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Evaluation of Sector Wise Energy Saving and Energy Rebound Effect in Bangladesh by Three Dimensional Decomposition Method

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Abstract: In this study, the energy saving pattern defined by the difference of trend and real values of energy consumption is analyzed by Complete Decomposition Method for Bangladesh during the period of 1991-2007. The trend of energy consumption that relies upon activity effect and the real energy consumption which depend upon activity effect along with the intensity effect and structural effect are analyzed for major economic sectors of the country namely, agriculture, industry and service. It has been revealed through calculations that the country has saved energy of about 4 MTOE in agriculture sector. On the other hand, industry and service sectors which together accounted for 90.2% of the total energy consumption, failed to save energy rather the country consumed 66.38 MTOE more energy than usual. The energy rebound effect that relies upon the activity effect and structural effect has also been estimated to examine the energy uses pattern of these sectors. The calculated data of energy rebound effect have shown the similar nature of energy saving pattern during the whole study period. The aggregate energy rebound effect was found to be 71.42 MTOE of which activity effect and structural effect contribute 101.2 and -1.2%, respectively.

Key words: Complete decomposition method, energy saving, energy rebound effect, energy consumption, structural effect, Bangladesh

INTROUCTION

The issues of energy efficiency and energy security are critically important for nations like Bangladesh with limited indigenous energy resource. Energy conservation and the optimal use of indigenous energy sources through evolving a suitable energy mix has become an important measure to ensure energy security. Presently, Bangladesh appears to have fallen into the vortex of power and energy crisis. This crisis has been snowballed for the last several years. Many studies have indicated that if the present trend of energy sector development continues, the energy scenario of the country will be very critical in the long-term future (Khosruzzaman, 2008). In view of the prevailing low consumption base in Bangladesh, a high growth rate in electricity is indispensable for facilitating smooth transition from subsistence level of economy to the development threshold.

An appropriate energy planning and sustainability is thus key factors influencing growth of this sector. The energy planning of Bangladesh is a complex phenomenon and systematic analyses of structural change of economy and sectoral energy demand in the long-term future are crucially important. The energy saving is an important measure of an appropriate energy planning of a country.

The level of overall activity or production, the composition or structure of the economy and the output or activity per unit of energy consumed are the main factors that can affect the level of energy consumption of a nation. The countries which use energy efficiently have sound and sustained economic growth in the international environmental agreement condition. Bangladesh has limited energy reserves. Traditional energy plays a significant role in the overall energy consumption pattern of the nation. Due to limited exploration and exploitation of indigenous resources, Bangladesh met its 69% commercial energy demand through energy import in 1990. After that indigenous gas based development has been realized the import dependency was reduced to 23.82% in 2005 and that was further reduced to 22.5% in 2007 (Bangladesh Bureau of Statistics, 1992). In 2008 the primary energy consumption (commercial) in Bangladesh was 30.98 MTOE. The major consumers were industry (46%), transportation (25%) and service (18%). The total energy intensity was 0.1877 KGOE/US$-2000 in 1990 and 0.47 KGOE/US$-2000 in 2007.

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Table 1: Energy consumption GDP and energy intensity in Bangladesh (Bangladesh Bureau Statistics, 1992)

Bangladesh	1990	1995	2000	2005	2007	1990-2007
Energy Consumption (MTOE)	4.80	6.27	16.80	24.66	28.71	235.33
GDP (mill. US$-2000)	25571	31700	40863	53234	60412	710889
I (KGOE/US$-2000)	0.187	0.197	0.41	0.46	0.47	0.33
Agriculture sector:						
Energy Consumption (MTOE)	0.32	0.52	1.38	2.79	3.25	23.09
GDP (mill US$-2000)	7341	7927	10055	11373	12478	169840
I (KGOE/US$-2000)	0.04	0.06	0.138	0.245	0.264	0.135
Industry sector:						
Energy consumption (MTOE)	2.77	3.15	8.83	11.37	13.23	114.34
GDP (mill US$-2000)	5167	7401	10106	14454	17192	177388
I (KGOE/US$-2000)	0.535	0.425	0.873	0.786	0.762	0.64
Service sector:						
Energy consumption (MTOE)	1.7	2.59	6.59	10.49	12.21	97.86
GDP (mill US$-2000)	13063	16372	20702	27407	30742	363661
I (KGOE/US$-2000)	0.130	0.158	0.318	0.382	0.396	0.27

