Energy Consumption Response to Climate Change under Globalization: Options for India

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Abstract: *The problem of mitigating climate change has continued to dominate public debates in terms of its origin, sources, potential impacts and possibly adaptation strategies. In this paper, the contributions of energy to the climate change debate are explored. The analysis based on the secondary information shows that the global use of fossil fuels has increased and dominated world energy consumption and supply. This case is quite similar to Indian case and the emissions in Indian are also increasing. To account for the change in CO_2 emission, we have followed index decomposition analysis using data from the PROWESS database of the Center for Monitoring Indian Economy. Two factors are considered to account for the changes in emission intensity of Indian economy, namely, (1) output shift among three sectors of the India economy (Agriculture, Service and Manufacturing) and (2) the structural change based on the aggregate output change with respect to the emissions change for the post globalised period. Based on the estimates we found that the structural change in Indian economy from 1991-2007 plays a major role in reducing emission as compared to the output shifts across the sectors. Based on the findings and international experiences, few policy options for Indian case such as; energy pricing reforms, promoting investment in renewable energy technologies and creating public environmental awareness are suggested.*

Keywords: Emission, Energy Consumption, Climate Change, Post-Globalization, Policy Instruments

JEL Classification: C63, Q43, Q58

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1. Introduction

There has been a rapid rise in the use of energy resources and consequently emission of greenhouse gas (GHG) due to structural changes in the Indian economy in the past fifty years. The energy mix in India has shifted towards coal, due to higher endowment of coal relative to oil and gas, which has led to a rapidly rising trend of energy emissions intensities (IEA, 2007). The energy intensity of India is over twice that of the matured economies, which are represented by the OECD member countries (IEA, 2007). However, since 1999, India's energy intensity has been decreasing and is expected to decrease (Planning Commission, Govt. of India, 2001[3]). The decline in energy intensity in the Indian economy could be attributed to several factors; some of them being demographic shifts from rural to urban areas, structural changes towards less energy intensive industries, impressive growth of services, improvement in efficiency of energy use, and inter-fuel substitution. Energy is and will continue to be a primary engine for economic development. The three last centuries have seen mankind's substantial dependence upon an ever-growing use of fossil fuels for industrialization and urbanization (Cao, 2003; Reddish and Rand, 1996).

Climate change is the long-term, significant change in the patterns, glaciations and related aspects of the global climate system. Mitigating the impact of climate change has dominated most public discourse not only by environmental economists but also by other environmental experts and scientists. The effects of energy consumption combustion are evaluated as greenhouse effects resulting from emissions of environmental pollutants such as carbon monoxide, hydrocarbon compounds, sulfur oxides, nitrogen oxides, methane and the particulates. Amongst several pollutants causing climate change, a great deal of attention has been given to CO_2 emission as the major factor in the climate change. While the impact of other forms of air pollutants is primarily local or regional, CO_2 emissions are, above all, global in scale. Sources of

[3] planningcommission.nic.in/plans/planrel/fiveyr/welcome.html

CO_2 emission often cited in the literature include the energy related component, especially, the combustion of fossil fuels. Others include the non-fuel use of energy inputs, and emissions from electricity generation using non-biogenic municipal solid waste and geothermal energy, emissions from industrial processes, such as cement and limestone production, etc.

This paper is concerned with the contribution of energy to the climate change debate mostly focused on the post globalised era for the Indian economy. An attempt has made to compare the recent scenario of developing and the developed world along with the aggregate scenario. In this connection, some useful questions could be raised: To what extent is energy responsible for CO_2 emission? What are the viable options for mitigating energy-related climate change for emerging economy such as India at the post globalised era? The structure of this paper is the following. In the next section, we undertake a brief review of the origin of the climate change debacle. Next, we examine the role of energy to climate change. Thereafter, we outline some policy options for mitigating climate change on the basis of a decomposition analysis of the CO_2 emission. The last section provides the summary and conclusion to the paper.

2. Relationship between Energy Consumption and Emission

The phrase "climate change" and "global warming" and more recently "global cooling" is increasingly assuming a topical dimension in global climatic and environmental discourse. It is one of the most challenging problems with which our contemporary world has been faced. It has become a subject of major international co-operation through the Intergovernmental Panel on Climate Change (IPCC) which was set up in 1988 by the World Meteorological Organization (WMO) and the United Nations Environment Programme. According to Girardet and Mendonca (2009), the origin of climate change can be traced to the impact of human activities that started about 300 years ago. As the industrial revolution unfolded, the increase in the use of coal, and then oil and gas, not only massively increased human productive power and mobility but was also a major contributor to the tenfold growth in human population, from some 700 million in 1709 to nearly 7 billion today (Girardet and Mendonca, 2009). Today, Japan, Korea, Brazil, Mexico, Venezuela, China, India and South Africa are on their path to becoming major industrial nations in their own right. China's industrial boom, for instance, is linked to a rapid increase in domestic energy consumption with millions of cars manufactured yearly. China's coal consumption, mainly in power station, is going up in similar rate.

