:

1.4 Balancing supply and consumption of fuel

This belief is common in the world that finally, fuel consumption in transportation sector is equal to supplying all kinds of fuels and there is no doubt that non-balance between consumption and supply is a negative factor. All of factors effective in non-balance between supplying and demanding energy must be identified and according to the intensity of effects of any of these factors, the necessary interventions should be done to use the effects of those factors. No country in the world has any experience based on which only using a method, balancing supplying and demanding energy is obtained. So it is necessary to identify all factors. The general methods of balancing consumption and supply are as follows [Khalatbari, Firouzeh, Dr., 2007]:

a. Consumption management

Consumption management is one of the important branches of policy making for adjusting the balance between supply and demand. In consumption management, the following points must be noted:

- Limiting energy consumption must not exclude people of a generation from their fair share relative to energy resources.
- In process of energy consumption management, it is necessary to make a position in which people don't lose their welfare.

- No management method destroying natural capital is acceptable. The effect of selective policy on the environment must be identified and measured.

b. Supply management

In this part, the following methods are used:

- increasing the amounts of gasoline and super fuels received by any barrel of petroleum
- supplying any alternative fuel that automobile manufactures can use
- improving energy consumer instruments extensively (including setting procedural plans for optimizing energy consumption in transportation sector, making standards and legal prevention from entering non-standard vehicles to the market, widely informing buyers and providing insights about benefits of vehicles through enacting various standards)
- changing mechanism of creating movement power in vehicles through replacing ignition mechanism by other mechanisms
- increasing effectiveness of all fuels using new technologies
- presenting financial aids to research organizations active in replacing fossil fuels

procedures implemented for reducing fuel consumptions of vehicles

- on-time engine tune-up and repairing and maintaining vehicles
- replacing air filter on time and using standard air filter
- using fuels according to level of technology and requirements of the automobile
- proper speed and the correct way of driving
- driving with proper gears
- on-time prediction of situations and conditions during driving and prevention from unnecessary acceleration
- avoiding from unnecessary stops
- changing engine oil on time
- adjusting tire pressures
- preventing from carrying overload
- preventing from overflow of gasoline during fuel taking
- parking the automobile in a suitable place in various seasons of the year (indoors, shadows, etc)
- using auxiliary equipments properly (cooler, heater, etc)

One of the most interventions for reducing energy consumption and release of its pollutants is reducing or removing subsidies. However, removing subsidies is a political issue and has economic and social outcomes. Therefore, it needs

a planning and a cautious enforcement. The government pays amounts annually for subsidies in energy sector of the country. This is in conditions where the share of high income class of the society is higher than the low income class for energy subsidies. However, only by maintaining the environment and issues like this, one can not adopt removing energy subsidies. Removing energy subsidies is not currently possible due to the existence of social and economic effects and also political tensions in the society. Therefore, more reasonable procedures such as making subsidies purposeful and increasing energy efficiency in various energy consuming sectors must be found.

Generally, energy planning must include aims of producing and consuming it in middle and long terms. Policies of energy demand must promote reasonable consumption and consumption patterns aiming to increase relying on native resources. Therefore, it is suggested to use all existing economical and technological interventions for energy economy to reduce energy demands without preventing from economic development.

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Table 1. Energy carriers consumption in Iran during 2002-2006⁽¹⁾ [Energy Balance, 2007]

year	Natural gas	Gasoline	Kerosene	Gas oil	Fuel oil	total
2002	4355	18440	8683	25880	14771	72128
2003	4305	20538	7889	26234	13601	72567
2004	4199	22159	7753	27348	13740	75200
2005	5032	24396	7531	28669	14486	80115
2006	5107	26867	7234	31429	15669	86307
The average annual growth (%)	4.4	9.86	-4.4	5	1.6	4.6

(1) Exception refinery use

Table 2. The share of energy carriers in Iran during 2002-2006 [Energy Balance, 2007]

year	Natural gas	Gasoline	Kerosene	Gas oil	Fuel oil	total
2002	6.04	25.57	12.04	35.88	20.48	100
2003	5.93	28.30	10.87	36.15	18.74	100
2004	5.58	29.47	10.31	36.37	18.27	100
2005	6.28	30.45	9.40	35.79	18.08	100
2006	5.92	31.13	8.38	36.42	18.16	100

Table 3. Gasoline consumption in Iran during 2003-2006 [Energy Balance, 2007]

year	Gasoline consumption in transport sector (Thousand liters)		The share of gasoline in transport sector(%)	
	Road and air transport	shipping	Road and air transport	Shipping
2002	18239929	26300	98.91	0.14
2003	20324287	26156	98.96	0.13
2004	21934586	29487	98.99	0.13
2005	24179207	34463	99.11	0.14
2006	26669302	39477	99.26	0.15

Table 4. Average gasoline consumption in different months in Iran during 2002-2006 (Million liters per day), [Energy Balance, 2007].