(Table 1) with an increasing trend. Since the industrial sector is a major consumer of energy improvements in its service, activity and output are important to enhance productivity and reduce environmental impacts. In this regard, energy intensity and energy saving indicators play a significant role to study the trend and the changes in the activity and output levels.

The energy saving of different economic sectors of Bangladesh can be described by the decomposition method (Ang and Zhang, 2000). The decomposition methodology has become a useful and popular tool for industry energy demand analysis and also for energy and environmental description. This approach takes into account the relationship between energy consumption and energy-related economy. It is a useful technique to give a broad view of the implementation of energy conservation measures. The forefront study of the application of the decomposition of energy conservation was that presented by others like Sun (2003). However, most of the studies were limited to two economic dimensions such as energy intensity and GDP.

Energy saving describes the effects from technological progress and structural changes of an economy. Energy saving indicates the total reduction of energy use if the overall economic activity remains unchanged. If the effectiveness of production technology increases, energy saving takes place. If the share of a sector of the total production volume decreases, energy saving may also occur. Energy saving also takes into account the structural shift such as the shift towards the use of services instead of energy commodities. The energy rebound effect captures the development that takes place if technological change is not directly included. It is the calculation of a sector's response in terms of energy consumption to the development of the value added plus the structural effect. The energy rebound effect is a reflection of the indirect effect of technological development on energy use insofar as technological development increased economic growth accompanied as structural shift in the economy.

In this study, the three dimension complete decomposition model was formulated to analyze the energy saving and energy rebound effect of different sector in Bangladesh. The study analyzed data of the period 1991-2007 as an attempt to assess the extent of the acclaimed success in Bangladesh.

MATERIALS AND METHODS

We have used the available up-to-date data from different national and international sources like Bangladesh Bureau of Statistics (1992), PDB, Petrobangla, ADB, WB, etc. The annual data of Gross Domestic Product is converted into US$ of 2000.

The GDP and commercial energy consumption of 1990 is considered as base value. The Complete Decomposition Method was used to construct the energy saving model in different sector. The model starts with GDP-related energy intensity E_t is the sum of sector's energy consumption E_{it}:

$$E_t = \sum_i E_{it} \quad (1)$$

Where i is the index of sector.

The total energy consumption E_t is a function of three variables:

- Level of output, A_t which measures aggregate sectoral activity either in economic or physical units and consists of sectoral inputs

$$A_t = \sum_i A_{it} \quad (2)$$

- Energy intensity of sectors, I_{it} defined as sectoral energy consumption E_{it} per unit of activity A_{it}:

$$I_{it} = E_{it}/A_{it} \quad (3)$$

- Structural parameter, S_{it} defining the share of sectors i in the aggregate sectoral output in the year t:

$$S_{it} = A_{it}/A_t \quad (4)$$

The following equations decompose total energy consumption into the terms of activity, structure and energy intensity:

$$E_t = \sum_i (A_t \times S_{it} \times I_{it}) \quad (5)$$

$$= \sum_i (A_t \times [A_{it}/A_t] \times [E_{it}/A_{it}]) \quad (6)$$

In the decomposition approach, changes in energy consumption between the base year and year t can be divided into activity, intensity and structure effects:

$$\Delta E_{ot} = E_t - E_o = \sum_i (A_t X S_{it} X I_{it}) - \sum_i (A_o X S_{io} X I_{io}) \quad (7)$$

$$GDP_{effect} + S_{effect} + I_{effect} \quad (8)$$

where, GDP_{effect}, S_{effect} and I_{effect} represents activity effect, structural effect and intensity effect, respectively. Following the decomposition method (Sun, 1998, 2001), these three effects can be decomposed as:

