

# Investigation and Comparison of Energy Intensity in Iranian Transportation Industry (Case Study Road Transportation Sector)

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**Abstract**—Energy intensity(energy consumption intensity) is a global index which computes the required energy for producing a specific value of goods and services in each country. It is computed in terms of initial energy supply or final energy consumption. In this study (research) Divisia method is used to decompose energy consumption and energy intensity. This method decomposes consumption and energy intensity to production effects, structural and net intensity and could be done as time series or two-periodical. This study analytically investigates consumption changes and energy intensity on economical sectors of Iran and more specific on road transportation(rail road and road).Our results show that the contribution of structural effect (change in economical activities combination) is very low and the effect of net energy consumption has the higher contribution in consumption changes and energy intensity. In other words, the high consumption of energy is due to Intensity of energy consumption and is not to structural effect of transportation sector.

**Keywords**—Divisia Method, Energy Intensity, Net Intensity Effect, Road Transportation , Structural Effect.

## I. INTRODUCTION

THE considerable distance of energy consumption in our country with regard to common global figures which has imposed importing of some energy carriers too necessitates special attention to optimization of energy consumption in the country. In this regard transportation sector allocates a major percentage of the total consumed energy to itself so that consumption portion in this sector in the country amounts to 6.4 billion Dollars based on the global prices from 20.9 billion Dollars that is the cost of fossil fuels among different sectors. The highest portion of fuel consumption has been allocated to this sector after domestic and commercial purposes. Therefore, necessity of paying attention to the issue of energy consumption optimization along traffic and environmental issues is totally obvious in the transportation sector [1].

Level of energy demand in transportation sector is affected by various economic, legal and technological factors and structure of transportation. Evaluation of the operation level, energy intensity and effective external conditions on transportation are needed in order to study the role of energy

in transportation sector. Rail transportation has been one of the most common ways of transportation in different countries and has a special importance because of its low cost. Low fuel consumption in lieu of load and passenger is resulted in proper and systematic approach of decision makers based on preferring of this sector to other sectors of transportation in order to consider it as the basis for developing of the country's transportation sector.

On the other hand, developing of rail transportation must be proportional to important factors and parameters of the society so that its effects would be appeared well in the economy, growth and development of the country. Selecting of rail transportation sector as one of the subcategories of the country's transportation and the development axis of this sector and a bed for macro-economy development is subjected to factors such as macro-economy programs of the country, climatical condition, necessary investments for capacitation in each sector and capabilities of the country in financial and technical sectors. Given the low energy consumption in this sector, another characteristic of rail transportation is generating of lower pollution and its compatibility with the environment. So it is necessary to pay much attention to this sector of goods and passenger transportation because of its partial benefits than other transportation sectors.

We will examine level of energy saving in rail transportation in passenger and load carrying sector with regard to road transportation sector and also impact of rail transportation development with respect to road transportation on country's economy in this study while studying subjects like energy economy, transportation sector and energy consumption intensity. At last scientific and operational recommendations will be represented.

## II. ENERGY ECONOMY

Energy plays a fundamental role in industrial economy life of societies, it means that whenever energy is available promptly and sufficiently economic development will be feasible too [2]. It is one of the main factors of production in national production function of each country and has a significant portion in real growth of the economy. It determines its portion among other production factors such as work and capital given the determined price for it [3].

Variety and complexity of economical activities and considerable transformation and enormous changes exist in the production structure of a country have created a system that reinforces the need for exchanges among economic

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sectors and interdependency of economic activities [4]. One of the calculation methods for relative benefit of the country in energy field is applying of energy consumption costs index to total intermediate production costs in different economic sectors which has a special sensitivity in the multi-aspect world business in terms of specific importance of energy for all countries whether producer or consumer. About 36.2 percent of energy is used in non-production sector in Iran. In fact we can say that the existent benefit has not been applied towards production growth or export growth (www.ifco.ir). Statistical researches show that total demand of annual final energy was improved averagely 8.08 during a forty year period from 1968 to 2008, so that consumption of oil products had just 6.68% growth in this period [5]. It shows that the need for power plants and new lines of energy and oil transfer, building of new refineries and other capital equipments are an ineludible issue in case of continuance of such process.