Month	2002	2003	2004	2005	2006
March	46	51.9	57.5	63.5	71.1
April	47.7	52.5	58.2	62.7	70.5
May	48.3	54	58.8	66.3	71.6
June	51.2	56.9	61.4	69	75.1
July	52.7	58.8	64.6	70.3	77.6
August	54.5	60.7	65	72.8	80.4
September	52.2	58.5	62.7	67	71.3
October	51	55.3	58.4	65.9	74.4
November	48.4	55.2	60.6	66.8	72.6
December	49	54.2	58.9	64.1	70.3
January	50.9	58	58.6	64.9	71.4
February	54.6	59.6	63.3	71.2	77.2
Average	50.5	56.3	60.7	67	73.6

Table 5. Gas oil consumption in Iran during 2002-2006 [Energy Balance, 2007].

year	Gas oil consumption in transport sector (Thousand liters)		The share of Gas oil in transport sector(%)	
	Road and air transport	shipping	Road and air transport	Shipping
2002	14753247	300568	57.01	1.16
2003	14825192	344098	56.51	1.31
2004	15413410	389015	56.36	1.42
2005	16321319	440980	56.93	1.54
2006	16407472	475239	52.20	1.51

Table 6. Average gas oil consumption in different months in Iran during 2002-2006 (Million liters per day), [Energy Balance,2007].

Month	2002	2003	2004	2005	2006
March	54.9	61.9	58.2	62.7	63.2
April	64.6	67.8	70.5	73.3	77.7
May	64.8	65.8	70.6	75.7	79.2
June	66.2	69.5	71.4	73	78.8
July	66.5	67.3	69	73.9	78.8
August	65.6	68.5	70.2	75.7	79.6
September	67.3	70.6	75.4	82.7	83.9
October	76.2	74.5	76.8	86.6	83/7
November	79	79.1	85.2	90.1	100.8
December	84.1	82.2	90.5	86.5	103.9
January	79.5	78.6	83.9	87.1	94.4
February	82.9	79.8	79.1	87.2	95.6
Average	70.8	72	75	79.4	84.8

Table 7. Fuel oil consumption in transport sector in Iran during 2002-2006 [Energy Balance, 2007]

year	Fuel oil consumption in transport sector (Thousand liters)	The share of Fuel oil In transport sector (%)
2002	647005	4.38
2003	624568	4.59
2004	592941	4.32
2005	594157	4.10
2006	490687	3.13

Table 8. Average Fuel oil consumption in different months in Iran during 2002-2006 (Million liters per day), [Energy Balance, 2007]

Month	2003	2004	2005	2006	2007
March	32.1	25.8	28.3	33.6	27.8
April	37.7	31.1	30.5	35	33.9
May	37.2	27.1	29.6	32.5	28.2
June	36.9	32.7	31.9	35.7	28.5
July	33.5	32.2	31.3	35.1	31.5
August	32.9	29	31.4	32	31.7
September	34.4	30.1	33.1	33.6	34
October	37.6	32.9	33.1	41.1	34
November	45.6	46	48.2	44.9	48.9
December	47.8	55.2	56.7	61.5	44.9
January	51.5	56.7	50.6	62.2	48.2
February	49.2	51.4	47.8	42.2	36.9
Average	39.6	37.3	37.6	40.7	36

Table 9. Natural oil consumption in transport sector in Iran during 2002-2006 [Energy Balance, 2007]

year	Natural gas consumption in transport sector (Thousand liters)	The share of Natural oil In transport sector (%)
2002	317550	13.16
2003	293479	12.30
2004	271195	11.65
2005	235425	8.44
2006	193085	6.82

Table 10. Average Natural oil consumption in different months in Iran during 2002-2006 (Ton per day), [Energy Balance, 2007]

Month	2002	2003	2004	2005	2006
March	6707	6432	6195	6007	5858
April	6494	6484	6311	5840	5617
May	5899	6025	5869	5575	5354
June	5799	5952	5448	5314	5234
July	5846	5838	5675	5453	5174
August	6091	5982	5758	5605	5376
September	6280	6102	6149	5692	6227
October	6969	6756	6800	6856	6180
November	7238	7436	7277	6900	6805
December	7717	7478	7184	6849	6976
January	7260	7243	7040	6954	7001
February	7158	6807	6903	6390	6642
Average	6612	6537	6376	6111	6025

Table 11. final Natural gas consumption in Iran, Middle East and World in transport sector during 2001-2005 (Million cubic meters), [Energy Balance, 2007]

	2001	2002	2003	2004	2005	Average growth (%)
world	-	69560	74594	82517	86358	7
Middle East	-	5	7	7	304	42
Iran	-	5	7	7	304	42

Table 12. Energy carrier's consumption in Iran, Middle East and World in transport sector during 2001-2005 (Thousand ton), [Energy Balance, 2007]

	2001	2002	2003	2004	2005	Average growth (%)
world	1626389	1654789	1705119	1768743	1974517	4.6
Middle East	66022	73398	84274	95388	100649	9.9
Iran	25307	27280	28852	30549	32836	6.3