$$\text{Activity effect}(GDP_{effect}) = \sum(\Delta A_t S_{io} I_{io}) + \left(\frac{1}{2}\right) \sum \Delta A_t (S_{io}\Delta I_{it} + \Delta S_{it} I_{io}) + \left(\frac{1}{3}\right) \sum (\Delta A_t \Delta S_{it} \Delta I_{it}) \quad (9)$$

$$\text{Structural effect } (S_{effect}) = \sum(A_o \Delta S_{it} I_{io}) + \left(\frac{1}{2}\right) \sum \Delta S_{it} \; (A_o \Delta I_{it} + \Delta A_t I_{io}) + \left(\frac{1}{3}\right) \sum (\Delta A_t \Delta \; S_{it} \Delta I_{it}) \quad (10)$$

And

$$\text{Intensity effect}(I_{effect}) = \sum(A_o \Delta S_{io} \Delta I_{it}) + (1/2) \sum \Delta I_{it} (A_o \Delta S_{it} + \Delta A_t S_{io}) + (1/3) \sum (\Delta A_t \Delta S_{it} \Delta I_{it}) \quad (11)$$

Where:

E_t, E_0 = Total energy used in year t and 0 (base year)

$I_{io}+\Delta I_{it}$, I_{io} = Energy intensity of sector i in year t and 0, respectively

$S_{io} + \Delta S_{it}$, S_{io} = Output share of sector i in year t and 0

$A_o + \Delta A_t$, A_o = Level of aggregated activity in year t and 0

ΔA_t = $A_t - A_0$

ΔS_{it} = $S_{it} - S_{io}$

ΔI_{it} = $I_{it} - I_{io}$

From Eq. 7, the real energy consumption in the year t can be expressed as:

$$Real = E_t = \Delta E_{ot} + E_o \quad (12)$$

The GDP_{effect} is used to predict the trend of the energy consumption in year t as in the following equation:

$$Trend = GDP_{effect} + E_o \quad (13)$$

Energy saving is defined as the difference between Trend and Real, thus:

$$\begin{aligned} \psi &= Real - Trend \\ &= \Delta E_{ot} + E_o - GDP_{effect} - E_o \\ &= \Delta E_{ot} - GDP_{effect} \\ &= GDP_{effect} + S_{effect} + I_{effect} - GDP_{effect} \\ &= S_{effect} + I_{effect} \end{aligned} \quad (14)$$

Energy saving is achieved only if $\Psi<0$ which indicates that the actual increase of energy consumption (real) is less than what should have otherwise, resulted from the growth of the economy (trend). This condition implies that the energy consumption has been comparatively reduced (saved) which is the indicator of the success of the energy conservation plan. In contrast if $\Psi>0$, energy saving is not achievable.The energy saving model (Ψ) can be written as:

$$\Psi = S_{effect} + I_{effect} = \sum(A_o S_{it} I_{io}) + (1/2)\sum \Delta S_{it}(A_o \Delta I_{it} + \Delta a_t I_{io}) + (1/3) \sum (\Delta A_t \; \Delta S_{it} \; \Delta I_{it}) + \sum(A_o S_{io} \Delta I_{it}) + (1/2) \sum \Delta i_{it} \; (A_o \Delta \; S_{it} + \Delta a_t S_{io}) + (1/3)\sum (\Delta A_t \Delta S_{it} \Delta I_{it})$$

$$= \sum(A_o \Delta S_{it} I_{io}) + (1/2)\sum \Delta S_{it}(A_o \Delta I_{it} + \Delta A_t I_{io}) + \sum(A_o S_{io} \Delta I_{it}) + (1/2)\sum \Delta I_{it}(A_o \Delta S_{it} + \Delta A_t S_{io})\Delta S_{it} \Delta I_{it}) \quad (15)$$

Energy saving appears mathematically in these models as a negative value of Ψ. Thus the negative values have S_{effect} and I_{effect} represent the saving caused by the change of the respective dimensions.

