Trends and Patterns of Energy Consumption in India

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1 Introduction

Energy has been universally recognized as one of the most important inputs for economic growth and human development. There is a strong two-way relationship between economic development and energy consumption. On one hand, growth of an economy, with its global competitiveness, hinges on the availability of cost-effective and environmentally benign energy sources, and on the other hand, the level of economic development has been observed to be dependent on the energy demand (EIA, 2006). Energy intensity is an indicator to show how efficiently energy is used in the economy. The energy intensity of India is over twice that of the matured economies, which are represented by the OECD (Organization of Economic Co-operation and Development) member countries. India's energy intensity is also much higher than the emerging economies. However, since 1999, India's energy intensity has been decreasing and is expected to continue to decrease (GOI, 2001).

The indicator of energy–GDP (gross domestic product) elasticity, that is, the ratio of growth rate of energy to the growth rate GDP, captures both the structure of the economy as well as the efficiency. The energy–GDP elasticity during 1953–2001 has been above unity. However, the elasticity for primary commercial energy consumption for 1991–2000 was less than unity (Planning Commission, 2002). This could be attributed to several factors, some of them being demographic shifts from rural to urban areas, structural economic changes towards lesser energy industry, impressive growth of services, improvement in efficiency of energy use, and inter-fuel substitution. The energy sector in India has been receiving high priority in the planning process. The total outlay on energy in the Tenth Five-year Plan has been projected to be 4.03 trillion rupees at 2001/02 prices, which is 26.7% of the total outlay. An increase of 84.2% is projected over the Ninth Five-year Plan in terms of the total plan outlay on energy sector. The Government of India in the mid-term review of the Tenth Plan recognized the fact that under-performance of the energy sector can be a major constraint in delivering a growth

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rate of 8% GDP during the plan period. It has, therefore, called for acceleration of the reforms process and adoption of an integrated energy policy.

In the recent years, the government has rightly recognized the energy security concerns of the nation and more importance is being placed on energy independence. On the eve of the 59th Independence Day (on 14 August 2005), the President of India emphasized that energy independence has to be the nation's first and highest priority, and India must be determined to achieve this within the next 25 years. The objective of the study is to examine the trend of total primary energy consumption of India from 1980 to 2005. From different research findings, it is prominent that the total primary energy consumption of the country may be a determinant of GDP. Hence here we have tried to find out the relationship between the total primary energy consumption and GDP from 1980 to 2005. We have tried to find out the relationship between different indicators such as Per capita energy consumption, Production of energy resources, Population with the total energy consumption, and checked whether there is a relationship between them and can they be partially determined by the other variables indicated in the literature.

In this study an attempt has been made to study the total energy consumption in Indian economy from 1980 to 2005. The structure of the study is as follows. In first section we have tried to study an overview of the Indian economy, which gives an idea about the structure of the economy. In the next section we have looked at the energy scenario of the country, which broadly deals with the energy consumption and production by sources. An attempt has been made in order to understand the nature and trend of the primary energy consumption from 1980 to 2005. The last section deals with the relationship between total energy consumption, GDP, population, per capita energy consumption and production of energy resources using statistical as well as econometric tools.

2 Review of literature

The relationship between use of energy and economic growth has been a subject of greater inquiry as energy is considered to be one of the important driving forces of economic growth in all economies (Pokharel, 2006). The increasing world demand for oil, leads to frequent escalation in the world oil prices. Like shortage of oil, there is also shortage of electricity and other forms of energies viz. natural gas. The shortage can significantly affect the consumption and production in the economy. One or the other forms of energy becomes vital

to all the sectors of the economy viz. agriculture, industry and services. This energy dependence being common to every sector of the economy justifies the association between energy utilization and the overall economic growth rate in an economy. Hence any deficiency in supply of oil, natural gas and electricity generations may directly constrain the economic activities, thereby the growth rate. The declining supply of these sources of energy not only raises the input prices[2] but also influences the prices of other commodities leading to a rise in overall inflation rate and thereby dampening the aggregate demand and growth rate.

It needs to be noted that India domestically meets up 30 percentage of its crude oil requirement and the rest is being imported from the oil producing nations. Indian transport sector is the principal consumer of petrol and diesel followed by big and small industrial units. Similarly, electricity consumption share too is the largest by this sector (GOI, 2005). India in the past had experienced a huge import bill on account of an increase in the price of crude oils. The inelastic oil demand and rising oil import bill had put pressure on the scarce foreign exchange resources and had also been largely responsible for shortages in energy supply. In the first oil embargo, India's import bill rose beyond 50 per cent, while the adverse impact of 1990-1991 Gulf War caused a huge balance of payment deficit and pushed up the inflation rate to an all-time high of 13 per cent. These economic uncertainties had deterred the pace of growth of India (Ghosh, 2006).

Even though the relationship between energy consumption and output growth has been a well-studied topic over the past three decades, the evidence is still controversial. The literature has extensively evaluated the nature of temporal causality between energy consumption and economic growth or employment. However, empirical evidence of these studies is mixed, ranging from bi-directional or unidirectional causality to no causality. These studies in the literature generally have no consensus judgment due to different countries or different time within the same country. The pioneering study of Kraft and Kraft (1978) provides evidence in support of unidirectional causality running from gross national product (GNP) to energy consumption for the case of the U.S. over the period 1947-1974. The results imply that energy conservation policies might be enforced without affecting GNP growth. Nevertheless, Akarca and Long (1980) failed to obtain causality between energy consumption and GDP when the period is shortened. They argued that Kraft and Kraft's

[2] Two years ago the international price of oil was just over USD 30 per barrel but today it is close to USD 75 per barrel (The Hindu, 15th August 2006).

study could suffer from temporal time period instability.

Masih and Masih (1996, 1997) in a multivariate framework examined the relationship between total energy consumption and real income of Asian economies such as India; Pakistan; Malaysia; Singapore; Indonesia; Philippines; Korea; and Taiwan. Energy consumption was found to be neutral with respect to income for Malaysia, Singapore and Philippines, unidirectional causality existed from energy consumption to GNP for India, exactly the reverse for Indonesia and mutual causality was present for Pakistan. Paul and Bhattacharya (2004) applied alternative econometric time series models viz Engle-Granger co-integration, Granger causality test and Johnsen's multivariate cointegration technique on the Indian data for the period 1950-96, found that Engle-Granger and Johnsen's result show that in the long run economic growth leads to energy consumption but the standard Granger causality shows that energy consumption leads to economic growth. The finding from Granger causality is also consistent with Johnsen's error correction result. From their survey, they found that while Cheng (1999) had established a unidirectional influence from economic growth to energy consumption but Adjaya (2000) found causality in the reverse direction. Ghosh (2005) using cointegratioin and error correction modeling approach found the existence of a long-run equilibrium relationship between total petroleum products consumption and economic growth in India for the period of 1970-71 to 2001-02.

