Iranian Economic Review, Vol.16, No.32, Spring 2012

An Analysis of Energy Consumption in Transportation and Industrial Sectors- a Multiplicative LMDI Approach with Application to Iran

Ebrahim Hosseini Nasab *
Robab Aalami **
Shermineh Foroughi Dahr ***
Mohammad Amin Sadeghzadeh ****

Received: 2012/2/21 Accepted: 2012/5/30

Abstract

Traditionally, there have been notable differences among accounting systems for tracking economy-wide energy efficiency trends. Quite recently, attentions are directed to formal studies that can meet the need for uniformity in the design and application of such systems. Uniform systems can give us better insights into energy efficiency indicators. In this paper, the multiplicative Logarithmic Mean Divisia Index (LMDI) decomposition technique is introduced and applied in an analysis of energy use in Iran. The aim of the following investigation is to find out what causes the changes in energy use in Irans industrial and transportation sectors. The data of this work consist of final energy use over the 2001-2006 periods from annual energy balance sheets and sectorial values added from Input-Output tables over the same years. The obtained results show that energy consumption changes are determined by the activity levels. Next among the significant energy consumption determinants are structural and energy intensity impacts.

Keywords: Decomposition, Energy Efficiency, Industry, Multiplicative LMDI, Transport

1- Introduction

Iran's ultimate energy consumption pattern over the last decades is inefficient and contributes towards the excessive consumption of fossil fuels which produces several quantities of pollutants and green house gases. Low

---

* Associate Professor, Department of Economics, Tarbiat Modaress University, Tehran, Iran.
** M.A. Student, Department of economic Development and Planning) AllamehTabatabaei University, Tehran, Iran.
*** M.A. Student, Department of Energy Economics, Tehran University, Tehran, Iran, (Corresponding Author).
**** M.A. Student, Department of Economics, Tehran University, Tehran, Iran.

price of energy and high subsidies represent an effective incentive for inefficient energy consumption pattern and accelerate energy consumption and environmental pollutions.

The process of economic development in the developing countries has involved a strong growth of energy demand over the last 50 years. As in most of the industrialized countries, these countries had to reduce energy requirements due to rising energy prices following the energy crisis in the 1970s.[1]

In Iran, Energy Planning office in Ministry of Power establishes an energy balance for Iran annually and recently Ministry of Petroleum has decided to establish an annual hydrocarbon's energy balance for Iran.

The most used energy carriers in this sector are gasoline and gas oil with total consumptions of 146.45 and 104.27 MBOE which is almost 95 percent of total energy consumption in Iran's light and heavy duty fleets. Light duty vehicles (LDV) fleet constitutes 99% of gasoline consumption in transportation sector. The next two carriers in this sector are aviation fuels with near 7.36 MBOE (2.37 percent of total) and fuel oil with 3.5 MBOE (1.32 percent of total) of energy consumption. The other energy carriers which consist the remaining 1.28 percent of total consumption of this sector are CNG (3.22 MBOE, 1.22%) and LPG (0.15 MBOE, 0.06%).

Consumption of natural gas was 77 percent more than the same amount in the last year due to current policies in conversion of public vehicle to CNG fueled.

The number of natural gas vehicles in Iran is 367000 (ranked 6th in the world) and 264 in-operation CNG refueling stations are established up to Oct. 2007. In the recent years, CNG is implemented and developed as a major alternative fuel in Iran.[2]

Petroleum products consumption has experienced an average annual growth rate of 2.5% in Iran.

Gasoline has maximum annual growth rate of 10%. According to the performed researches, and based on the historical trends of gasoline, main reasons of high gasoline consumption in Iran are as follows:

1- Joberta, T., Karanfilb, F., (2007).
2- Institute for International Energy Studies.

A. in Iran, price of gasoline is too low.

B. there is no policy for setting goals on fuel prices.

C. incompatible growth rate of sale prices with growth rate of international prices (imports), caused subsidies to increase sharply.