Malaska *et al.* (1999) proposed a group of metrics in order to relate the decomposition analysis to matters of sustainability.

Dematerialization of energy production, immaterialization of consumption and rebound effect are important factors in shaping sustainable energy. We have analyzed the energy rebound effects of different sectors based upon Malaska *et al*. (1999)'s approach.

The equation for Energy sustainability (Es) can be presented in the following matrix form:

$$Es = \begin{pmatrix} E_{De} \\ E_{Sa} \\ E_{Re} \end{pmatrix} = \begin{pmatrix} -1+0+0 \\ -1-1+0 \\ +0+1+1 \end{pmatrix} \begin{pmatrix} I_{effect} \\ S_{effect} \\ GDP_{effect} \end{pmatrix}$$

where, E_{De} is dematerialization, E_{Sa} is immaterialization (energy saving) and E_{Re} is energy rebound effect. From the solution of above matrix we get:

$$Es = \begin{pmatrix} E_{De} \\ E_{Sa} \\ E_{Re} \end{pmatrix} = \begin{pmatrix} -I_{effect} \\ -I_{effect} - S_{effect} \\ 0 + S_{effect} + GDP_{effect} \end{pmatrix} \quad (16)$$

Where:

E_{de} = Dematerialization = $-I_{effect}$
E_{sa} = Immaterialization = Energy saving = $-(I_{effect}+S_{effect})$
E_{re} = Energy Rebound effect = $S_{effect} + GDP_{effect}$

The Eq. 16 is used in energy rebound effect calculation.

RESULTS AND DISCUSSION

The analysis shows that during the period 1991-2007, the total energy saving indicator in Bangladesh was 62.38 MTOE (positive value means over-consumption instead of saving). This indicator when resolved into three sectors namely agriculture, industry and service, respectively, their corresponding values turns out to be -4, 28.18 and 38.20 MTOE, respectively. Since the energy consumed by the agriculture sector was only 9.8% of the total energy consumption, its contribution to the energy saving is minimal. During the period 1991-2007 we observed that energy saving occurred in agriculture sector of which -17.36 MTOE of energy saving was due to structural changes (S_{effect}) as shown in Table 2. During the same period the extra energy consumption in agriculture sector of 13.36 MTOE came from intensity changes (I_{effect}). The agriculture sector, however failed to save energy in every year. In Table 2 it is found that trend value is greater than real value that is the value of Ψ<0 (trend of graph is decreasing) which is the condition for energy saving as shown in Fig. 1.

As the industrial sector consumes the major amount of energy and contributes to the economic development substantially, energy conservation activities have targeted this sector. Energy consumption in this sector during 1990-2007 was 114.34 MTOE (Table 2). It accounted for 48.5% of the total energy consumption. Hence, energy conservation in this sector is vital. Emphasis will be placed on analyzing energy saving in this particular sector.

Energy saving did not occur in industrial sector as shown in Table 3. During the period 1991-2007 the extra energy consumption (28.18 MTOE) in industry sector came from structural change (S_{effect}) and intensity change (I_{effect}) with amounts of 16.39 MTOE and 11.79 MTOE, respectively. In Table 3 it is found that from1991-1999, the trend value is greater than real value in that period energy saving occurred but after 2000 the real value became grater than trend value which is a unsatisfactory condition of energy saving. Punyong *et al*. (2008) stated that the energy saving in Thai industry was 1401.95 KTOE (over consumption instead of saving) during the period