Several researchers have since joined the debate, with some who have either confirmed or contradicted Kraft-Kraft's results. There are cases where unidirectional Granger causality was found to be running from energy use to economic growth. These studies include the Philippines (Yu and Choi, 1985), India (Masih and Masih, 1996), Singapore (Glasure and Lee, 1997), Indonesia (Asafu-Adjaye, 2000), and in the cases of France, West Germany, Japan, and Turkey by Soyta and Sari (2003). In some other works, an opposite unidirectional Granger causality running from economic growth to energy use was found by Yu and Choi (1985) and Soytas and Sari (2003) for South Korea, and in Cheng and Lai (1997) for Taiwan. Finally, the remaining cases uncover causality running in both directions with respect to the neutrality hypothesis. These are the United States (Stern, 1993, 2000) and Cheng (1995), Thailand and the Philippines (Asafu-Adjaye, 2000), and Taiwan (Yang, 2000).

To sum up the reviewed research papers gives different direction and casual relationship between energy consumption and GDP. Box 1 below describes the summary of the findings.

Box- 1: Summary of findings from review of literature

Author (s)	Year	Study Area	Findings
Kraft and Kraft	1978	U.S.	Unidirectional causality running from gross national product (GNP) to energy consumption
Yu and Choi	1985	Philippines	
Masih and Masih	1996	India	
Glasure and Lee	1997	Singapore	
Asafu-Adjaye	2000	Indonesia	
Soyta and Sari	2003	France, West Germany, Japan, and Turkey	
Akarca and Long	1980	U.S.	Opposite unidirectional Granger causality running from economic growth to energy use
Yu and Choi	1985	South Korea	
Cheng and Lai	1997	Taiwan	
Soytas and Sari	2003	South Korea	
Stern	1993, 2000	United States	Causality running in both directions with respect to the neutrality hypothesis
Cheng	1995	United States	
Asafu-Adjaye	2000	Thailand and the Philippines	
Yang	2000	Taiwan	

3 Data and Methodology

In this study we have tried to find out the trend of total energy consumption in India from 1980 to 2005. We have adopted the general trend analysis technique. After looking at the growth rate at different time period we have used double log regression model between energy use and other independent variables in order to find out the relationship between variables. To examine the structural stability of the regression model we have divided the sample period into two, 1980-1990 and 1991-2005 and introduced the multiplicative dummy[3]. The growth rate is calculated using the least squares growth rate equation which is as follows.

The least-squares growth rate, *r,* is estimated by fitting a linear regression trend line to the logarithmic annual values of the variable in the relevant period. The regression equation takes the form

$$\ln X_t = a + bt,$$

[3] Gujurati, D, N, Basic Econometrics, Chapter 9, Page 306-310

which is equivalent to the logarithmic transformation of the compound growth equation;

$$X_t = X_o (1 + r)^t .$$

In this equation *X* is the variable, *t* is time, and $a = \ln Xo$ and $b = \ln (1 + r)$ are parameters to be estimated. If b^* is the least-squares estimate of *b,* the average annual growth rate, r, is obtained as [exp (b^*) – 1] and is multiplied by 100 for expression as a percentage. The calculated growth rate is an average rate that is representative of the available observations over the entire period.

After looking at the growth rate and their values for different variables at different time periods, in order to study whether there is any relationship between them and whether the total primary energy consumption can be partially determined by the GDP and different other variables simple regression as well as regression models using dummy variable (multiplicative dummy) is used. Detail of the econometric analysis is given at the model description section of the study. The description of the variables used is given in Box 2.

Box 2: Descriptions of the Variables used in the study

Name of the variable	Time Period	Description of the variable in the study
Total primary Energy Consumption	1980-2005	The unit of the data is in (Quadrillion (10 15) Btu), the natural log of the variable is used. The variable is presented as 'TPEC'
Total Primary Energy Production	1980-2005	The unit of the data is in (Quadrillion (10 15) Btu), the natural log of the variable is used. The variable is presented as 'TEP'
Population	1980-2005	The unit of the data is in (Millions), the natural log of the variable is used. The variable is presented as 'Population'
Gross Domestic Product	1980-2005	The unit of the data is in (Rupees Crore). The natural log of the variable is used. The variable is presented as 'GDP'
Per capita consumption of Energy resources	1980-2005	The unit of the data is in (Million Btu), the natural log of the variable is used. The variable is presented as 'PCC'

3.1 Data Sources

The study deals with secondary data. Data are collected from 'Energy Information Administration (EIA[4])' website which is the official Government website of US Government. As well as many secondary data are also collected from different Government of India websites such as Ministry of Statistics and Programme Implementation[5], NATCOM India[6] etc. Information on the Indian Economy and the basic macro economic profile of the country is collected from different Government of India published documents and web search.

4 Energy Sector and the Indian Economy: an overview

India occupies a strategic position in Asia, looking across the seas to Arabia and Africa in the west and to Myanmar, Malaysia and the Indonesian archipelago in the east. Geographically, the great Himalayan ranges keep India apart from the rest of Asia. The mainland comprises seven regions which are, the northern mountains including the Himalayas and the north eastern mountain ranges; the Indo-Gangetic plain; the Thar desert; central highlands and the peninsular plateau; east coast; west coast; and bordering seas and islands.

India is a fast growing developing economy. In the post-reform period India remains a developing economy. Three-quarters of the population lives in the rural areas. Vast informal and traditional sectors with weak market relations co-exist with the growing formal and the modern sectors. The traditional to modern transitional dynamics is expected to continue in the foreseeable future. The real national income in India grew annually at a rate of nearly 6% in the latter half of the last decade, and at 6.4% in 1999-2000 (GOI, 2001). Real GDP growth is projected at around 6% over the next several years (GOI, 2001). Table 1 gives an economic profile of India and Table 2 gives the contribution of the agriculture, industry, transport, and commercial/services sectors to the GDP.