D. Iran's economy has intensived dependency on fuel prices which caused fear to higher price setting.

E. Automobile manufacturing has had large growth rates in the recent years and number of vehicles has increased.

F. the technologies of manufactured vehicles and motorcycles are too old, thus the average fuel consumption of most of the new-manufactured vehicles is too higher than same classes in other countries of the world (state-of-the-art vehicles).

G. new products can not pass the existing standards.

H. average age of Iran's LDVs is more than developed countries, whereas it has decreased in the recent years.

In addition there are some other important and effective factors which are not directly derived from historical trends analysis:

A. Undeveloped and weak public transportation.

B. Departure of rural inhabitants and increasing population of big cities that have increasingly resulted in transportation demand.

C. Lack of appropriate rules and regulations in order to decrease the number of single-passenger vehicles.

After gasoline, gas oil has a large amount of consumption with annual growth rate of 3%. It should be considered that this product is consuming in several various sectors like industrial, agricultural, power plants and transportation which result in high gas oil consumption in Iran.

The transportation sector by about 26 percent of ultimate energy consumption has the second place, but from the economics point of view and value of total energy consumed in this sector, it stands in the first place. Therefore, consideration on fuel conservation policies is of vital importance in this sector. The basic energy carriers in this sector are gasoline and gas oil, and other carriers, such as aviation fuels (ATK, JP4), fuel oil (for ships), LPG and natural gas (CNG) are being used by this sector. The industrial sector by about 23 percent of ultimate energy consumption has the third place. The basic energy carriers in this sector are natural gas, electricity and fuel oil, and other carriers such as gas oil, coal, LPG, kerosene and gasoline are being used by this sector.[1]

Energy efficiency and reduction in operational costs are becoming critical in the energy intensive industry. Energy efficiency is defined as the ability to generate the same economic output with less energy input. There are various motivations to improve energy efficiency. The more reduction the energy use the lower the energy costs and it may result in a financial cost saving to consumers if the energy savings offset any additional costs of implementing an energy efficient technology.It is also observed that Reducing the energy use is a key solution to the problem of reducing greenhouse gas emissions. According to the International Energy Agency, improved energy efficiency in buildings, industrial processes and transportation could reduce the world's energy needs in 2050 by one third, and help control global emissions of greenhouse gases. There are various motivations to improve energy efficiency. For these reasons many countries have prioritized to undertake studies for tracking economy –wide energy efficiency trends on a regular basis and directly address policy questions that bear on economic competitiveness, energy security, and environmental sustainability.

Since the early 1990s, a number of accounting systems for tracking economy-wide energy efficiency trends have been proposed. The objective has been to come up with energy efficiency indicators that can substitute for the traditional index of energy consumption to GDP ratio. There are wide variations among these accounting systems, reflecting differences in their analytical framework and the way they measure and report performance. One reason for this variation may be because these accounting systems are essentially developed by different scholars with little formal collaboration. Application of different accounting systems will lead to different numerical results and levels of achievement in energy efficiency improvement even though the data set used is the same. The issue calls for the need to undertake comprehensive studies though using a standard accounting framework that will help to ensure consistency and transparency.

Tracking energy efficiency trends are rather multifaceted and in some specific cases quite intricate. It involves substantial efforts in system design

1- Institute for International Energy Studies ,(2006).

and development as well as in data collection. On the other hand, there is an urgent need for energy performance assessment in order to ascertain trends in energy use and see how much if any they are off target. The performance indices developed in the process give effective diffusion assist in raising public awareness of energy efficiency and enable incessant upgrading.

The methodological approach of this study is inspired by Park(1992). Park used a decomposition method to study industrial energy consumption in the Republic of Korea. In this study the domain of analysis was extended to evaluate the energy consumption in the industry and transportation sector of Iran.

Binay Kumer Ray and B.Sudhakara Reddy(2007) have found that energy consumption increase is highly influenced by activity effect which is always positive.

Wing[1] studies conflicting explanations for the decline in U.S. energy intensity over the last 40years of the 20th century. Decomposing changes in the energy–GDP ratio into shifts in the structure of sectoral composition and adjustments in the efficiency of energy use within individual industries reveals that while inter-industry structural change was the principal driver of the observed decline in aggregate energy intensity, intra-industry efficiency improvements played a more important role in the post-1980 period.