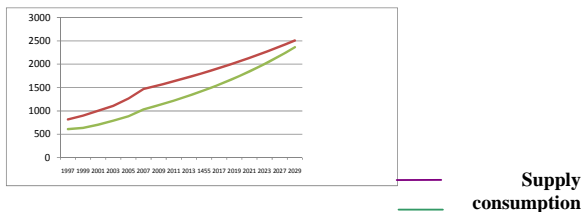


Fig. 1 process of demand and supply level of energy in Iran until 1986

Source: Iranian Fuel Conservation Company

General growth of energy consumption in the country during (1989 to 2008) has been accompanied by high rates of economic growth because of enjoying from empty capacities of the economy and its amount is equal to 8.06 annually. This is while value of gross domestic product of the country with regard to fixed prices in year 2008 during this 34 year period from 1973 to 2007 had been the average capita growth of energy consumption equal to 24.85 while average capita growth of gross domestic product was equal to 0.69 during that period. Energy balance sheet of Iran in 2007 shows about 900 tones of petroleum is consumed to generate one million Dollars of gross domestic income. The required energy to produce one unit of goods and services in Iran is 2.5 times average proportion of the Middle East, since average amount of such level of energy consumption to produce one million Dollars of gross domestic income in the Middle East is about 361.1 tones of petroleum. In other words, this consumption level is 3.5 times Turkey, 2.3 times China, 14.5 times Japan and 5 times of the global average [6].

Iran has a special importance as one of the main producers of oil and gas in the world. According to recent statistics, proved oil reserves of Iran at the end of 2009 has been 137.5 billion barrels and is placed in the second class after Saudi

Arabia having 264.3 million barrels. Proved gas reserves of Iran are equal to 28.13 trillion cubic meters that is in the second class after Russia having 47.65 trillion cubic meters. This amount of gas in Iran is equal to 176.49 billions of oil barrels. If we calculate sum of proved gas and oil reserves of Iran and the world in terms of the equivalent oil barrel, then Iran will have 314.44 billion oil barrels in its proved gas and oil reserves sector and Saudi Arabia has 312.73 billions of equivalent oil barrel, Russia has 379.22 billions of equivalent billion oil barrel and Iraq has 134.94 billions of equivalent billion oil barrel (www.niordc.ir).

### III. TRANSPORTATION SECTOR

Transportation sector is one of the important sectors of energy consumption in the country. This sector has averagely allocated

29.5% of the total final energy consumption to itself and is the second highest consumer of the country and the first sector in terms of financial value after domestic and business sector which consume about 40 percent of the total energy.[1] Also this sector is the largest consumer of liquid oil products with allocation of 55 percent of them. Consumption of oil products in transportation sector has an increasing growth during recent years so that 99 percent of gasoline and 53.7 percent of gas oil are consumed in transportation field [7].

TABLE I

VALUE ADDED RELATED TO ROAD TRANSPORTATION

Year	Value added related to road transportation	Transp ortation sector	Portion in transportation n	Porti on in GDP	Value added growth
1989	251	10651	2.36	.14	
1990	248.3	11473	2.16	.13	7.73
1991	241.7	12621	1.92	.11	10
1992	244.7	12621	1.94	.10	.01
1993	253.6	12939	1.96	.10	2.52
1994	288.6	15178	1.90	.11	17.31
1995	334.1	16804	1.99	.13	10.71
1996	370	18369	2.01	.14	9.31
1997	420.4	21228	1.98	.15	15.57
1998	447.8	21596	2.07	.15	1.73
1999	393.1	22093	1.78	.13	2.30
2000	443	25054	1.77	.15	13.40
2001	458.1	26218	1.75	.14	4.64
2002	507.6	27424	1.85	.15	4.60
2003	500.1	27113	1.84	.14	-1.14
2004	525.3	33283	1.77	.15	5.11
2005	542.1	38202	1.89	.15	3.19
2006	561.3	38843	1.70	.16	3.50
2007	587.6	42730	1.81	.16	4.68
Averag e	.13	1.91			