Table 2: Energy saving in agriculture sector

Years	Activity effect (MTOE)	Structural effect (MTOE)	Intensity effect (MTOE)	ΔE_{0t} (MTOE)	Real energy Consum.	Trend energy Consum.	Energy saving (MTOE)
1991	0.010	-0.003	-0.037	-0.029	4.770	4.810	-0.0390
1992	0.027	-0.159	-0.009	-0.142	4.657	4.826	-0.1680
1993	0.039	-0.246	-0.049	-0.256	4.544	4.839	-0.2950
1994	0.056	-0.389	0.004	-0.329	4.471	4.856	-0.3860
1995	0.091	-0.638	0.175	-0.372	4.428	4.891	-0.4620
1996	0.101	-0.694	0.095	-0.498	4.302	4.901	-0.5990
1997	0.124	-0.678	0.092	-0.463	4.337	4.924	-0.5860
1998	0.146	-0.771	0.089	-0.536	4.263	4.946	-0.6830
1999	0.162	-0.781	0.058	-0.559	4.241	4.963	-0.7220
2000	0.364	-0.862	0.829	0.333	5.133	5.166	-0.0325
2001	0.456	-1.014	1.018	0.459	5.259	5.256	0.0040
2002	0.508	-1.269	1.079	0.318	5.118	5.308	-0.1900
2003	0.726	-1.540	1.663	0.848	5.648	5.526	0.1230
2004	0.923	-1.784	2.049	1.187	5.987	5.723	0.2650
2005	0.969	-2.003	1.958	0.925	5.725	5.769	-0.0440
2006	1.109	-2.170	2.097	1.036	5.836	5.909	-0.0730
2007	1.257	-2.360	2.246	1.143	5.943	6.057	-0.1140
1991-2007	7.072	-17.360	13.360	3.067	84.670	88.670	-4.0000

1998-2002. Energy consumption in service sector during the period 1990-2007 was 97.86 MTOE (Table 2). It accounted for 41.58% of the total energy consumption. Energy saving did not occur in service sector, shown in Table 4. During the period 1991-2007 the extra energy consumption (38.20 MTOE) in service sector came from structural change (S_{effect}) and intensity change (I_{effect}) with amounts of 0.06 and 38.13 MTOE, respectively. From Table 4 it is shown that in the time period 1991-2007, the real value is grater than trend value which was again contrary to energy saving.

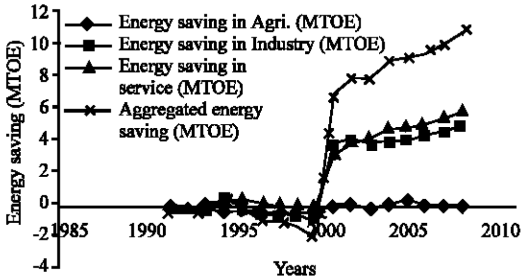

Fig. 1: Sector wise and aggregate energy saving in Bangladesh

The aggregate energy saving indicator in Bangladesh was 62.38 MTOE in the time period 1991-2007, shown in Fig. 1 which shows an over-consumption instead of saving. During the period 1991-2007 the extra energy consumption in Bangladesh came from Structural change (S_{effect}) and intensity change (I_{effect}) have values -0.91 and 63.29 MTOE, respectively. In the same time period, the real value was grater than trend value. So energy saving did not take place in the above mentioned time period.

Table 3: Energy saving in industrial sector

Years	Activity effect (MTOE)	Structural effect (MTOE)	Intensity effect (MTOE)	ΔE_{0t} (MTOE)	Real energy Consum.	Trend energy Consum	Energy saving (MTOE)
1991	0.0840	0.031	-0.535	-0.419	4.3810	4.884	-0.5030
1992	0.2190	0.078	-0.510	-0.213	4.5870	5.019	-0.4320
1993	0.3450	0.163	-0.628	-0.119	4.6800	5.145	-0.4650
1994	0.5290	0.314	0.016	0.861	5.6600	5.329	0.3310
1995	0.6390	0.431	-0.689	0.382	5.1820	5.439	-0.2570
1996	0.7430	0.477	-1.158	0.062	4.8620	5.543	-0.6810
1997	0.9190	0.503	-1.204	0.218	5.0181	5.719	-0.7010
1998	1.0790	0.594	-1.453	0.221	5.0210	5.879	-0.8580
1999	1.2200	0.595	-1.648	0.167	4.9670	6.020	-1.0520
2000	2.4410	1.080	2.541	6.062	10.8610	7.240	3.6210
2001	2.8190	1.243	2.659	6.722	11.5220	7.619	3.9020
2002	3.0660	1.364	2.421	6.852	11.6520	7.865	3.7860
2003	3.4410	1.519	2.411	7.372	12.1720	8.241	3.9300
2004	3.8590	1.634	2.288	7.782	12.5820	8.659	3.9220
2005	4.3710	1.852	2.379	8.602	13.4020	9.171	4.2300
2006	4.9637	2.135	2.401	9.500	14.3000	9.763	4.5360
2007	5.5910	2.374	2.504	10.469	15.2690	10.390	4.8780
1991-2007	36.3300	16.390	11.790	64.510	146.1100	117.930	28.1870