Pela et. Al [2] describe the current energy sector in Ecuador, its present structure, the oil industry, subsidies, and renewable energy, focusing on the evolution and reform of the electricity sector. They proposed increasing the utilization of NG and renewable energies to meet Ecuador commitments to the Kyoto Protocol.

Ghisi, Gosch and Lamberts[3] surveyed electricity end-uses in the residential sector of Brazil. They assess the actual scenario of electricity consumption and estimate electricity end-uses in the residential sector of Brazil for different bioclimatic zones.

Along with the above studies, some issues such as Energy Consumption in Transportation and Industrial Sectors have been the major concerns that

1- Wing, I, (2007).

2- M.R. Pela´ ez-Samaniego, M. Garcia-Perezc, L.A.B. Cortezb, J. Oscullod, G. Olmedo, (2007).

3- Ghisi, E., Gosch, S., and Lamberts, R.,(2007).

made human attention to focus on consumption changes in order to manage them.

This paper is a contribution to fill gap in the development and application of standard accounting systems and energy efficiency indices and for this purpose some essential concepts and methods of economy-wide energy efficiency accounting were examined and energy efficiency index is introduced that is often included in an energy efficiency accounting system. The present work leads to a calculation energy performance indicators, namely hypothetical energy and energy performance index that can be used in international comparisons and benchmarking. Afterward, compare the main features of energy efficiency accounting approaches and systems were compared and the computation of energy efficiency indicators are explained. Finally, an accounting framework commensurate was ellaborated with the “multiplivative logarithmic mean divisia index approach (LMDI)” in index decomposition analysis (IDA) and its desirable features[1] are described. Numerical examples are presented and some of the accounting issues ans most likely problems are highlighted.

2- Basic Concepts, Indicators and Terminology[2]

In proposing an energy efficiency accounting framework, one of the first issues is deciding on whether changes in energy consumption over time are to be measured by the difference or by ratio criteria [3]. The difference criteria is stated in physical units, while the ratio criteia is a dimensionless index. For example, assuming a country’s annual final energy consumption(for example Iran in 2006) increases from 938.2 MTOE (million tones of oil equivalent) to 1033.6 MTOE over a one year period, the difference measure gives a change of 95.4 MTOE while the ratio measure gives a change of

1- Different energy organizations use different LMDI-based energy efficiency accounting frameworks.
2- This section and the next draws on the methodological and conceptual discussions of Ang, B.W., Mu, A.R., Zhou, P.(2010), and Ang 2004 to whom we remain indebted. Our contribution mainly has been extending the domain of application to concentrate on energy consumption in Irans industrial and transportation sectors.
3- We use the term “ accounting framework ” in the same sense as Ang, B.W., Mu, A.R., Zhou, P.(2010) to refer to the analytical framework used in an energy efficiency accounting system . It is part of an “ accounting system ”that is operational and includes such other features as data requirements, data entry, and result generation.

10.17% of the consumption in the base year(2006)[1]. In the Index Decomposition Analysis(IDA) literature, factors contributing to a difference change in an aggregate are studied by stating the relevant variables or components in the additive form while in the case of a ratio change they are studied in the multiplicative form.

an index for tracking energy efficiency trends as a basic indicator in an energy efficiency accounting system is defined. The index is normally given as a weighted sum of changes in sub-sector(or end-use) energy intensities. Since energy efficiency is often taken as the reciprocal of energy intensity, it may be transformed to give an index for energy efficiency that is called Energy Performance Index (EPI) as a more general index. Unless otherwise specified, EPI is calculated in terms of energy intensity, i.e. a decrease in EPI implies an improvement in energy efficiency. EPI is closely linked to the ratio change in energy consumption. Its derivation often follows formulation that is expressed multiplicatively.

Another indicator is the energy consumption that would be if there were no changes in energy efficiency. The design of an energy efficiency accounting system is often based either on the difference measure or the ratio measure of energy consumption change.