According to the 1992 World Bank projections, world population will be more than double by 2150 (World Bank, 1992). High population growth and increased urbanization invariably will lead to increased demand for energy, implying increased expected environmental damage as well. The increased concentrations of key greenhouse gases (GHGs) are direct consequences of human activities. Energy production and consumption have various environmental implications, one of which is climate change. Among the many human activities that produce GHGs, the use of energy represents by far the largest source of emissions (IEA statistics on CO_2 emission, 2011). Energy accounts for over 83% of the global anthropogenic GHGs, with emissions resulting from the production, transformation, handling and consumption of all kinds of energy commodities. Energy use emissions are predominantly responsible for CO_2 emissions (92%). Smaller shares correspond to agriculture, producing mainly CH_4 and N_2O from industrial processes not related to energy, producing mainly fluorinated gases and N_2O. GHG emissions from the energy sector are dominated by the direct combustion of fuels, a process leading to large emissions of CO_2. A by-product of fuel combustion, CO_2 results from the oxidation of carbon in fuels (IEA, 2011). Responsible for about 92% of the energy-related emissions, CO_2 from energy represents about 83% of anthropogenic GHG emissions for the Annex 1 countries[4] (IEA, 2011). A key factor responsible for the higher energy-related emissions and climate change challenge is the increased global reliance on primary energy supply to drive economic growth and development. The Global total primary supply (TPES) doubled between 1971 and 2009, primarily relying on fossil fuels. In other words, fossil fuels still account for most of the world energy supply. The figure shows that in-spite of the growth of non-fossil energy (such as nuclear and hydropower) which are usually considered as non-polluting, fossil fuels have

[4] Annex I Countries include Australia, Austria, Belarus, Belgium, Bulgaria, Canada, Croatia, the Czech Republic, Denmark, Estonia, Finland, France, Germany, Greece, Hungary, Iceland, Ireland, Italy, Japan, Latvia, Liechtenstein, Lithuania, Luxembourg, Monaco (included with France), the Netherlands, New Zealand, Norway, Poland, Portugal, Romania, Russian Federation, the Slovak Republic, Slovenia, Spain, Sweden, Switzerland, Turkey, Ukraine, the United Kingdom and the United States. The countries that are listed above are included in Annex I of the United Nations Framework Convention on Climate Change as amended on 11 December 1997 by the 12th Plenary meeting of the Third Conference of the Parties in Decision 4/CP.3. This includes the countries that were members of the OECD at the time of the signing of the Convention, the EEC, and fourteen countries in Central and Eastern Europe and the Former Soviet Union that are undergoing the process of transition to market economies.

continue to maintain their dominance in TPES for the past 37 years under review. In 2009, it accounted for 81% of the TPES in the world.

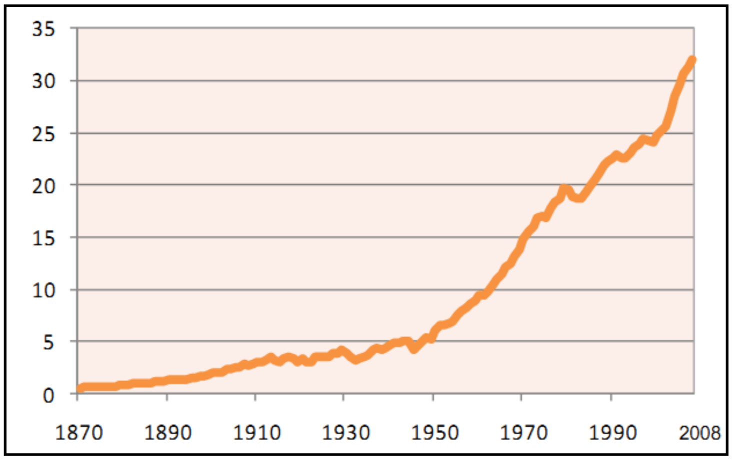
The high global dependence upon fossil fuels clearly is responsible for the observed upward trends in the global CO_2 emissions, as illustrated in Figure-1. Since the industrial revolution, CO_2 emissions from fuel combustion have witnessed a dramatic increase from its near zero level in the 1870s (See Quadrelli and Peterson, 2007, IEA, 2010a) to about 29.4 million tons by 2008 (Figure-3). The figure shows that CO_2 emissions from fossil fuels combustion in 2008 are increasing at a faster rate from 1870. Meanwhile, total global energy supply is projected to rise by 52% between 2008 and 2030 (IEA, 2010a) and with fossil fuels remaining at 81% of TPES, CO_2 emissions are consequently expected to continue their growth unabated (unless some drastic measures are taken) and will reach 40.4 Gt CO_2 by 2030 (IEA, 2010a). The trend is expected to be intensified due to the projected high increase in world energy consumption demand by the BRICS countries like China and India. It is projected that the shares of China in world energy consumption would outstrip that of the United States by the year 2020. It is obvious that the socio-economic and technological characteristics of development paths of the industrializing countries will strongly affects energy-related emissions and hence, the rate and magnitude of climate change, climate change impacts, the capability for adaptation and mitigation of climate change emissions. However, presently, the figure shows that the United States still dominates world energy consumption followed by China and India and doubtless the higher emitters of CO_2 energy-related emissions.