Table 4: Energy saving in service sector

Years	Activity effect (MTOE)	Structural effect (MTOE)	Intensity effect (MTOE)	ΔE_{0t} (MTOE)	Real energy Consum.	Trend energy Consum.	Energy saving (MTOE)
1991	0.057	0.0024	-0.002	0.0560	4.856	4.8570	-0.0001
1992	0.141	0.0139	-0.118	0.0360	4.836	4.9420	-0.1040
1993	0.241	0.0115	0.152	0.4041	5.204	5.0410	0.1636
1994	0.325	0.0117	0.173	0.5110	5.310	5.1250	0.1852
1995	0.455	0.0235	0.409	0.8880	5.689	5.2550	0.4331
1996	0.525	0.0161	0.129	0.6720	5.471	5.3260	0.1459
1997	0.642	0.0069	0.097	0.7470	5.547	5.4430	0.1048
1998	0.752	-0.0023	0.021	0.7700	5.570	5.5520	0.0184
1999	0.871	-0.0015	0.012	0.8810	5.680	5.6700	0.0108
2000	1.745	-0.0320	3.168	4.8820	9.681	6.5450	3.1365
2001	2.141	-0.0360	3.859	5.9600	10.762	6.9400	3.8220
2002	2.458	0.0072	4.247	6.7130	11.513	7.2580	4.2540
2003	2.872	0.0064	4.773	7.6500	12.453	7.6730	4.7800
2004	3.217	0.0205	4.814	8.0500	12.853	8.0180	4.8350
2005	3.640	0.0432	5.095	8.7830	13.583	8.4440	5.1380
2006	4.152	-0.0058	5.465	9.6120	14.410	8.9520	5.4590
2007	4.687	-0.0233	5.841	10.5050	15.310	9.4870	5.8180
1991-2007	28.930	0.0610	38.140	67.1300	148.730	110.530	38.2000

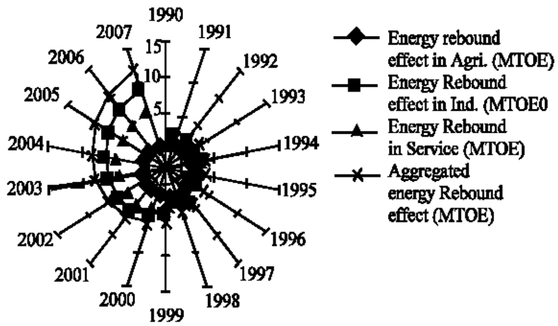

Fig. 2: Sector wise and aggregate energy rebound effect in Bangladesh

Table 5: Aggregate energy rebound effect

Years	Rebound effect in agriculture (MTOE)	Reboundd effect in industry (MTOE)	Rebound effect in service (MTOE)	Aggregate rebound effect (MTOE)
1991	0.0070	0.115	0.059	0.1820
1992	-0.1320	0.297	0.155	0.3210
1993	-0.2060	0.508	0.253	0.5550
1994	-0.3330	0.844	0.337	0.8470
1995	-0.5470	1.071	0.478	1.0030
1996	-0.5930	1.221	0.542	1.1690
1997	-0.5540	1.422	0.649	1.5170
1998	-0.6250	1.673	0.749	1.7970
1999	-0.6180	1.816	0.868	2.0650
2000	-0.4950	3.521	1.713	4.7380
2001	-0.5589	4.063	2.103	5.6070
2002	-0.7610	4.430	2.468	6.1346
2003	-0.8130	4.961	2.879	7.0260
2004	-0.8620	5.494	3.238	7.8710
2005	-1.0330	6.223	3.687	8.8770
2006	-1.0610	7.098	4.146	10.1840
2007	-1.1030	7.965	4.664	11.5260
1991-2007	-10.2900	52.720	28.990	71.4200