3- Energy Efficiency Accounting Approaches and Systems

3-1- Accounting approaches

In this study a multiplicative LMDI energy efficiency accounting framework was designated using the Index Decomposition Analysis (IDA) approach.[2] In this approach , the economy is divided into several major sectors, for example: transportation, industrials and services with each further divided into sub-sectors(and where appropriate into finer end uses). The activity that drives energy consumption in a sub-sector and an indicator

1- Researcher Calculation.

2- Our proposed framework is based on multiplicative LMDI. For the differences between LMDI-I and LMD I-II(Logarithmic mean Divisia index decomposition method II) , see Ang (2004) and Ang et al. (2009) .

that provides a good measure of the activity level are identified[1]. Data on this activity indicator and on energy consumption are complied by each sub-sector and used together with a particular accounting framework to estimate EPI.

The ease of formulation is an attractive feature of multiplicative LMDI. The multiplicative LMDI formulae can be readily derived once the IDA identity has been specified. The multiplicative LMDI formulate contain logarithmic terms and the variables cannot have negative values. This is a limitation of multiplicative LMDI but in IDA negative values seldom occur. From the application viewpoint these practical advantages can be mentioned for multiplicative LMDI method. 1- Decomposition is perfect, 2- Multiplicative and additive decomposition results are linked by a simple formula so that there exists a simple relationship between multiplicative and additive decomposition, 3- Multiplicative LMDI possesses the additive property in the log form $\ln(D_{tot})=\ln(D_{x1})+\ln(D_{x2})+\ldots+\ln(D_{xn})$.

The basis of the IDA approach is the IDA technique (Ang and Zhang, 2000, Ang, 2004). It is used to decompose a change in energy consumption overtime in a sector into several predefined effects that determine the change. Energy intensity effect is one of them which is estimated based on changes in the energy intensities of the sub-sectors. The EPI for a sector is then derived from the corresponding intensity effect estimate. The aggregate estimate is given as the weighted sum (in the case of EPI) for all sectors.

The choice within the IDA approach has largely been between the LMDI and the Laspeyres methods (Ang, 2004). The LMDI method has two versions, namely LMDI-I- and LMDI-II The IDA approach is consistent with the use of either an additive or multiplicative accounting framework.

Both of these approaches are approximately related in some ways. As an example, consider the transportation sector which is broken down into a number of sub-sectors. There are three possible situation as to how the sub-sector activity indicators are defined: (a) all use the same measure, e.g. economic measure such as value-added, (b) all use different measures, e.g. physical measures in terms of weight, volume, units, etc., and (c) a mix of

1- Folloing Ang, B.W., Mu, A.R., Zhou, P.) we use the term “ activity ” to characterizes the driver of energy use in a sub-sector (or end use), such as passenger-kilo metres travelled in passenger transport and floor space area in factory buildings buildings.

economic and physical measures. In all these cases, both approaches can be applied to derive EPI. When the formulae for estimating the intensity effects are the same in both approaches, and this is quite a possibility, the same EPI will result. In addition, in the IDA approach, activity effect and structure effect can also be estimated for case (a) and for those sub-sectors having the same activity indicator for case (c). Since the IDA approach allows for formulation in either the additive or multiplicative form, it is more general than the unit consumption approach.

3-2- An Overview of Existing Accounting Systems

The industrial sector includes manufacturing and non-manufacturing activities such as mining and construction. Industry uses a large amount of energy to power a diverse range of manufacturing and resource extraction processes. Many industrial processes require large amounts of heat and mechanical power, most of which is delivered as natural gas, petroleum fuels and as electricity. In addition some industries generate fuel from waste products that can be used to provide additional energy.

Because industrial processes are so diverse it is impossible to describe the multitude of possible opportunities for energy efficiency in industry. Many depend on the specific technologies and processes in use at each industrial facility.

A sectoral clasification along the sectors in transport and industry are fairly common. Differences in industry tend to be greater than transportation, Since energy use in these sectors is dependent on geographical location and climate, different activity indicators may be used to represent drivers of energy use. There are several ways to enhance a vehicle's energy efficiency. Using improved aero-dynamics to minimize drag can increase vehicle fuel efficiency. Reducing vehicle weight can also improve fuel economy, which is why composite materials are widely used in car bodies (Kenneth A. Small and Kurt Van Dender , 2005)

Most accounting systems and studies use the IDA approach, and within that the multiplicative LMDI decomposition method is used more widely. The choice depends partly on the accounting approach and this has implications on how EPI is computed.