It may be important to further disaggregate the sources of energy-related CO_2 emissions. Available data on the contribution of fuel to global CO_2 emissions as at 2009 is shown in Figure-2. It can be seen that although coal represents only one-quarter of the world TPES in 2009, it accounted for 43% of the global CO_2 emissions due to its heavy carbon content per unit of energy released. Compared to gas, coal is on the average nearly as twice emission intensive[5]. Without additional measures the supply of coal is projected to grow from 2775 million tons of oil equivalent (Mtoe) in 2004 to 4441 Mtoe in 2030 (Quadrelli and Peterson, 2007). In the future, coal is therefore expected to satisfy much of the growing energy demand of emerging developed

[5] See further evidence in IEA (2010a) for the IPCC default carbon emissions factors from the 1996 IPCC Guidelines which are 15.3 t C/TJ for gas, 16.8 to 27.5 t C/TJ for oil products and 25.8 to 29.1 t C/TJ for primary products.

countries like China and India, where energy intensive industrial production is growing rapidly and large coal reserves exist with limited reserves of other energy sources (Quadrelli and Peterson, 2007).

Figure-1: Trend in CO_2 emission from fossil fuel (1870-2008) (GT CO_2)



Source: IEA statistics on CO_2 emission, 2011

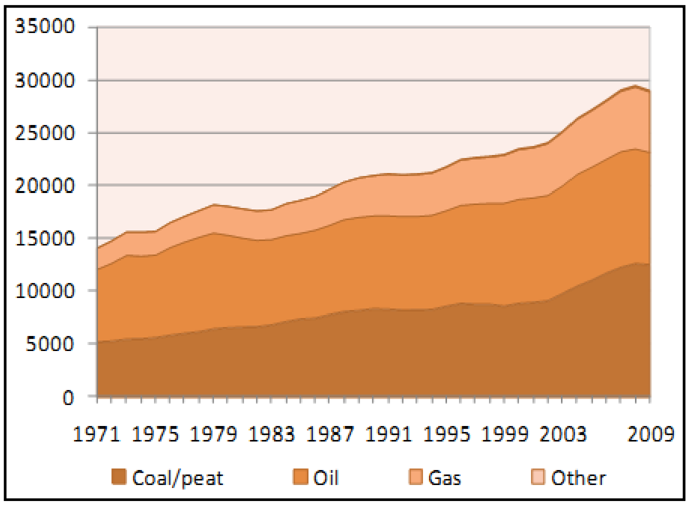
Information on the contributions of the four largest carbon emitters in the world[6] between 1971 and 2008 narrates although the United States remained the largest CO_2 emitter up to 2007; its contribution is relatively stable over time. However, the rate at which it grows in India and in particular China is troublesome. In fact, China overtook the United States in 2007 as the world's largest annual emitter of energy-related CO_2, although as shown by IEA (2010a) the United States will still remains the largest in many years to come in terms of cumulative and per capita terms.

In other words, it has been argued that China's emission rate of CO_2 is important to significantly affect world indicators. Quadrelli and Peterson (2007) have shown that the rise in China's per capita emissions (+17%) causes global emissions to rise by 4%. It is important to note that fossil fuels represents more than 80% of China's energy mix; the country draws more than 60% of its energy supply from coal alone (IEA, 2010a). Generation of electricity and heat was by far the largest producer of CO_2 emissions and was responsible for 39% of the world CO_2 emissions in

[6] The ten top CO_2 emitting countries in the world as at 2008 were China, United States, Russian Federation, India, Japan, Germany, Canada, United Kingdom, Islamic Republic of Iran and Korea, in that order. These ten countries account for 19.1 Gt CO_2 out of the world's 29.3 Gt CO_2 in 2008 (see Fig. A1 at Appendix).