[4] www.eia.doe.gov
[5] http: // mospi.nic.in/mospi_energy_stat.htm
[6] http: // www. natcomindia. org/pubenergy.htm

Table 1: Macroeconomic Profile of India

Year	1980-81	1985-86	1990-91	1995-96	1999-2000
GNP at Factor Cost* (Rs. Billion)	4020.04	5111.29	6838.50	8869.61	11403.89
Annual Growth Rate+ of GNP* (%)	7.3	4.9	5.5	7.5	6.5
Population (Million)	683.3	754	846.3	934.2	1000
Per Capita Net National Product* (Rs.)	5352.7	6082.9	7322.8	8498.5	10204.1

* At constant 1993-94 prices, + Average growth rate over five years
Source: GOI (2001)

Table 2: Sectoral Composition of India's GDP*

Year	1980-81	1990-91	1995-96	1999-2000
Agriculture	1677.70	2420.12	2751.53	3167.80
Industry+	866.05	1697.03	2290.98	2837.16
Services++	1467.87	2813.36	3953.12	5514.95

* All figures are in Rs Billion, at constant 1993-94 prices
+ Industry includes Manufacturing, Mining, Construction, Electricity, Gas and Water Supply
++ Services sector includes Commercial, Transportation, Finance, Real Estate, Communication, Trade, Hotels & Restaurants
Source: GOI (2001)

In the last two decades, the share of agriculture in the economy has declined substantially while that of industry and services has increased. This is evident from the recent trends (Table 2). There has been a significant slowdown in agriculture and allied sector growth from 7.1% in 1998-99 to a mere 0.7% in 1999-2000, despite a record level of food grains production in 1999-2000. There was a significant improvement in the overall growth in industrial value added from 3.4% in 1998-99 to 6.8% in 1999-2000. This was due to growth in value added by the manufacturing sector from 2.5% in 1998-99 to 6.8% in 1999-2000, and that in construction from 6.1% to 8.1% over the same period (GOI, 2001).

Service sectors too performed well in 1999-2000. Average growth rate of trade, hotels, transport and communication, improved from 7.1% in 1998-99 to 8% in 1999-2000 and that of financial, real estate and business services grew from 8.4% to 10.1% over the same period (GOI). India's balance of payments situation remained comfortable in 1999-2000. The deficit on the current account increased only marginally from US $ 4 billion in 1998-99 to US $ 4.2 billion in 1999-2000 (GOI, 2001). As percentage of GDP, the current account deficit recorded a marginal decline from 1 per cent in 1998-99 to 0.9 percent in 1999-2000. The trade deficit on the BOP account widened to US $17.1 billion or 3.8 per cent of GDP in 1999-

2000 from US $ 13.2 billion (3.2 per cent of GDP) in 1998-99. Exports made a welcome recovery from a negative growth of (-) 3.9 per cent in 1998-99 to 11.6 percent in 1999-2000. Total imports, on payment basis, also rose sharply by 16.5 per cent in 1999-2000 mainly due to a 63 per cent increase in the oil import bill. Export growth accelerated further in the financial year 2000-2001. Merchandised exports in US Dollar value in April-December 2000 witnessed a strong growth of 20.4 per cent, much higher than 10.3 per cent in April-December 1999. Imports grew by 9.0 per cent in April-December 2000 compared to 10.7 per cent in April-December, 1999. The rise in imports was primarily due to the continued surge in oil imports, which increased sharply by 78.2 per cent due to hardening of international oil prices. The spurt in POL imports has, however, been offset by non-POL imports, which have declined by 8.3 per cent, reflecting weak domestic demand and subdued industrial activity. The continued buoyancy in exports and the declining trend in non-POL imports have resulted in a substantial decline in customs trade deficit from US $ 8.2 billion in April-December 1999 to US $ 5.9 billion in April-December 2000 (GOI, 2001). The year 2000-01 began with an inflation rate of 6.75 per cent. Over three fourths of this inflation rate may be attributed to the increase in the administered prices of fuel products like liquid petroleum gas (LPG), aviation turbine fuel (ATF) and kerosene in March 2000. Inflation rate hovered a little over 6 per cent in the first half of the year (April-September 2000), when a further increase in the prices of petroleum products - LPG, kerosene, diesel and petrol - at the end of September, caused the inflation rate to cross the 7 per cent level (GOI, 2001).

India's population reached one billion in the year 1999. Its population is growing at a rate of about 1.7% per annum. If India continues on the projected demographic path it would become the most populous country by the middle of the present century with a population of 1.53 billion. India has achieved substantial improvements in infant mortality rates (per 1000 live births). The infant mortality rate (IMR) has reduced from 146 in 1951 to 70 in 1999. Life expectancy, which stood at 37.2 for males and 36.2 for females, reached 62.4 for males and 64 for females by the end of the last century (GOI, 2001). According to the survey conducted by the National Sample Survey Organization (NSSO), under the Department of Statistics, the literacy in India has increased from 52.21% in 1991 to 62% presently.

From the above macro economic profile of India it is obvious that India is developing rapidly as well as the other indicators such as IMR, literacy rate, human development index etc. are too attaining higher growth. With the implementation of the new economy policy, India now

has become one of the major developing countries in the world. The industrialization process in the country has supported the economy to grow rapidly. As indicated earlier energy consumption is an important factor for the growth of any economy it is important to study the energy use pattern in India, to investigate the nature and trend of the energy consumption. The next section deals with the energy scenario of the country as well as deals with different sources of the energy consumption and production.

4.1 Energy scenario in India

The decade of seventies has witnessed major world oil supply disruptions. During the 1970s the OPEC production was cut down by two and a half per cent causing severe oil supply distortions. From 1975 oil prices remained high but not as high as in 1973-74. But the Iranian revolution in 1979 worsened the situation and oil prices again rose sharply in 1979, generating the second oil shock. From the mid 1980s, there was again a resumption of the growth of demand for refined products. This demand upsurge led to an increase in oil prices from the late 1980s. From July to October 1990, following Iraq's invasion of Kuwait, there was a near doubling of oil prices. However, this 1990 oil price shock had substantially lesser impact on the world economy than the other two oil price shocks (Mukhopadhyay, 2002). The reason for this diminished effect was the short duration (only 4 months) of the 1990s oil price hike, the substitution of oil, to a large extent, by competing energy sources and an overall recession of economic activities that had already begun before the price hikes. India being an oil importing country witnessed significant changes in the energy consumption pattern due to the oil shocks.