3-3- Desirable feature of an accounting system

In a study on the desirable properties of IDA methods, Ang (2004) points out the following criteria for evaluation: (a) theoretical foundation, (b) adaptability, (c) ease of use, and (d) ease of the result interpretation. Similarly, a good energy efficiency accounting system should be one that has a sound theoretical foundation and can sufficiently serve its intended purpose which in this case can capture the true economy-wide energy efficiency trends. In this issue and with respect to the desirability of an energy efficiency accounting system, two broad areas need to be addressed, i.e. theoretical foundation and usability.

The construction of EPI is related to the index number problem. Index number theory there for provides a basis that is appropriate for evaluation in accounting frameworks. The problem can be studied in the same way as that in the IDA literature and the evaluation criteria given in Ang (2004) remain relevant. These criteria include several tests of the desirability of an index number such as factor-reversal, time-reversal, proportionality and aggregation tests, which are applicable here. In addition, since changes in energy consumption can be analyzed additively or multiplicatively..

An important feature of an accounting system is the level of sector disaggregation. It has a direct impact on how sufficiently a system is able to capture real energy efficiency change. Theoretically, the finer the classification of the sub-sectors the better is the EPI estimate. The best level of disaggregation is dependent on data availability and quality in each specific situation, it cannot be judged in isolation. Other things being equal, an accounting system with a higher disaggregation level would be taken as more refined. Such a system could be more difficult to implement since more data are needed.

Some index numbers, such as the laspeyres index that is pertinent to the development of a robust EPI, are easy to use and the results given are easy to interpret, but does not satisfy all index number tests.

4- The Multiplicative LMDI Energy Efficiency Accounting Framework

In this method, a price index or quantity is used that considers the price and quantities as a continuous function of the time. These indices can not practically be calculated but could be approximated by chain indices. In this study an LMDI-II energy efficiency accounting framework using the IDA approach[1] is proposed. Because of some multiplicative LMDI attractive features which were described before, The multiplicative LMDI version is being recommended although it is more intricate than the additive LMDI to use. The relevant formulae for both non-chaining and chaining analyses are presented below.

4-1- Index decomposition analysis

Assume an economy is divided into m major energy-consuming sectors. Further assume that the total energy consumption in sector I (E_i) is the sum of energy consumption in k_i sub-sectors and the same activity indicator for all sub-sectors are employed.

$$E_i = \sum_{j=1}^{ki} E_{ij} = \sum_{j=1}^{ki} X_i \cdot \frac{X_{ij}}{X_i} \cdot \frac{E_{ij}}{X_{ij}}$$

$$E_i = \sum_{j=1}^{ki} X_i \cdot S_{ij} \cdot I_{ij} \tag{1}$$

where E_{ij} and x_{ij} are respectively the energy consumption and activity level of sub-sector j in sector I, X_i is the total activity level of sector i,
$S_{ij}(=X_{ij} / X_i)$ is the activity share of sub-sector j in sector I and $I_{ij}(=E_{ij} / Q_{ij})$ is the energy intensity of sub-sector j. Eq. (2) gives the basic three-factor IDA formula.

According to Eq. (2), a change in E_i over time, e.g. from year 0 to year T, is assumed to be driven by three effects: level of the aggregate activity (the activity effect), activity structure (the structure effect) and sub-sector energy intensity (the intensity effect).[2]

$$D_{tot} = E_i^T / E_i^o = \sum_{j=1}^{k_i} I_{ij}^T \cdot X_{ij}^T / \sum_{j=1}^{k_i} I_{ij}^o \cdot X_{ij}^o \tag{2}$$

1- Our proposed framework is based on LMDII. For the differences between LMDI-I and LMD I-II(Logarithmic mean Divisia index decomposition method II) , see Ang (2004) and Ang et al. (2009) .
2- More factors can be defined where appropriate and in fact this is the case in some accounting systems. See, for example OEE (2008).