2008. Globally, evidence (from IEA, 2010a) indicates that this sector is noted for its heavy reliance on coal, the most carbon-intensive of fossil fuels and thus amplifying its share in worldwide emissions of CO_2. In this connection, studying Indian case for the emission scenario becomes important in order to estimate the changes those attributes in the globalised era.

Figure-2: Global CO_2 emission by fuel types (MT CO_2)



Source: IEA statistics on CO_2 emission, 2011

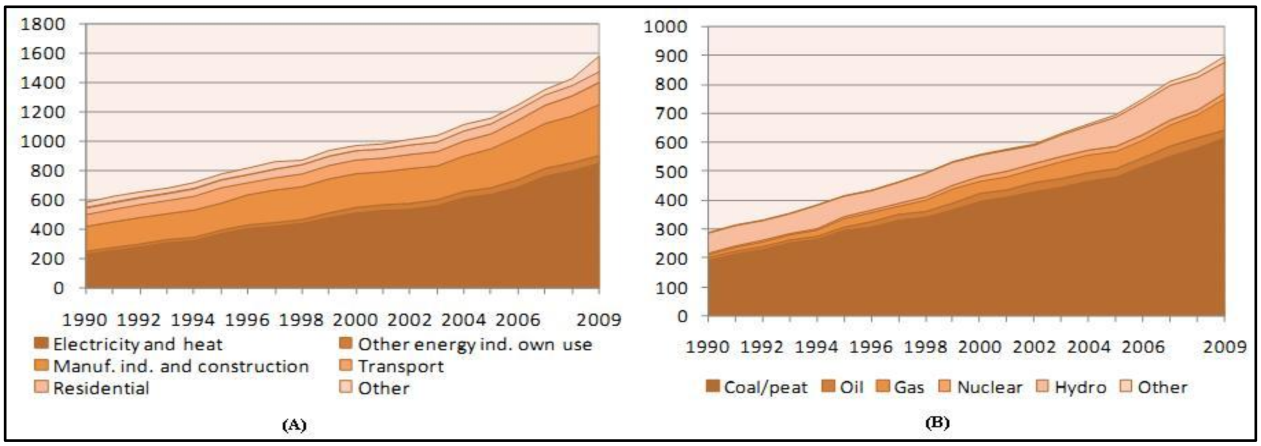
3. Decomposition of CO_2 emission: The Indian Case[7]

India's development path is based on its unique resource endowments, the overriding priority of economic and social development and poverty eradication. In charting out a developmental pathway which is ecologically sustainable, India has a wider spectrum of choices precisely because it is at an early stage of development. India is faced with the challenge of sustaining its rapid economic growth while dealing with the global threat of climate change. This threat emanates from accumulated greenhouse gas emissions in the atmosphere, anthropogenically generated through long-term and intensive industrial growth and high consumption lifestyles in developed countries. Climate change may alter the distribution and quality of India's natural resources and adversely affect the livelihood of its people. With an economy closely tied to its natural resource base and climate-sensitive sectors such as agriculture, water and forestry, India may face a major threat because of the projected changes in climate. India emits more than 5% of

[7] For detail methodology please see *B. W. Ang, 1994, Energy Economics, V-16, No.3*

global CO_2 emissions, and emissions continue to grow. CO_2 emissions have almost tripled between 1990 and 2009. The WEO 2010 New Policies Scenario projects that CO_2 emissions in India will increase by almost 2.5 times between 2008 and 2035. Large shares of these emissions are produced by the electricity and heat sector, which represented 54% of CO_2 in 2009, up from 40% in 1990. CO_2 emissions in the transport sector accounted for only 9% of total emissions in 2009, but transport is one of the fastest growing sectors (figure-3a).

Figure-3: (A) CO_2 emission by sector and (B) electricity generation by sector in India



Source: IEA statistics on CO_2 emission, 2011

In 2009, 69% of electricity in India came from coal, another 12% from natural gas and 3% from oil (Figure-3b). The share of fossil fuels in the generation mix grew from 73% in 1990 to 85% in 2002. The share of fossil fuels has declined steadily since then, falling to 81% in 2006, although increasing back up to 84% in 2009. Although electricity produced from hydro has actually risen during this period, the share fell from 25% in 1990 to 12% in 2009. India is promoting the addition of other renewable power sources into its generation mix and had an installed capacity of 17 GW of renewable energy sources on 30 June 2010. Under its National Action Plan on Climate Change, India plans to install 20 GW of solar power by 2020. With an installed wind capacity of 12 GW in 2010, India has the world's fifth-largest installed capacity of wind power of the BRICS countries, India has the lowest CO_2 emissions per capita (1.4 T-CO_2 in 2009), about one-third that of the world average. However, due to the recent large increases in emissions, the Indian ratio is more than two times that of its ratio in 1990 and will continue to grow. India's per capita emissions in 2035 will, however, still be well below those in the OECD member countries today. In terms of CO_2/GDP, India has continuously improved the efficiency of its economy and reduced the CO_2 emissions per unit of GDP by 16% between 1990 and 2009.