Faced with rising inflation and a balance of payment crisis in mid 1991 the government of India introduced a fairly comprehensive policy reform package comprising currency devaluation, deregulation, de-licensing, privatisation of the public sector. The government of India initiated these policy changes to overcome the critical situation. The rising oil import bill has been the focus of serious concerns due to the pressure it has placed on scarce foreign exchange resources.

The brief discussion about the commercial energy shows that the country is having potential in some cases but utilization is not up to the desired level. From the oil front, it is apparent that country has to rely on import. Due to the volatility of the international market country’s import bill is rising. On the other hand transmission and distribution losses are making the

electricity sector critical. The industrial sector in India is a major energy user, accounting for about 65% of the commercial consumption (EIA, 2004). There are wide variations in energy consumption among different units within the same industry using comparable technology.

Table 3: Growth of energy consumption in different sectors of the economy

Years	Energy consumed in agriculture	Energy consumed in industry	Energy consumed in transport	Energy consumed in services
1990-91	4.36	56.01	24.93	14.69
1991-92	4.75	55.89	24.85	14.50
1992-93	4.96	55.69	24.88	14.47
1993-94	5.31	55.43	24.67	14.60
1994-95	5.70	54.74	24.74	14.81
1995-96	5.19	53.53	27.87	13.41
1996-97	5.16	57.14	26.06	11.64
1997-98	5.40	48.01	29.49	17.10
1998-99	4.86	44.04	31.29	19.82
199-00	4.79	45.69	32.30	17.31
2000-1	3.53	47.26	32.64	17.56
2001-2	3.02	46.52	33.30	17.75
2002-3	3.33	49.52	31.93	15.27
2003-4	3.85	47.05	32.16	17.27

Source: TEDDY, Teri report various issues

Table 3 reflects the growth pattern of the energy consumption in different sectors of the economy since the 1990s. Transport sector shows high energy consumption growth through out. Though the industrial sector records high growth in first half of the 1990s but it starts decline from later half of the 1990s.

4.1.1 Energy Consumption in India

India's per capita commercial energy consumption, increased from 9% of global average in 1965 to 19.4% in 2000 (TERI, 2000). In 1998-99, commercial energy consumption in India was estimated at 195.11 MT of oil equivalent, indicating a 75% growth over a decade. However, India’s per capita consumption of commercial energy continues to be much lower than the global average of about 1684 Kg of oil equivalent and is 5-10% that of developed countries like Japan, France and the USA. In India, commercial energy demand grew at six percent (CMIE, 2001).

Energy Consumption by Sources: Overall Production and Consumption

India is both a major energy producer and consumer. India currently ranks as the world's eleventh greatest energy producer, accounting for about 2.4% of the world's total annual energy production, and as the world's sixth greatest energy consumer, accounting for about 3.3% of the world's total annual energy consumption. Despite its large annual energy production, India is a net energy importer, mostly due to the large imbalance between oil production and consumption. An historical summary of India's Total Primary Energy Production (TEP) and Consumption (TPEC) is shown in Table 4.

Table 4: India's TEP and TPEC, 1993-2003

(in Quads)

	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003
TEP	7.49	8.00	9.48	8.75	9.17	9.37	9.58	9.83	10.23	9.99	10.15
TPEC	9.24	9.97	11.49	11.14	11.76	12.17	12.74	13.50	13.85	13.79	14.03

note: 1 Quad = 1 quadrillion Btu
Source: EIA, 2006

Petroleum

India's proved oil reserves are currently estimated (January 2005) at about 5 billion barrels, or about 4.5% of the world total. Most of these reserves lie offshore near Mumbai and onshore in Assam state. However, exploration is still happening, and India's off-shore and on-shore basins may contain as much as 11 billion barrels. India presently ranks as the 25th greatest producer of crude oil, accounting for about 1% of the world's annual crude oil production. About 30% of India's energy needs are met by oil, and more than 60% of that oil is imported. A strong growth in oil demand has resulted in India's annual petroleum consumption increasing by more than 75% from what it was a decade ago. India is currently the world's sixth greatest oil consumer, accounting for about 2.9% of world's total annual petroleum consumption. An historical summary of petroleum production and consumption in India is shown in Table 5.

Table 5: Petroleum Production and Consumption in India, 1993-2003

(in thousands of barrels per day)

	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003
Production (total)*	578	651	770	751	780	761	765	770	782	813	815
Production (Crude Oil only)	534	590	703	651	675	661	653	646	642	665	660
Consumption	1,311	1,413	1,575	1,681	1,765	1,844	2,031	2,127	2,184	2,263	2,320

* includes crude oil, natural gas plant liquids, other liquids, and refinery processing gain
Source: EIA, 2006

Natural Gas

India's natural gas reserves are currently estimated (as of January 2005) at about 29-32 trillion cubic feet (tcf), or about 0.5% of the world total. Most of these reserves lie offshore northwest of Mumbai in the Arabian Sea and onshore in Gujarat state. India does not yet rank in the top 20 of the world's greatest natural gas consumers, but that will soon change. Natural gas has experienced the fastest rate of increase of any fuel in India's primary energy supply; demand is growing at about 4.8% per year and is forecast to rise to 1.2 tcf per year by 2010 and 1.6 tcf per year by 2015. An historical summary of natural gas production and consumption in India is shown in Table 6.

Table 6: Dry Natural Gas Production and Consumption in India, 1993-2003

(in tcf)

	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003
Production	0.53	0.59	0.63	0.70	0.72	0.76	0.75	0.79	0.85	0.88	0.96
Consumption	0.53	0.59	0.63	0.70	0.72	0.76	0.75	0.79	0.85	0.88	0.96

note: "dry" gas means gas with condensates removed
Source: EIA, 2006

Coal

India's has huge proven coal reserves, estimated (as of January 2005) at more than 90 billion tons, or about 10% of the world's total. Most of these reserves are relatively high ash bituminous coal and are located in Bihar, West Bengal, and Madhya Pradesh states. At the current level of production and consumption, India's coal reserves would last more than two hundred years. India is currently the third-largest coal-producing country in the world (behind

China and the United States), and accounts for about 8.5% of the world's annual coal production. India is also currently the third-largest coal consuming country (behind the China and the United States), and accounts for nearly 9% of the world's total annual coal consumption. More than half of India's energy needs are met by coal, and about 70% of India's electricity generation is now fueled by coal. The annual demand for coal has been steadily increasing over the past decade, and is now nearly 50% greater than it was a decade ago. Even though India is able to satisfy most of its country's coal demand through domestic production, less than 5% of its reserves is coking coal used by the steel industry. As a result, India's steel industry imports coking coal, mainly from Australia and New Zealand, to meet about 25% of its annual needs. An historical summary of coal production and consumption in India is shown in Table 7.