With due regard to the point that about 90 percent of the country's transportation is done through roads, value added portion of road transportation constitutes about 10 percent of the total gross domestic product. In other words, 10.5 percent of national domestic product's value added has been allocated to transportation sector that is more than 7 percent of job opportunities in the country. Given table 1 it is observed that portion of this sector is increasing both on macro level and in the transportation sector [8].

Among different phases of consumers of oil products, transportation sector allocates the highest amount of energy consumption to itself, so that figures related to year 2008 show that it has allocated about 40 percent of total oil products and 27.47 percent of total final energy of the country to itself.

Consumption of oil products in transportation sector is mainly related to transferring of goods and passengers that is done through heavy and light vehicles in road transportation. For instance, about 86 million liter of gas oil and 72 million liter of gasoline are consumed daily in country's roads and in the cities. Totally we can say that consumption of gas oil and gasoline has been exceeded from 7 percent of growth annually in country, while this figure for developed countries is 1.6.

TABLE II  
COMPARISON OF ENERGY CONSUMPTION IN TRANSPORTATION, DIFFERENT PARTS OF THE WORLD WITH IRAN 1992

Area	Energy consumption in transportation, million barrels of petroleum per day				Average annual rate of change	
	1992	2002	2012	2022	1992-2002	2002-2022
Industrial countries	21	25	31	35	2	1.6
America	13	15	19	23	2.1	2
Western Europe	6	7	8	9	1.8	1
Developing countries	7	18	18	29	5.2	4.8
Middle East	1	2	3	5	4.1	4.8
Iran	.26	.5	.98	1.5	6.5	7

Value added related to rail transportation reveals that average portion of this sector is 0.13 in the country and is 1.95 in transportation sector. Also, portion of this sector has increased during this period and growth of value added of this sector is averagely 7.05<sup>3</sup>[9].

#### A. Rail Transportation

Rail transportation is advantageous because of its 70 percent safety over road transportation, one sixth of fuel consumption than road fuel, compatibility with environment

<sup>3</sup>It is necessary to point that this sector can take action towards carrying of loads (loads like haematite, coke and etc) that road transportation sector doesn't show any tendency towards such loads.

and cheaper price with regard to other vehicles. However 90 percent of transferring of load and passenger is performed through road transportation network of the country and the remained 10 percent is done by means of rail, marine and air networks [10].

TABLE III  
VALUE ADDED RELATED TO RAIL TRANSPORTATION SECTOR OF THE COUNTRY

Year	Value added	Transportation sector	Portion in transportation	Portion in GDP	Value added growth
1989	251	10651	2.36	.14	
1990	248.3	11473	2.16	.13	7.73
1991	241.7	12621	1.92	.11	10
1992	244.7	12621	1.94	.10	.01
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2001	458.1	26218	1.75	.14	4.64
2002	507.6	27424	1.85	.15	4.60
2003	500.1	27113	1.84	.14	1.14
Average			1.91	.13	7.05

Source: National accounts of the Central Bank

#### B. Estimating of Energy Consumption in Rail Transportation sector

Given that the major part of fuel consumption in railway trains of the Islamic Republic of Iran is gas oil<sup>4</sup>, thus it is possible to exploit amount of fuel consumption from statistical year-books of Railway Company and exploit consumption level of each year from sum of gas oil consumption in electrical diesels, maneuver diesels and cranes.