To understand the factors affecting the increase in CO_2 emission in India, we have followed the index decomposition analysis. Most importantly we have focused on the post 1991 case for the Indian economy. In analyzing the increase in CO_2 emission, we have used the three important sectors of the economy and their output changes from 1991. The three sectors of Indian economy are the agriculture, manufacturing and the service sector. The decomposition of CO_2 emission is as follows. The detail methodology followed in the study is narrated to explain the underlying concept with reference to the decomposition of a change in the aggregate emission intensity of Indian Economy. We are following the two-factor case in which a change in the aggregate intensity is decomposed to give the impacts of structural change and sectoral output change using with intensity approach. Let us assume that total emission of the economy is the sum of emission from '***n***' different sectors time '***t***'. The emission intensity is defined as a ratio of the emission of the Indian Economy of sector '***i***' at time '***t***' to the total output of the same sector (defined as value added).

E_t = Total Emission of the economy
$E_{i,t}$ = Total Emission in sector i
Y_t = Total Sectoral Output
$Y_{i,t}$ = Output of sector i
$S_{i,t}$ = Output share of sector i $(= Y_{i,t} / Y_t)$
I_t = Aggregate Carbon Emission Intensity $(= E_t / Y_t)$
$I_{i,t}$ = Carbon Emission intensity of sector i $(= E_{i,t} / Y_{i,t})$

Let us express the aggregate emission intensity as a summation of the sectoral data as:

$$I_t = \sum_i S_{i,t} I_{i,t} , \qquad (1.1)$$

Where, the summation is taken over the n sectors.

We derive the general parametric Divisia method in a manner the same as that described in Liu and Ang (2007). Differentiating equation above with respect to t yields the following:

$$I_t^{'} = \sum_t I_{i,t} S_{i,t}^{'} + \sum_t I_{i,t}^{'} S_{i,t} \tag{1.2}$$

This involves the decomposition of two aggregate emission intensities. Now dividing equation 1.2 by I_t and integrating on both sides from year *0* to year *t*, we have

$$In(I_t / I_0) = \int (\sum_i I_{i,t} S_{i,t}^{/} / I_t) dt + \int (\sum_i I_{i,t}^{/} S_{i,t} / I_t) dt \tag{1.3}$$

Let us define $\widehat{R} = I_t / I_0$, where; $\widehat{R}$ is the change in aggregate emission intensities. As we are considering the two-factor decomposition, $\widehat{R}$ is defined as the changes in the emission intensity in time ***t*** over time ***0***. Now equation 1.3 can be rewritten as the following expression:

$$\widehat{R} = \exp\{\sum_i I_{i,t} S_{i,t}^{/} / I_t dt\} \exp\{\sum_i S_{i,t} I_{i,t}^{/} / I_t dt\} = \widetilde{R}\overline{\overline{R}}\overline{R} \tag{1.4}$$

Where $\widetilde{R}$ is estimated structural effect, $\overline{\overline{R}}$ is the estimated intensity effect and $\overline{R}$ is the residual of the model. The equations for the structural as well as the intensity effect are as follows:

$$\widetilde{R} = \exp\left[\sum_i \left[I_{i,0} / I_0 + \beta_i (I_{i,t} / I_t - I_{i,0} / I_0)\right](S_{i,t} - S_{i,0})\right] \tag{1.5}$$

and

$$\overline{\overline{R}} = \exp\left[\sum_i \left[S_{i,0} / I_0 + \tau_i (S_{i,t} / I_t - S_{i,0} / I_0)\right](I_{i,t} - I_{i,0})\right] \tag{1.6}$$

Where, $0 \le \beta_i, \tau_i \le 1$

The result of the decomposition drawn using the General Parametric Multiplicative Divisia Method, is presented in table-1. It can be clearly visible from figure-4 and table-1 that the residuals are tending to one, which is following the characteristics of the multiplicative index of decomposition, and hence the decomposition is assumed to be near perfect. However, adding more sectors can lead to a perfect decomposition for the Indian case.