The LMDI decomposition formulae for quantifying activity, structure and intensity effects are:

Activity effects= $D_{act} = \exp\left(\Sigma_{j=1}^{ki} W_{ij} L_n\left(\frac{x_{ij}^{T}}{x_{ij}^{0}}\right)\right)$ (3)

Structure effects= $D_{str} = \exp\left(\Sigma_{j=1}^{ki} W_{ij} L_n\left(\frac{s_{ij}^{T}}{s_{ij}^{0}}\right)\right)$ (4)

Intensity effects = $D_{\text{int}} = \exp\left(\Sigma_{j}^{ki} w_{ij} L_n\left(\frac{I_{ij}^{T}}{I_{ij}^{0}}\right)\right)$ (5)

Where

$$W_{ij} = \left(\frac{(E_i^T - E_i^0)/(\ln(\frac{E_i^T}{E_i^0}))}{\frac{E^T - E^0}{Ln\left(\frac{E^T}{E^0}\right)}}\right)$$

Total effect = $D_{tot} = D_{act} \cdot D_{str} \cdot D_{\text{int}}$ (6)

[For more details on the LMDI approaches see Ang (2004, 2005).]

4-2- Energy Performance Index

The energy intensity effect obtained through applying the multiplicative LMDI method is simply the EPI. By virtue of the simple analytical relationship between additive and multiplicative LMDI as given in Ang (2004), we can derive the EPI of sector i for year T from the results given by the multiplicative LMDI as follows:

$$EPI^{o/T} = \exp\left(\Sigma_{i=1}^{m}\Sigma_{j=1}^{ki}\frac{\left(E_{ij}^{T} - E_{ij}^{0}\right)/(Ln(\frac{E_{ij}^{T}}{E_{ij}^{0}})}{(E_i^T - E_i^0)/(Ln(\frac{E_j^T}{E_i^0})}\right) \tag{7}$$

As an example, an EPI of 0.9 derived from an intensity effect of 10 (MTOE) can be interpreted as “a 10% improvement in energy efficiency”.

4-3- Application of LMDI to Iran

The LMDI accounting framework is adopted to develop an accounting system for tracking Iran’s economy-wide energy efficiency trends. The system incorporates a sector classification system that is appropriate for the structure of energy use in the country. The sectors considered are industry and transport. As table 1 indicates, The transportation sector activities are: air transport, rail transport, pipeline transport, passenger transport, land transport and support services. The industrial sector activities considered are: coal extraction, petroleum and gas extration, iron extraction , copper extraction and construction material production for industry.

This clasification along with the relevent dataset is used to illustrate the application and properties of the multiplicative LMDI framework. The value-added in constant prices and final energy consumption data over the 2001 -2006 period for the two sectors are given in Table 2 and Table 3. The objective is to study the change in final energy use over the 2001 -2006 period.

Table1: The Dataset in Case Study

Sector/Subsector	Activity and Activity level						
	Activity (unit)	**2001**	**2002**	**2003**	**2004**	**2005**	**2006**
transport							
Water Transport	(VMT)	76.3	76	85.5	93.4	97.5	110.2
Air Transport	(VMT)	0.08	0.09	0.1	0.1	0.2	0.17
Rail Transport	(VMT)	26.4	26.5	28.8	29.5	30.3	33
Land Transport	(VMT)	268.5	298	348.1	388.9	406.8	437.6
Water Transport	(PMP)	2.4	2.5	3.7	4.6	3.9	3.7
Air Transport	(PMP)	11.6	11.9	13.2	13.5	15.7	18.1
Rail Transport	(PMP)	13.1	14.3	16.1	17.4	19.4	21.3
Land Transport	(PMP)	394	389.3	404.3	409.3	414.7	419.8
Industry							
Copper Extraction	VA(106 $)	596	656	716	776	836	896
Construction Material Production	VA(106 $)	3678	3742	3804	3865	3925	3985
Other Activity	VA(106 $)	11946	12078	12175	12254	12323	12388

Notes:VMT: Vehicle Million Ton. PMP: Passenger Million Person

Table 2: Value- Added and Energy Consumption in Irans Industrial Sector (2001-2006).