TABLE IV  
AMOUNT OF FUEL CONSUMPTION (GAS OIL) IN RAIL TRANSPORTATION (MILLION LITERS)

Year	Consumption of gas oil	Year	Consumption of gas oil	Year	Consumption of gas oil	Year	Consumption of gas oil
1980	102	1987	139	1994	159	2001	207
1981	93	1988	163	1995	163	2002	218
1982	104	1989	160	1996	189	2003	225
1983	139	1990	160	1997	201	2004	242
1984	138	1991	210	1998	212	2005	244
1985	149	1992	166	1999	192	2006	267
1986	164	1993	162	2000	199	2007	303

Source: Railway Company of Islamic Republic of Iran

<sup>4</sup> In this research consumption of gas oil has just been studied.

TABLE V  
COMPARISON OF FUEL CONSUMPTION IN ROAD TRANSPORTATION WITH  
RAIL TRANSPORTATION

Year	Road Fuel Consumption (1000- liter)	Railway Fuel Consumption (1000- liter)	amount of fuel consumption in road(liter per 100 unit)	amount of fuel consumption in railway (liter per 100 unit)
1998	11864270	212155	10.74	1.034
1999	11582502	192313	10.69	1.052
2000	12223594	199201	10.38	.970
2001	13089750	107313	9.61	.973
2002	13674430	217591	10.50	.960
2003	14536785	225262	10.72	.922
2004	14582130	243062	9.36	.889
2005	15168109	245301	9.17	.870
2006	16053000	268000	9.30	.890
2007	16733000	286000	8.90	.860

Source: statistics journal of Railway Company of Islamic Republic of Iran, 2008- Iranian Transportation organization

With due attention to table 4 it is observed that in 2007 railway consumed 286 million liters of gas oil in lieu of carrying of 33091 million units. While in road transportation 16733 million liters of gas oil was consumed in lieu of carrying of 188071 million carrying units (estimated) and amount of 132070 million carrying units with statement. We can use the following proportions in order to prove benefits of railway over road transportation.

$$\begin{aligned} \frac{58/5}{5/7} &= 10/27, \quad \frac{16722}{286} = 58/5 \\ \frac{58/5}{4} &= 14/7 \\ \frac{188071}{22091} &= 5/7, \quad \frac{89}{8/6} = 10/2 \\ \frac{122070}{22091} &= 4 \end{aligned}$$

Comparison of obtained figures shows that road transportation carries load and passenger 5.7 times railway, but consumes 58.5 times fuel than railway. So we conclude that road transportation consumes fuel 10.27 times railway and if we want to exert this relation for the carrying unit with bill of lading, then obtained results reveal that road transportation in this case consumes fuel 14.7 times railway. On the other hand it could be said that road transportation consumes 89 cubic centimeters fuel for carrying of one carrying unit [11].

On the other hand, average cost for building of each kilometers of main road is 4000 to 8500 million Rials and for freeway is 1 to 35 billion Rials; while the cost for building of each kilometer of railroad is between 7000 to 10000 billion Rials.[6]. Also, field researches demonstrate that [12] the cost for building of a two-line railroad must be compared at least with a four-line highway.

So the required currency for truck is more than 4 billion dollars and for carrying by train is 62 percent of the recent figure. If building of one kilometer of a two-line railroad needs an investment equal to 500 thousand dollars, it is possible to build a two-line railroad of 3800 kilometers during 25 years with such saving.

### III. ENERGY CONSUMPTION INTENSITY

Energy intensity is an important index for evaluation of manner of applying of energy on macro level in the country. It shows how much energy has been used to produce a certain amount of goods and services. In order to calculate energy intensity we can divide final internal consumption of energy by gross domestic product. According to this, energy intensity in years 1968, 1978, 1988, 1998 and 2008 had been 0.57, 0.93, 1.02, 1.98 and 2.01 petroleum equivalent barrels respectively in lie of one million Rials of gross domestic product with fixed prices of year 1998 [13].