Table-1: Results of the Decomposition based on the General Parametric Multiplicative Divisia Method

Year	$\widehat{R}$	$\widetilde{R}$	$\overline{\overline{R}}$	$\overline{R}$
1991	0.97	0.99	0.99	1.00
1992	0.74	1.44	0.73	0.71
1993	1.35	0.72	1.41	1.32
1994	1.03	0.94	1.04	1.04
1995	0.89	1.09	0.90	0.91
1996	0.94	1.03	0.94	0.96
1997	1.03	0.93	1.05	1.05
1998	1.04	0.94	1.04	1.06
1999	0.93	1.00	0.98	0.95
2000	0.97	1.02	0.96	0.99
2001	0.95	1.01	0.96	0.98
2002	0.93	1.04	0.94	0.95
2003	0.99	0.99	0.98	1.01
2004	0.99	0.99	0.98	1.02
2005	0.84	1.17	0.84	0.87
2006	0.96	1.01	0.97	0.99
2007	0.91	1.08	0.91	0.93

Source: Authors' own calculation using data from CMIE accessed on 16th August, 2011

Figure-4 : Output of the residual term in decomposition analysis based on General Parametric Multiplicative Divisia Method

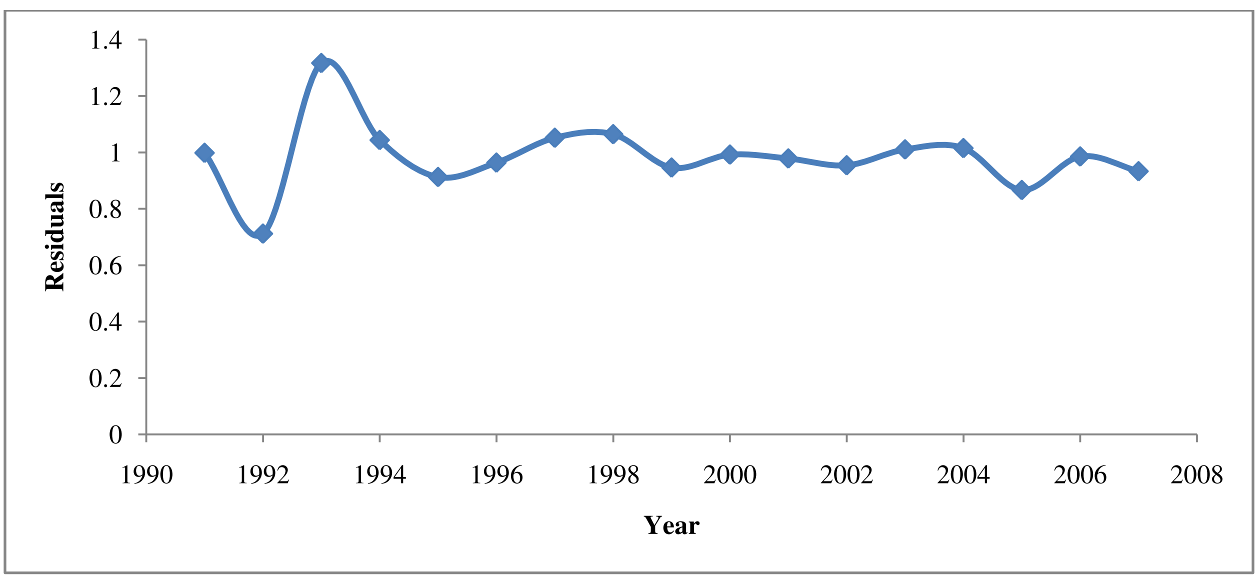


Table-2: Percent changes in Emission Intensity due to Structural Change and Sectoral Change Intensity from the General Parametric Multiplicative Divisia Method