Table 7: Coal Production and Consumption in India, 1996-2005

(in millions of tons)

	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005
Production	295.56	311.96	323.63	319.93	326.58	337.94	352.60	367.29	389.20	412.95
Bituminous	273.41	289.32	300.40	296.51	304.10	313.69	327.79	341.27	361.24	382.61
Lignite	22.15	22.64	22.23	23.42	22.48	24.25	24.81	26.02	27.96	24.34
Consumption	332.2	358.5	362.9	375.4	406.1	413.6	430.6	430.6	N/A	N/A

note: components may not add to total due to rounding
Source: GOI, 2006

Electricity

India is presently the sixth-greatest electricity generating country and accounts for about 4% of the world's total annual electricity generation. India is also currently ranked sixth in annual electricity consumption, accounting for about 3.5% of the world's total annual electricity consumption. Overall, India's need for power is growing at a prodigious rate; annual electricity generation and consumption in India have increased by about 64% in the past decade, and its projected rate of increase for electricity consumption is one of the highest in the world. An historical summary of electricity generation and consumption in India is shown in Table 8.

Electricity consumption in India has more than doubled in the last decade. The primary energy supply in the country is coal-dominant, with the power sector accounting for about 40

percent of primary energy and 70 percent of coal consumption (CMIE, 2000). The Indian power sector is characterized by large demand-supply gap. Faced with unreliable power supply, many industries have invested in on-site power generation that now accounts for more than 10 percent of total capacity (CMIE, 2000). Five regional grids operate in India, with regional grids connecting state transmission networks within a region.

Table 8: Electricity Generation and Consumption in India, 1997-2005

(in billions of kilowatt-hours)

	1997	1998	1999	2000	2001	2002	2003	2004	2005
Net Generation	441.1	470.7	504.3	529.1	548.0	563.5	556.8	558.33	587.37
hydroelectric	73.9	82.2	79.9	73.7	73.0	63.5	68.5	73.77	84.50
nuclear	10.4	10.6	11.4	14.1	18.2	17.8	16.4	17.77	16.84
geo/solar/wind/ biomass	0.9	1.0	2.3	2.9	3.9	4.1	4.2	n/a	n/a
conventional thermal	355.8	376.8	410.7	438.5	453.0	478.2	467.7	466.82	486.03
Net Consumption	411.6	439.0	470.1	493.4	510.9	525.4	519.0	n/a	n/a
Imports	1.6	1.5	1.4	1.5	1.5	1.5	1.4	1.4	1.4
Exports	0.1	0.2	0.3	0.2	0.3	0.2	0.2	0.2	0.2

n/a - not applicable
note: generation components may not add to total due to rounding
Source: EIA, 2006 and GOI, 2006

Renewable Energy Sources

Though the present contribution of renewable energy is small, existing capabilities offer the flexibility to respond to emerging environmental and sustainable development needs. Renewable energy technologies (RETs) have a vast potential and have the advantage of being environmentally sustainable. Table 9 gives a detailed estimated potential for RET in India.

Table 9: Estimated Potential for RETs in India

Source/System	Approximate Potential
Biogas Plants (In Numbers)	12 million
Improved Cookstoves (In Numbers)	120 million
Biogas Power Plants	17000 MW
Solar Energy	20MW/km^2
Wind energy	45000 MW
Small hydro Power	15000 MW
Ocean energy	5000 MW
Urban and Industrial Wastes	1700 MW

Source: GOI, 2000

Small Hydro Power

Hydro based power generation up to 25 MW capacity, classified as small hydropower, and offers a number of advantages for electricity generation. It has been one of the earliest known renewable energy sources, in existence in the country. Estimates place the small hydro potential in India at 15,000 MW (TERI 2000). Since a large potential of this technology exists in remote hilly areas, development of small hydropower for decentralized power generation leads to rural electrification and local area development. The gestation period of the technology is low and the indigenous manufacturing base is strong.

Wind Power

India is positioned among the top five countries in wind power installation after Germany, the USA, Denmark, and Spain. Wind power capacity reached nearly 1267 MW by December 2000 with an aggregate generation of about 6.5 billion units of electricity. Private projects constitute around 95.5 percent of the total capacity and the rest are demonstration projects. Out of the total energy generated, about 80 percent of consumption is for captive purposes while the rest is sold to the grid. Wind energy is one of the clean, renewable energy sources that hold out the promise of meeting energy demand in the direct, grid-connected modes as well as stand-alone and remote 'niche' applications (for instance water pumping, desalination, and telecommunications) in developing countries like India. Estimates place the economical wind energy potential in India at 45,000 MW (GOI, 2001).

Biomass-based Power Generation/Cogeneration

Biomass, consisting of wood, crop residues and animal dung continues to dominate energy supply in rural and traditional sectors, having about one-third share in the total primary energy consumption in the country. Cogeneration technology, based on multiple and sequential use of a fuel for generation of steam and power, aims at surplus power generation in process industries such as sugar mills, paper mills, rice mills, etc. The aggregate biomass combustion based power and sugar-cogeneration capacity by the end of December 2000 was 273 MW, with 210 MW of cogeneration and the rest biomass power. In the area of small-scale biomass gasification, a total capacity of 35 MW has so far been installed, mainly for stand-alone applications (TERI, 2000).

Solar Technologies

Solar Photovoltaic (SPV) contributes at present around two and a half percent of the power generation based on renewable energy technology in India. Solar photovoltaic systems with an aggregate capacity of 47 MW have been deployed for different applications (GOI, 2001), that includes solar photovoltaic power projects aggregating 1.615 MW for providing voltage support in rural areas and peak load shaving in urban areas. Solar thermal technologies have a very high potential for applications in solar water heating systems for industrial and domestic applications and for solar cooking in the domestic sector. Solar Thermal Power Generation potential in India is about 35 MW per Sq. Km Estimates indicate 800 MW per year potential for solar thermal based power generation in India during the period 2010 to 2015, with worldwide advancements in the parabolic trough technology (TERI, 2000). The technologies for power generation using solar thermal technology are parabolic dish, parabolic trough collectors, central receivers, solar ponds and solar chimneys. Dissemination of SPV technology has been undertaken by a technology-push approach adopted by the government.