TABLE VI  
GROSS DOMESTIC PRODUCT, INITIAL ENERGY SUPPLY, FINAL ENERGY  
CONSUMPTION AND ENERGY INTENSITY

	Unit	2002	2003	2004	2005	2006	2007
Gross domestic product to fixed price of year 1998	Million Rial	330565	355350	379838	398234	419705	446880
Initial energy supply	Petroleum equivalent million barrels	1055.1	1105.6	1179.6	1268	1344.8	1468.15
final energy consumption	Petroleum equivalent million barrels	731.7	791.6	846.1	886	937.97	1034.82
Initial energy intensity supply	Barrel to million Rial	3.19	3.11	3.11	3.19	3.20	3.29
final energy intensity consumption	Barrel to million Rial	2.21	2.23	2.23	2.22	2.23	2.32

Although studying of energy in the period of 1968-2008 shows that this index has increased averagely with a growth rate equal to 3.7 percent per year but growth of the above index has been regulated during the two recent decades. It has been reached to 2.01 in year 2008 from 1.98 percent in year 1998 with annual growth rate of 1.2. Paying attention to phase model of energy consumption could be helpful for analyzing of energy intensity in Iran. Portion of domestic and business, industry, transportation and agriculture sectors in year 2008 have been 40.2, 28.6, 27.3 and 3.9 percent respectively [14].

Energy efficiency is the proportion of transformation of energy input in energy production technologies to the final consuming devices of energy. Energy intensity index is the subcategory of energy efficiency indices but it has a high correlation with it. It should be noted that economic growth is in relation with energy efficiency subject.

#### IV. RESEARCH METHODOLOGY

This research is of historical-documentary type and represents the appropriate model, solves it and then analyzes obtained results from solving of model through descriptive and investigatory method. Through figures and capabilities of rail and road transportation sector in transferring of load and passenger, portion of each one was determined in this research in Iran's transportation and possibility of displacement between sectors were studied and estimated. Amount of energy intensity of rail and road transportation was estimated with due regard to the current demand for fuel materials given the intensity of energy consuming in transportation sector with regard to other sectors of the industry.

##### A. Research hypotheses

1- Rail transportation in comparison with road transportation has a high saving in energy costs.

2- Energy consumption in road transportation will be reduced by development of rail transportation.

##### B. Statistical population

Statistical population includes Ministry of roads and transportation, Railway Company of Islamic Republic of Iran and Iranian transportation organization.

##### C. Sampling method and plan

The applied data in this research are based on published statistics and information from Iran statistics center, Central Bank, Iranian transportation organization, Railway Company of Islamic Republic of Iran, Ministry of Energy and Oil Products Distribution Center. Given that data is not existed by segregation of each section in discussion related to added value we have necessarily used the time from when data was existed.

##### D. Sample volume and its method of calculation

Sample volume has generally been applied from year 1968 to 2008. Samples are variable in each discussion given the limitation of the applied statistics and information. For example, the starting year for analysis is from 1989, since data related to value added of rail and road transportation sector exists from this year onwards.

##### E. Data analysis method

We have tried in this research to analyze energy intensity through Divisia model. General principles of this model are as the following:

Decomposition issue in most studies of energy has two main attitudes. One of them is energy consumption attitude and the other is energy intensity.