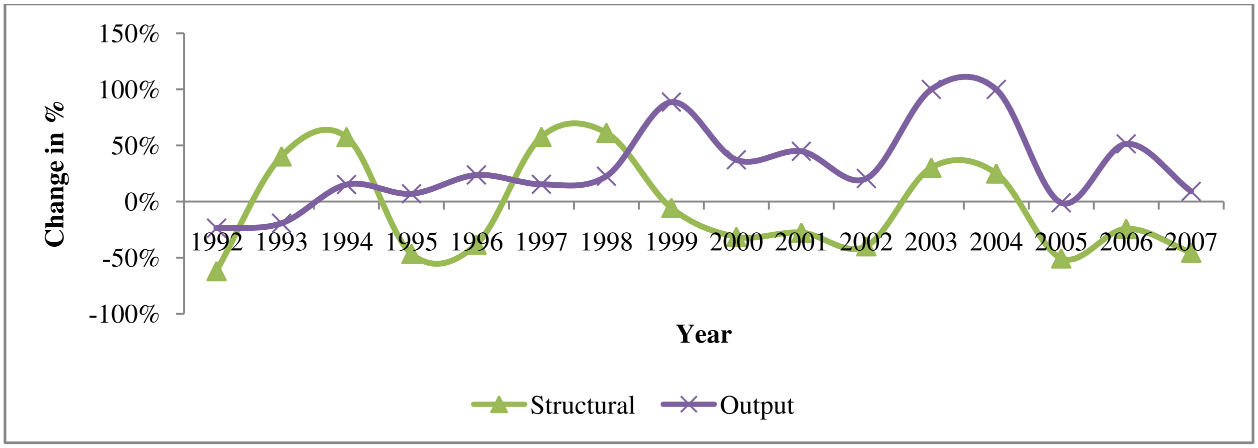
Year	% change in $\hat{R}$	% Change in $\tilde{R}$	% Change in $\bar{\bar{R}}$
1991-1992	25.97	-44.11	27.21
1992-1993	-35.12	27.86	-41.19
1993-1994	-2.59	5.96	-4.39
1994-1995	11.06	-9.08	10.45
1995-1996	6.00	-3.49	5.66
1996-1997	-3.01	6.88	-5.04
1997-1998	-4.11	5.79	-3.65
1998-1999	7.02	-0.10	1.67
1999-2000	3.12	-1.90	4.16
2000-2001	4.52	-1.42	3.73
2001-2002	6.94	-4.08	6.20
2002-2003	1.20	0.69	1.59
2003-2004	0.78	0.58	1.73
2004-2005	15.72	-16.69	16.35
2005-2006	3.75	-1.07	3.34
2006-2007	9.00	-7.83	9.40

Source: Authors' own calculation using data from CMIE accessed on 16th August, 2011

We can see from the table-2 that the changes in emission intensity is driven by the change in the structural change of the economy and changes in the sectoral output change in Indian economy. In case of the year 1992, we can see that the positive change of 25.97 percent in the energy intensity as compared to the 1991 is driven by -44.11% change in structural change in the output, and 27.21% change in sectoral energy intensity. The change in the energy intensity is not consistence from 1991 to 2007, so as the case with both sectoral emission intensity change and the structural effect. Figure-9 explains this phenomenon using a diagram.

We can observe the variation in the total emission intensity, sectoral emission intensity and the change in sectoral output intensity due to the structural effect from figure-5. It can be clearly noticed from the figure that the emission intensity change in Indian economy in mainly due to the change in the structural output change and yielded a negative relation. Once there is a negative change in the sectoral share of output, the emission intensity of the different sectors of the economy are rising and vice versa. However, the sectoral emission intensity has a positive relationship with the total emission intensity of the Indian economy. It can be noted that the change in the emission due to the structural change of the economy is largely during the implementation of the LPG policy mostly during 1992-1999, however thereafter, a negative relationship between emission change and structural change is found out. As the output of the economy from the three sectors (agriculture, manufacturing and service) are growing over the period it adds up the change in the emission facture.

Figure-5: Percent changes in Structural Change and Sectoral Energy Intensity



Analysis based on the decomposition analysis has resulted that the structural change and output change are negatively related while we consider the emission change from 1991-2007 for the Indian economy. Hence at the post globalised scenario Indian economy should concentrate more of stabilizing the structural change in the economy and use of more technological sophisticated machines and aim of shifting towards clean energy sources. From the review and international experience and suggestions we can divide the policy intervention in seven broad areas from regulations and standards to institutional initiatives. It is important to note that irrespective of any policy choice, mitigating the impact of energy related climate change will require the following four key considerations: Box 1 presents an overview of some available policy instruments.

- Environmental effectiveness: The extent to which the policy meets its intended environmental objectives or realizes positive environmental outcomes
- Cost effectiveness: The extent to which the policy can achieve its objectives at minimum cost to the society

- Distributional considerations: The incidence or distributional consequences of the policy. Fairness and equity are dimensions of this though there are other dimensions to distribution.
- Institutional feasibility: The extent to which a policy instrument is likely to be viewed as legitimate, gain acceptance, adopted and implemented (IPCC, 2007).

Box 1: An Overview of Climate Change Policy Instruments	
Regulations and Standards	Specify abatement technologies (technological standards) or minimum requirements for pollution output (performance standards) to reduce emissions.
Taxes and Charges	A levy imposed on each unit of undesirable activity by a source Tradable Permits : Also know as marketable permits or cap-and-trade systems, this instrument establishes a limit on aggregate emissions by specified sources, requires each source to hold permits equal to its actual emissions, and allows permits to be traded among sources.
Voluntary Agreements	An agreement between a government authority and one or more private parties to achieve environmental objectives or to improve environmental performance beyond compliance to regulated obligations. Not all voluntary agreements are truly voluntary; some include rewards and/or penalties associated with joining or achieving commitments.
Subsidies and Incentives	Direct payments, tax reductions, price supports, or the equivalent from a government to an entity for implementing a practice or performing a specified action.
Information Instruments	Required public disclosure of environmentally related information, generally by industry to consumers. Include labeling programs and rating and certification
Research and Development	Direct government spending and investment to generate innovation on mitigation, or physical and social infrastructure to reduce emissions. Include prizes and incentives for technological advances
Non-climate Policies	Other policies not specifically directed at emissions reduction but that may have significant climate-related effects