5 Empirical Results

From the discussion above in the review of literature section conforms that there is a strong one way/two way causal relationship between energy consumption and GDP. Here we have tried to find out the relationship between GDP with many other variables (detail given in Box 2). For the specific objectives of our study we have followed a trend analysis and regression models. To find out the structural break, we have applied double log regression model using multiplicative dummy.

5.1 Trend analysis

Growth of Production of energy resources

Table 10 depicts the production and growth rate in production of energy resources of the country from 1980 to 2005. From the table it is clear that the production of the total primary energy resources has considerably increased from 1980 till 2005. The growth rate of the production has been calculated for different time periods. The first phase from 1980 to 1985 has recorded the highest growth rate in production of the energy resources. Again the third phase from 1991 to 1996 has recorded the second highest growth rate. However other time phase has not recorded rapid growth rate. The new economic policy partially implemented from 1990, and that may be one of the reasons for the rapid growth rate in the production for 1991-1996. But during the implementation phase from 1995 even the production of the energy resources has increased but the growth rate was not more rapid. From the total production point of view the country has recorded an increasing trend at a diminishing rate. When the growth rate of the production is calculated considering that the structural break in Indian economy took place after 1990, the result shows that the growth rate of the production was faster from 1980 to 1990 (7.11%) compared to 1991 to 2005 (3.22%) (Table 11). The growth rate of production of energy resources was calculated to be 4.57% from 1980 to 2005 (Table 11). The growth rate from 1980 to 1990 was more rapid than 1980 to 2005. During the previous time frame the country has started developing and the development process started form 1991 onwards. When we compare the growth rate at three different times the result shows that the growth rate of the production of the energy resources for the entire period from 1980 to 2005 is less that of the growth from 1980 to 1990 and more than the next period from 1991 to 2005. In the second period the country has more depended on the imports and may be that is one of the reasons that the extraction and production rate of the

energy resources was more rapid from 1980 to 1900 compared to the other time frame (1991-2005). The growth of production of energy resources is presented in figure 1 below.

Figure 1: Growth rate of energy Production in India from 1980 to 2005 at different time period

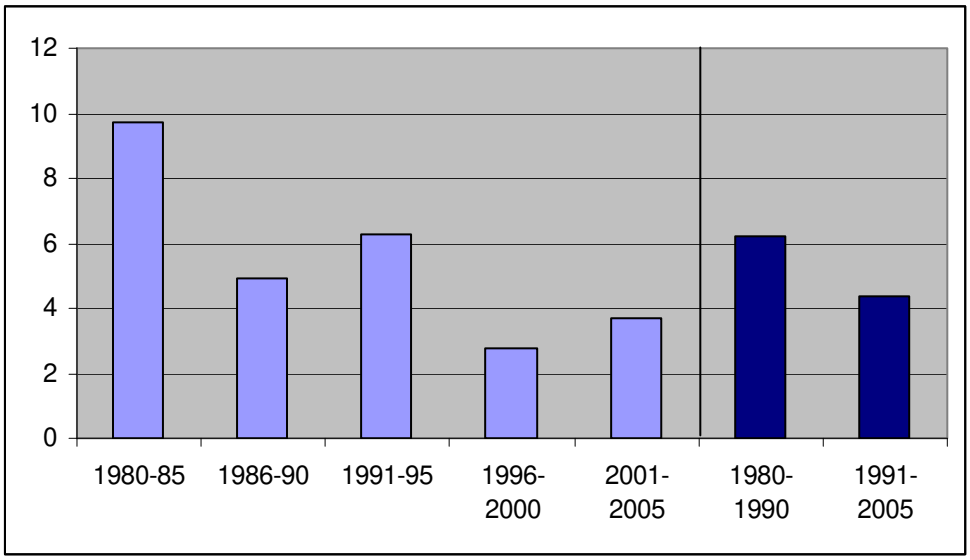


Table-10 Growth of Production of energy resources, Consumption of energy resources and GDP from 1980-2005

Year	TEP	Growth Rate	TPEC	Growth Rate
1980	3.10		4.04	
1986	5.67	**9.7**	6.35	**7.04**
1991	7.16	4.9	8.37	5.58
1996	8.74	**6.28**	11.04	**7.15**
2001	10.29	2.74	13.93	4.93
2005	11.73	3.68	16.20	4.07

Note: TEP in (Quadrillion (10 15) Btu), growth rate in %, TPEC in (Quadrillion (10 15) Btu)

Table-11: Growth rate of TPEC and TEP in different time frame from 1980-2005

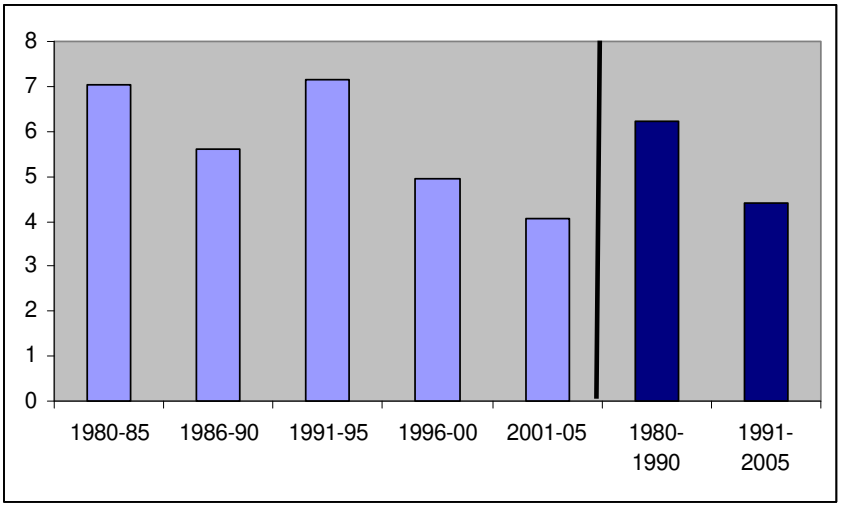
Year	TPEC (%)	TEP (%)
1980-1990	6.22	7.11
1991-2005	4.38	3.22
1980-2005	5.28	4.57