In total consumption attitude we have:

(1)

$$\Delta E_{tot} = \Delta E_{out} + \Delta E_{str} + \Delta E_{int} + R$$

That

$\Delta E_{tot}$  is change in energy consumption or productive effect from the basis year to the current year

$\Delta E_{out}$  is change in total energy consumption by change in activity level or productive effect

$\Delta E_{str}$  is change in total energy consumption by change in combination of economical activities or structural effect

$\Delta E_{int}$  is change in energy consumption by change in energy intensity or net intensity effect

R is the hysteresis term

In the attitude related to total energy intensity, the aim is to analyze structural effects and net intensity related to total energy intensity. In this attitude we have:

$$\Delta I_{out} = \Delta I_{str} + \Delta I_{int} + R \quad (2)$$

In which:

$\Delta I_{out}$  is the difference of energy intensity in the current year and basis year

$\Delta I_{str}$  is change in energy intensity as a result of economical activities or structural effect

$\Delta I_{int}$  is change in energy intensity resulted from net intensity factor

R is the hysteresis term

Decomposition studies related to the two approaches is performed in two ways in terms of time:

A: two periodical or two-series method: in this case, decomposition is done based on production and consumption data related to two years including basis year and current year and data related to middle years is neglected.

B: time series analysis method: decomposition in this method is studied annually and done continuously for all years. We calculate changes of total consumption or total energy intensity of this period by paying attention to one year as the basis year and regulate the required information in a time-series form.

Since there are different methods for estimating of main models of decomposition, it is necessary to select the best solution based on a suitable criterion through comparing of estimated results of each solution and consider is as a basis for

decision making and studying. Sum of squares of hysteresis is one of the best criteria [15].

Energy decomposition in Divisia analysis method is done according to four total methods of Laspiers, Pashe, simple average and weight regulation [16]. The best energy decomposition has been done in the model that has the lowest hysteresis squares. Therefore, we will study all methods in each case and select the one which has the lowest square of hysteresis effect as the best solution for decomposition of energy consumption and intensity. Total structural and productive effects and net intensity effect are calculated separately for calculation of changes in energy consumption (energy decomposition) based on formula (1). Also, the hysteresis effect is estimated by formula (1). Hysteresis effect was obtained by subtracting of total structural and productive effects and net intensity from the total effect and at last all solutions of Divisia were executed. The solution that had the lowest squares of hysteresis effect described decomposition of energy consumption well.

## VI. CONCLUSION AND RECOMMENDATIONS

### A. RESULTS OBTAINED FROM ENERGY INTENSITY ANALYSIS

By analyzing of the obtained results we conclude that energy intensity of transportation industry especially in road transportation sector is high in comparison with other industries. This is because of oldness of transportation fleet and using of old fleet with high consumption. On the other hand we can refer to low price of energy in Iran which is resulted in reduction of goods and services' cost price from one side and on the other side is irregular and irrational dissipation and consumption of energy in the country that more programming should be done about it. Such energy dissipation has been resulted in increasing of energy consumption and consequently energy intensity.

Results obtained from decomposing of consumption and energy intensity in Iran's road transportation sector illustrate that structural effects of total energy intensity have had very low figures and portion in the studying period. Net intensity during the whole studying period has had predominant portion in total energy intensity and this portion has been maintained until the end of the period. Thus we can say that total energy intensity is a relative complete index from energy efficiency during the studying period in Iran's economy and applying of total energy intensity in analyses regarding energy efficiency is close to reality to a high level by means of primary information of total energy intensity. Studying of annual growth rate of total energy intensity, structural effects and net intensity determine the manner of economic activities' orientation in terms of energy consuming. Energy consumption growth is positive in the country and it shows that energy consumption is increased along with economic growth. During years that production or GDP had reduced the negative relation between reduction of national production had been accompanied by very insignificant reduction of energy consumption. This refers to very low final productivity of energy factor during the studying years. Also, during such

period it is observed that energy consumption was reduced or remained stable by increasing of national production in Iran.

High energy intensity doesn't always show low efficiency in applying of energy, since some countries have a high percentage of energy consuming industries in their economy sector. Therefore, their energy structure is energy consuming and it has high energy intensity that energy consumption decomposition analysis must be done in order to better studying of energy efficiency.