Parametr / Year	**2001**	**2001**	**2002**	**2003**	**2004**	**2006**
Value- Added (Constant Price 2000)	415999	871970	1743939	2732685.3	4944231	8588669
Energy Consumption (MBOE)	175.6	195.7	209.6	214.4	224.3	216.4

Table 3: Value- Added and Energy Consumption in Irans Transportation Sector (2001-2006).

Parametr / Year	2001	2001	2002	2003	2004	2006
Value- Added (Constant Price2000)	4773262	1615009	323001586	10952980	1.35E+8	160561369
Energy Consumption (Mboe)	191.58	206.25	217.99	230.91	251.03	266.45

The decomposition results which were obtained by using Eqs. (3) –(5) for sectors in industry and transport are shown in Table 4

Table4: Results Given by Applying the LMDI Accounting Framework to Iran (2001 -2006) (MBOE)

Sector / Effect	Activity Effect	Structure Effect	Intensity Effect	Total Effect	EPI
Industry	22.78	-22.6	-22.5	11591	1.06
Vehicle	16	-14	-25	5751	0.41

For each sector, the decomposition satisfies Eq.(2). The economy-wide results are the sum of estimates for secors in industry and transport. The last column gives the EPI estimates obtained using Eqs. (7). The indusrty EPI of 1.06 indicates that energy efficiency improved by 11%, and the vehicles EPI of 0.41 indicates that energy efficiency improved by 5%. from 2001 to 2006. It can be seen that, there has been a reduction in energy intensity in the transportation sector and hence a reduction in energy consumption in this sector. these reductions can be attributed to better energy management practices. Industrial energy intensity is positive implying an increase in energy consumption.

The energy intensity index demonstrates the amounts of energy an activity uses in producing one unit of goods and services. Many factors including weather and the structure of the economy influences energy intensity. Countries with high levels of living standards have higher levels of energy consumption and hence higher energy intensity. Installations, equipment, fuel and transportation types, public transportation capacity, natural events, wars and energy subside are factors which generally influence energy intensity. According to the previous comparison, it should be noted that Iran’s marginal consumption intensity is one of the highest among the countries in North America, Africa and Middle East. In these countries, in 2007, about 122.4 tons of crude oil were used to produce 1 million dollars of value-added while the corresponding figure in Iran is about two-folds.[1]

5- Conclusion

Energy efficiency and reduction in operational costs is becoming critical in the energy intensive industry. Energy efficiency is defined as the ability to generate the same economic output with less energy input.

an accounting framework called the multiplicative LMDI energy efficiency accounting framework is presented which is based on the IDA approach. This framework has actually been adopted by 6 years in Iran and is a applicable treatment, which refines the procedures and formulae and fill up gaps. The desirable properties of multiplicative LMDI accounting framework, such as its flexibility in handling both the ratio change and difference change in energy consumption and the handling of a mixture of activity indicators for a sector are presented.

To summarize the paper, we used a multiplicative LMDI accounting framework to account for the transportation and industrial energy consumption changes during 2001 to 2006. We calculated energy intensity consumption and energy efficiency indices over the 2001-2006. Finally, we explore the relation between industrial and transportation energy consumption and value added.

To summarize, an application of multiplicative LMDI framework to Iran seems to show that industrial energy consumption in Iran increased by 3.8% from 2001 to 2006. However, transportation energy consumption decreased by 4.3% from 2001 to 2006. Shifts in the composition of output towards less energy-intensive sectors can be viewed as a structural change inducing the reduction in energy consumption. Energy intensity effect in 2006 is nearly 0.59 times that of 2001. There was a decreasing trend in transportation

1- www.iies.org

energy intensity, implying a decreasing trend in energy consumption. Better energy management practices may have caused these decreasing trends. Industrial energy intensity however is positive implying an increase in energy consumption. Changes in industrial and transportation energy consumption can be effectively traced by quantifying the impact of changes overall industrial activity (activity effect), activity mix (structure effect) and sectorial energy intensity (intensity effect). Our calculations show that in Iran the activity effect seems to dominate. By way of a concluding policy remark, we may say that Iran would need to broaden its use of the multiplicative LMDI accounting framework in order to meet its energy efficiency concerns and adopt policies in the manner of guiding its activity levels, product mix and structural changes.