Consumption

The consumption of total primary energy resources and their growth rate is given in table 10. The consumption has been increasing from 1980 at a faster rate. 1980 to 1985 has recorded the highest growth rate in consuming energy in India, and the next highest growth rate has calculated for the period 1991 to 1996. The calculated growth rate in consumption for the

different time period is being positive but except the above two periods all other periods the rate of growth is not much rapid. The consumption during 1991 to 1996 was more rapid as that was the period when the new economic policy was at the beginning stage. After 1996 the total primary energy consumption has increased but at a decreasing rate. Considering the structural break in 1990 the growth rate was calculated and the result found to be more faster for 1980 to 1990 (6.22%) compared to 1991 to 2005 (4.38%) (Table 11). The overall growth rate from 1980 to 2005 in consumption is calculated to be 5.28% (Table 11). The consumption was more rapid in the first phase compared to the second as well as compared to the overall growth rate. Hence is can be said that in the developing process from 1980 to 1990 there has been more rapid energy consumption. Figure 2 presents the growth rate in total primary energy consumption.

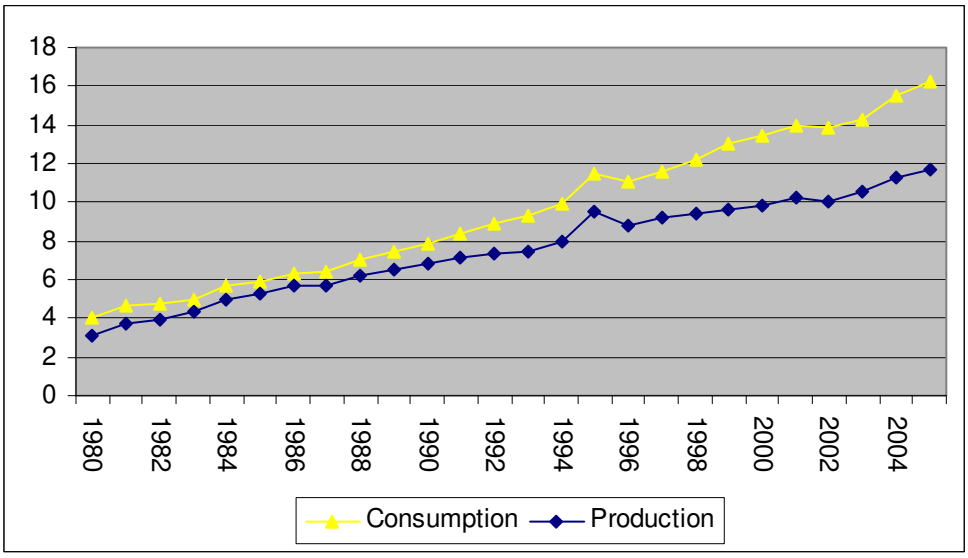
Figure 2: Growth rate of energy consumption in India from 1980 to 2005 at different time period



Production and Consumption

From table 10 its clear that growth rate in production is more than that of consumption from 1980 to 1985, but the scenario has changed and in due time period the rate of growth in consumption moved more faster then that of the total primary energy consumption. From 1991-1995 the growth rate of consumption has recorded faster than the growth rate in production. Figure 3 presents the trend line of production and consumption of energy resources from 1980-2005.

Figure 3: Primary total energy Consumption and Production (1980-2005)



From figure above we can see that both the energy consumption as well as the production of the energy resources is increasing from 1980 till 2005. However the gap between the consumption and production is also increasing in other words the gap between both is becoming wider in recent years. Specially, after the country adopted the liberalized economy the gap between them is more compared to the past experiences. It should be noted that the import of the crude oil and petroleum products has been more rapid after 1990 and as the economy is developing more rapidly with the rapid industrialization process more and more energy is consumed.

Per capita consumption

The growth rate of per capita use of energy resources was calculated to be highest during 1991-1995 (5.45%), compared to 1980-1985 (5.10). However from 1986-1990 and 1996-200 the rate of growth was calculated to be 3.71% and 3.21% respectively (Table 12). During 2001-2005 the rate of growth in per capita energy consumption was at a slow rate of growth and calculated to be 2.43%. From 1980 to 1985 both total consumption and production growth rate was found to be highest and again during 1991-1995 the growth rate was found to be highest. From the per capita energy consumption we found during those years the rate of growth was highest. The per capita consumption of energy resources is increasing but the rate of growth of per capita consumption is following a decreasing trend as observed from table 12.

Table-12: Growth rate of Population, per capita consumption of energy resources from 1980-2005

Year	Population	Growth Rate	PCC	Growth Rate	GDP	Growth Rate
1980	684.89		5.9		679	
1986	775.06	2.04	8.2	5.1	771	0.31
1991	853.72	1.93	9.8	3.71	856	0.29
1996	934.69	1.79	11.8	5.45	946	0.26
2001	1,021.97	1.77	13.6	3.21	1037	0.26
2005	1,093.56	1.67	14.8	2.43	1107	0.24

Note: Population in millions, growth rate in percentage and PCC in Million Btu, GDP in Rupees in Crore

Table-13: Growth rate of PCC, population and GDP in different time frame from 1980-2005

Year	PCC (%)	Population (%)	GDP (%)
1980-1990	4.30	2.00	0.30
1991-2005	2.67	1.76	0.25
1980-2005	3.49	1.84	0.27

When we analyse the trend in population we can see that the rate of growth of population is decreasing in the given time frame, however in real term the population is rising. The highest rate of growth in population was calculated during 1980-1985 (2.04%), and continuously the growth trend is decreasing till 2005 (Table 12). The calculated growth rate of the population for the full sample from 1980-2005 is 1.84%, which is more than the growth rate from 1980-1990 and less than 1991-2005 (Table 13). Even the population is growing at a faster rate compared to other developing countries but from 1980 to 2005 the rate of growth of population has came down and so as the per capita consumption of energy resources. The real GDP is increasing from 1980 to 2005 as given in table 13. The GDP growth has recorded a positive growth from 1980 till 2005. However the growth rate was more from 1980-1985 (0.31%) it has a decreasing trend afterwards. Even the rate of growth of GDP is growing in due time period, it has a declining trend. We have tried to calculated the GDP growth rate in different time period and found that the GDP growth from 1980-2005 was 0.27%, where as the growth rate was more from 1980-1990 and found to be less from 1991-2005.