The energy rebound effect which is the combined result of activity effect and structural effect is found to increase in industry and service sector and to decrease in agriculture sector as shown in Fig. 2.

In agriculture sector rebound effect decreased by 183 fold in 2007 compared to that in 1991 (Table 5). On the other hand, rebound effect increased by 72 and 79 fold in industry and service sector, respectively in 2007 compared to 1991.

The aggregate rebound effects increased by 64 fold in the time period of 1991-2007 of which activity effect contributes 72.33 MTOE and structural effect contributes -0.91 MTOE, respectively. From rebound effect analysis it is found that the technological development has increased in industry and service sector rather than agriculture sector and our structure of economy is shifting from agriculture to industry but with no good effect in respect of energy saving. The reason is that there have been more structural changes than new innovations in industries.

CONCLUSION

This study presents a detailed analysis of energy saving and energy rebound effect in Bangladesh. It can be concluded that:

- In the time period of 1991-2007, energy saving occurred in agriculture sector of an amount -4 MTOE
- Energy saving did not happen in industrial sector. Extra energy consumption (28.18 MTOE) in industry sector came from structural change (S_{effect}) and intensity change (I_{effect}) with amount of 16.39 and 11.79 MTOE, respectively
- There is no energy saving in service sector. During the period 1991-2007 the extra energy consumption (38.20 MTOE) in service sector came from structural change (S_{effect}) and intensity change (I_{effect}) with amount of 0.06 and 38.13 MTOE, respectively
- The aggregate energy saving in Bangladesh was +62.38 MTOE in the time period of 1991-2007. The positive value indicates the over-consumption instead of saving which is the general characteristic of infrastructure building period
- The aggregate rebound effect increased by 64 fold in the time period of 1991-2007, of which activity effect contributes 101.2% and structural effect contributes -1.2%, respectively. The energy rebound increased in industry and service sector but decreased in agriculture sector. From rebound effect analysis it is found that the technological development increased in industry and service sector rather than agriculture sector and our structure of economy is shifting from agriculture to industry

It appears that as in most developing countries there has been more stress on administrative measures for structural changes than scientific and technological innovation in industries which are main barriers for energy saving through greater efficiency.

REFERENCES

Ang, B.W. and F.Q. Zhang, 2000. A survey of index decomposition analysis in energy and environmental studies. Energy, 25: 1149-1176.

Bangladesh Bureau of Statistics, 1992. Statistical Pocketbook of Bangladesh. Government of the People's Republic of Bangladesh, Dhaka.

Khosruzzaman, S., 2008. The energy strategy in Bangladesh-Present consumption pattern and possible future. Bangladesh J. Phys., 5: 107-115.

Malaska, P., J. Luukkanen and J. Kaivo-Oja, 1999. Decomposition Method in Sustainability Analysis. FUTU-Publications, Turku.

Punyong, K., J. Taweekun and S. Prasertsan, 2008. Evaluation of energy saving in Thai industry by 3-D decomposition method. Asian J. Energy Environ., 9: 15-37.

Sun, J.W., 1998. Change in energy consumption and energy strength: A complete decomposition model. Energy Econ., 20: 85-100.

Sun, J.W., 2001. Energy demand in the fifteen European Union countries by 2010: A forecasting model based on the decomposition approach. Energy, 26: 549-560.

Sun, J.W., 2003. Dematerialization in Finnish energy use, 1972-1996. Energy Econ., 25: 23-32.