According to performed studies it is concluded that portion of energy consuming sectors like industrial activities and transportation in Iran are averagely 29 and 8 percent respectively and have very low growth rate of 0.5. The conclusion is that no tangible attitude has been done towards these sectors. Energy intensity in the 1980's in Iran had average growth of 7 percent and it had been about 3 percent during the whole studying period. Thus we can say that energy intensity growth especially in the 1980's wasn't resulted from improving of activities of energy consuming portion or structural effects, rather it's because of energy efficiency that was observed in the process of net energy intensity.

Results of this research show that total energy intensity of transportation sector is high with regard to other economic sectors. This difference has been increased with regard to first years of study. Productive effect of 57 percent and net intensity effect of 38.5 percent form total energy intensity in this sector. Also portion of structural effects is about 0.1.

Results obtained from energy consumption decomposition reveal that consuming of energy has been increased during the studying period in sections under analysis. All diagrams in which added value method has been used in energy consumption decomposition show that productive effect of energy consumption during recent years of the studying period has more portions in describing of energy changes. This illustrates that economic growth has been resulted in increasing of energy consumption during these years. Also, net intensity effect has a lower portion than productive effect during recent years of the period which reveals decreasing of energy intensity consumption and higher productivity of energy during these years.

Structural effect has a very low portion in describing of consumption changes and energy intensity in all diagrams. This shows that no structural effect has been occurred in economic sectors of the country and even in transportation sector.

In analyses that person-kilometer and tone kilometer methods were used to decompose consumption and energy intensity it was shown that energy consumption had been too efficient in loading sector of road transportation, i.e. more consumption of energy causes moving of more load than energy consumption in this sector. Similarly, results related to passenger sector of road transportation demonstrate that productive effect plays a very predominant role in explaining of energy consumption changes. Energy consumption

intensity is decreased by applying of the above assumption with regard to the beginning of the studying year.

About energy consumption and production of various pollutants it must be pointed that transportation is considered among those sectors that have the highest amount of fuel consumption and as a result producing of pollutants is high in it. Information shows that  $NO_2$ ,  $SO_2$  and  $CO_2$  are produced in road sector more than 6.5 times in railway.

#### *B. Results obtained from statistical data analysis*

Results obtained from comparison of secondary statistical data reveal that road transportation allocates the highest portion of fuel consumption to itself with 61.6 percent totally given that consumption of gas oil and gasoline in fossil fuel products are the most major consumptions in the country. Statistics confirm 25 percent of total produced energy of the country is consumed in transportation sector and this states that the government pays three billion Dollars as the gasoline subsidiary each year and this credit volume is ten times the total budget of rail transportation sector.

Also in comparing of all kinds of transportation about fuel consumption it is determined that just 2 percent of gas oil consumption of the country has been allocated to rail transportation in Iran.

By calculating of the above statistics and obtained results of data analysis it is perceived that 30 liter of fuel will be saved in rail transportation sector for transferring of each one thousand tone-kilometer of load. Through this 480 million liters of fuel will be saved each year by paying attention to the current volume of load transferring in the country that is equal to 16 billion tones.

Comparison of fuel consumption in rail sector with other sectors of transportation shows that under equal conditions rail transportation consumes fuel 10 percent lower than bus, 30 percent lower than minibus, 75 percent lower than car and 85 percent lower than airplane. This is while amount of passenger and load transfer in each train traffic will be more than any other types of transportation since each train transfers about 600 passengers and load under favorable conditions; but airplane transfers about 300 in its highest capacity, bus transfers about 60, car transfers 4 and minibus transfers 20 persons.

On the other hand, traversed person-kilometer amount by private and public vehicles show that undoubtedly fuel consumption of public vehicles will be economic because of carrying of more passengers and investment on them will earn more productivity for the country.

Comparison of thermal value of the consumed fuel per one thousand persons-kilometers of transfer (BTU)<sup>5</sup> in Iran illustrate that automobile, bus, minibus, airplane and

passenger locomotive have fuel value of 157, 49.7, 63, 272.5 and 46.7 BUT per one thousand passenger respectively.