Source: IEA, 2007 and IPCC, 2010

Under the Energy Conservation Act (2001), energy intensive industrial sectors, i.e. thermal power stations, fertilizer, cement, iron and steel, aluminum, railways, textile and pulp and paper, are required to employ a certified energy manager, conduct energy audits periodically, and adhere to specific energy-consumption norms that may be prescribed. Currently, almost every industrial sector is characterized by a wide band of energy efficiencies in different units. Several of them are at global frontier levels, but some others have relatively poor performance. As an approach to enhancement of overall energy efficiency in each sector, the efficiency band-width of the sector is divided into bands. To promote technology upgradation in the SME (small and medium enterprise) sector, it would be essential to evolve sector-specific integrated programmes for technology development. This would require external support for significantly longer durations to address various technological barriers and promote energy efficiencies at the unit level. Most of the energy-efficient equipment requires higher upfront investment. This means that there is no one-size-fit-all policy prescription to climate change mitigation. A combination of policy options is needed. In line with this, the following options are preferred:

(a) Energy Pricing Reform

The World Bank estimates for 1993 showed that developing countries and transition economies spent more than $230 billion per year on subsiding energy (Cao, 2003). Energy products like coal in China, India, Poland and Turkey have been heavily subsidized (World Bank, 2000), just as Nigeria spends billions on petroleum subsidy. The implication of this has been inefficient use of energy as well as serving as a disincentive for controlling energy-related emissions. Efficient energy pricing will not only remove these price distortions but would sharply reduce the growth in energy consumption and could also cut world carbon emissions by 10% (see World Bank, 2000:41)[8].

(b) Emission Taxes

It is obvious that efficient pricing reforms that results in energy prices reflecting production may still be far from reflecting social cost. Emission taxes could prove useful in adjusting market prices to reflect externalities. A high taxes on carbon-intensive fuels like coal could reduce their consumption and hence carbon emissions. In Mexico, an application of gasoline tax, among other measures, has helped to dramatically reduced GHG emissions coming from transportation (World Bank, 1992).

(c) Promotion of Investment in Renewable Energy

Ultimately, the mitigation of energy-related climate change rest upon the use of renewable energy including hydro, solar, wind, biomass and other forms of renewable ,

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[8] It is important to note that the removal of energy subsidies has always faced the problem of trade-off between worsening the level of poverty for the majority of the population and improving the environmental quality. Again, it is usually reasoned that one-stop removal of such subsidies may worsen the environmental problems because the affected poor may substitute poorer quality fuels for the cleaner but now (with removal of subsidies) dearer fuels

which are more environmentally friendly than conventional fuels (Cao, 2003). In many developing countries, there is a huge untapped and inefficiently utilized renewable energy resource which need specific national policy initiatives and international support, including finance, capacity building and technology transfer to be exploited. Environmental taxes on fossil fuels may be required to stimulate reactions in favor of renewable energy. Increased funding of R&D in renewable energy should also be pursued.

(d) Improve Public Environmental Awareness

Ignorance of the serious impact of their collective actions on climate change by the general public is an important cause of environmental damage and a serious impediment to finding solutions. Adequate environmental information is required to enlighten the public on the seriousness of the worsening environment they are living in, the costs to their health and quality of life. Such enlightenment would help to raise peoples' consciousness and enlist public support for environmental protection laws or policies. This could help to facilitate and augment official enforcement of environmental policies.

5. Summary and Conclusion

One of the major problems facing humanity in terms of achieving sustainable development is climate change. Many economic activities release greenhouse gasses within the earth's atmosphere. The paper explored the role of energy in the climate change in particular case relating to the emission. Evidence has revealed that fossil fuels constitute the single largest human influence on the climate change debate, accounting for over 80% of the anthropogenic greenhouse emissions. Given the fact that primary energy still dominates the world energy mix, reducing energy-related carbon emissions may require reducing the amount of fossil fuel consumption and hence economic growth.

In case of Indian economy empirical estimates based on a decomposition analysis found that the structural changes in the economy are more important to reduce emission. However, the output changes are surely increasing the CO_2 emission largely due to use of fossil fuel. Hence, improving energy efficiency, reforms of inefficient energy pricing, imposition of carbon emission taxes, promoting investment in renewable energy and creating public environmental awareness are some of the mitigation strategies suggested for the Indian economy.

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