References

1- Ang, B.W., 2005. “The LMDI approach to decomposition analysis: a practical guide”, Energy Policy, 33, 867-871.

2- Ang, B.W., 2004. Decomposition analysis for policymaking in energy: which is the preferred method? Energy Policy 32, 1131 –1139

3- Ang, B. W. and N. Liu (2009): “Energy decomposition analysis: IEA model versus other methods,” Energy Policy, Vol. 35, pp. 1426-1432.

4- Ang, B.W., Mu, A.R., Zhou, P., 2010. “Accounting frameworks for tracking energy efficiency trends”, Energy Economics 32, 1209 –1219.

5- Balk, B.M., 2008. Prices and Quantity Index Numbers, Cambridge University Press, Cambridge.

6- Boyd.Gale,M.Roop ,”A Note on the Fisher Ideal Index Decomposition For Structural Change In Energy Intensity ”,Journal of Energy, Vol125,pp87-101,2004.

7- EERE, 2009. “Indicators of energy intensity in the United States”, Office of Energy Effciency and Renewable Energy, US Department of Energy, http:// www1.eere.energy.gov/ba/pba/intensity indicators

8- Ghisi, E., Gosch, S., and Lamberts, R., "Electricity end-uses in the residential sector of Brazil", *Energy Policy*, Volume 35, Issue 8, August 2007, Pages 4107-4120.

9- Gudarzi- Rad, Reza, 2009. “Decomposition method, quantitatively analyzing the reason for energy consumption changes in industry”, 7thNational Energy Congress, Decomder 22 and 23.

10- Institute for International Energy Studies, "Iran's Hydrocarbons Energy Balance 2006", Ministry of oil and gas, 2006.

11- Joberta, T., Karanfilb, F., "Sectoral energy consumption by source and economic growth in Turkey", *Energy Policy*, Volume 35, 2007, Pages 5447-5456.

12- Kenneth A. Small and Kurt Van Dender (September 21, 2005). "The Effect of Improved Fuel Economy on Vehicle Miles Traveled: Estimating the Rebound Effect Using U.S. State Data, 1966-2001". University of California Energy Institute: Policy & Economics. http://repositories.cdlib.org/ucei/policy/EPE-014. Retrieved 2007-11-23.

13- Key Worlds Enegy Statistics, www.iea.org.2007

14- Li.J,"Structural Change and energy use: the case of the manufacturing Sector in Taiwan"Energy Economics ,Vol 12, pp109-115, 1990.

15- Ma Chunbo, Stern David," Chaina`s changing energy intensity trend:A decomposion analysis". Energy Economics,Vol 30,p1037-1053,2008

16- M.R. Pela´ ez-Samaniego, M. Garcia-Perezc, L.A.B. Cortezb, J. Oscullod, G. Olmedo, "Energy sector in Ecuador: Current status", *Energy Policy*, Volume 35, 2007, Pages 4177–4189.

17- ODYSSEE, 2009. "Energy Efficiency Indicators in Europe", http://www. odyssee-indicators.org/

18- OEE, 2006. "Energy efficiency Trends in Canada 1990 to 2004". Natural Resources Canada, Ottawa.

19- Sandu, S., Petchey, R., 2009, End use energy intensity in the Australian economy. ABARE

20- Research report 09,17 Canberra.

21- Sattari, S., Houri-Jafari, H., Baratimalayeri, A., "The Crisis of Gasoline Consumption in the Iran's.

22- Transportation Sector", Energy Planning, Energy Saving, Environmental Education (EPESE 2007).

23- Ten Raa, T. (2005). "the economics of Input-out put Analysis", Cambridge university Press, Cambridge, New York.

24- World Bank, "Human Develompet report 2008".

25- World Bank, "world Development indicators 2008".

26- "Journal of Political Economy, 1988".