It could be simply perceived in these statistics that value of fuel in passenger locomotive is the highest and bus and minibus are in the successive classes. Airplane has a more expensive fuel in comparison with all kinds of transportation.

Studying of fuel consumption per one kilometer of transfer in liter scale shows that transferring of each person in rail sector has fuel saving of 0.5 milliliter than bus, 3 milliliter than minibus, 21.7 milliliter than car and 41.7 milliliter than airplane. Importance of this issue will be increased when we know that sixty-eight thousand and five-hundred and fifty (68550) million persons-kilometers have been transferred during 2007 in rail and road public transportation.

About pollution of all types of transportation in lieu of equal carrying of load and passenger road transportation had eight times more pollution than rail transportation. Eliminating of each kilogram of  $NO_2$ ,  $SO_2$  and  $CO_2$  pollutants will have costs equal to 19272, 2640 and 72.6 for the society, so rail transportation with its abundant benefits has been considered as the green transportation. By comparing of rail and road transportation in terms of safety component we can simply find out that there is no doubt about rail transportation priorities, because about 27000 are killed in road accidents each year based on current statistics and more than 200000 are injured and become disabled. In addition to specific psychological and social issues, this imposes a heavy loss on the economic sector of the country. According to current statistics, number of accidents and the deceased related to road transportation in the country is still the second main reason of mortality in spite of intensification of controls and reduction of that in recent months. Rail transportation accidents during the ten recent years (1999-2010) don't even have one killed person among its passengers and holds the record in this aspect too. Killing of sixty five in this sector has been related to slummers and passers from railways who have not observed railways limits.

Rail transportation development in Iran is too valuable for the country in fuel consumption sector in addition to studied numerous benefits in the past that it could be resulted in retrieving of structure costs during long years of exploitation. On the other side, electrising approach of railways in developed countries is a new window that will be resulted in minimization of low fossil fuel consumption in rail sector in Iran and this sector will become the most economic sector which is economical for transportation of the country. With due attention to what has been mentioned, we can conclude that saving of energy in rail transportation is more than road transportation and development of rail transportation is more effective for the economy of the country than road transportation.

#### *C. Recommendations*

Despite passive approaches in recent years towards transportation subject, we have observed again that rail

<sup>5</sup> Is the usual measurement unit for comparison of fuels and its amount is equal to the required energy to increase temperature of one pound of water to about one degree of Fahrenheit.

transportation has always been encountered with loss of credit in spite of numerous benefits. So it could never reach to a suitable level in discussion about substructures and fleet and whenever benefits of this sector are mentioned just a reference to its cleanness and safety has been made and less attention has been paid to processing of other benefits of it. The following recommendations are mentioned given this issue and above conclusions:

With due attention to the point that transportation sector of the country grants itself more than one third of energy subsidiary, so it is better that orientation of energy subsidiary leads towards increasing of energy productivity in this sector and prohibits any energy dissipation in production, distribution and consumption of energy through gradual subsidization of costs and executing of codified programs.

Determination of load and passenger transfer portion in the future outlook of the next two decades in lieu of each transportation sector, developing of transportation networks with due regard to this portion

Implementing of modern technologies for developing and offering of various services in load transportation in economical and industrial poles and passenger transportation in population poles of the country

Increasing of rail substructures and electrising of the rail network and optimized and appropriate utilization of minimum possibilities in rail transportation

Strengthening of the existent organizations in the field of energy productivity and enhancing of their position on the government level

Taking action towards compiling of standards of energy consuming equipments and energy consumer processes of transportation sector

Executing of operational programs in order to prevent from energy consumption growth in public and private sectors

National investment and supporting from enhancement of energy productivity index in transportation sector

Approving of clear rules and regulations with encouraging and punitive approach in energy consumption in transportation sector

Compiling of a collection of standards and criteria in the field of energy consumption in transportation sector of the country.

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