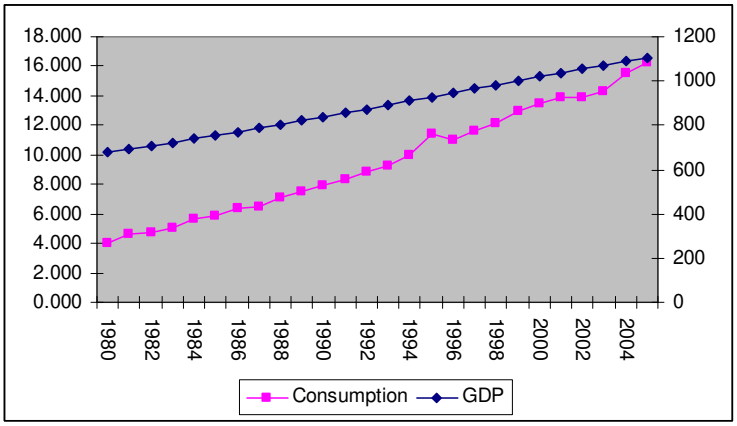
From the trend analysis of different variables above gives us an idea how all the variables in the study are behaving from 1980-2005. Many of the variables have rapid growth rate from 1980-1990 compared to 1991-2005. The consumption of the energy resources has also following the same trend. From the literature we are getting an idea that there is a relationship

between energy consumption and GDP. As evidence from the many developed and developing countries more the economy will grow more energy resources will be consumed. Due to the fact that heavy industrialization, better standard of living etc. leads to more energy use. To investigate whether there is any relationship between the energy consumption and other variables used in the study the following econometric methods are employed and verified.

Model 1- Relating Energy Use and GDP

From different studies it has been found out that many developed as well as developing countries have consumed higher energy resources while achieving rapid growth in GDP. In case of India we find that since 1980 till 2005 India is achieving a higher growth rate in GDP as well as in total primary energy consumption. Figure 4 below presents the total primary energy consumption and the GDP in real values from 1980 to 2005. The total primary consumption is taken as Quadrillion (10 15) Btu, and the GDP is taken in rupees crores. The figure below depicts the relationship between TPEC and GDP. Both the variables are having a rising trend from 1980 to 2005. However the growth of primary energy consumption is more rapid compared to GDP as shown in the figure, which reflects an idea that both the variables have a positive direction and are correlated.

Figure 4 Total Energy consumption and GDP from 1980 to 2005



In order to find out the relationship between energy consumption and GDP, in other words to check whether energy consumption can partially be determined by GDP the following regression model has been computed.

$$\ln Y_t = \alpha + \ln \beta X_t + u_t$$

Where, LnY_t = Log of total primary energy consumption from 1980 to 2005

X = Log of GDP from 1980 to 2005

Table 14: Regression result1

	Variables	Coefficient	t value	R^2	$\bar{R}^2$
Model1	Constant	-16.41	-48.33	0.96	0.95
	lnGDP	2.74	54.75*		

* relates significant at 1% level

Model 1 presents the double log regression result between total primary consumption of energy resources to GDP. Log value of the GDP as well as the consumption of energy resources has taken in order to run the model. The result is presented in table14. From the table we can observe that there is high R^2 as well as $\bar{R}^2$, 0.96 and 0.95 respectively. The t value of the independent variable (lnGDP) has turned out to be significant at 1% level and has a positive sign. Hence we can assume that the energy consumption increases with increase in GDP. In other words single unit change in log GDP leads to 2.74 unit change in energy consumption. Here we can assume that the total primary energy consumption can be determined by the GDP. The trend analysis as well the regression result shows that there is a positive relationship between the primary energy consumption and GDP. As evidence from secondary sources total primary energy consumption is one of the major determinants of GDP and higher the GDP, higher will be the energy consumption in the economy. Here too the result shows (with +ve coefficient) that growth in GDP leads to growth in primary energy consumption.

Model 2- Relating Energy use Per capita energy consumption and Total energy production

The trend analysis gives us a clear picture that there may be link between total energy consumption, per capita energy consumption and the production of energy resources. It is evidence from figure 3, the gap between the consumption of energy resource has been getting wider recently compared to the 1980s. Hence in order to check whether there is any relationship sustains between the total primary energy consumption, per capita energy consumption and production of energy resources the following regression is formulated.

$$\ln Y_t = \alpha + \ln \beta_1 X_{1t} + \ln \beta_2 X_{2t} + u_t$$

Where, LnY_t = Log of total primary energy consumption from 1980 to 2005

X_1 = Log of per capita consumption of energy resources from 1980 to 2005

X_2 = Log of production of energy resources

Table 15: Regression result2

	Variables	Coefficient	t value	R^2	$\bar{R}^2$
Model2	Constant	-1.44	-12.82	0.97	0.96
	lnPCC	1.66	12.84*		
	lnTEP	-0.11	-1.19		

* relates significant at 1% level

In the regression model 2 we have tried to examine the regression with log of energy consumption as the dependent variable and log of per capita consumption and production as the independent variables. From the table 15 we can observe that the per capita energy use has turned out to be highly significant where as the production of energy sources has turned out to be insignificant. From the coefficient value of the per capita consumption we can however assume that one unit change in the log of per capita consumption leads to 1.66 unit change in the total energy consumption. Here the production variable has turned out with a negative sign. However it should be noted that in this model we are getting high R^2 as well as $\bar{R}^2$ value. It is quite evident from the result that one of the partial determinate of the primary energy consumption is per capita energy consumption. There is a positive relationship between the PCC and the TPEC. As from the total consumption point of view per

capita consumption has a major share a unit growth in the PCC lead to significant change in the total energy consumption of the economy. After 1990-91, with the liberalize market in India most of the energy needs met from the imports of the energy resources. That is one of the reasons why in the trend analysis we are getting the slower growth rate in case of production of the energy resources after the 1990s. That might be one of the reasons why we are getting a negative sign in the coefficient value of the total energy production.

Model 3

Model 1 above described the regression result of the total energy consumption and the GDP, where we found that there is a positive relationship between both of them and energy consumption may be one of the determinate of the GDP of the country. But the previous trend analysis of both the variables shows that they are showing higher growth in real terms but have a decreasing growth rate from 1980 to 2005. Hence it is necessary to look at the structural stability of the regression model we had carried out. In order to carry out the new model we have divided the sample period into two, 1980-1990 and 1991-2005. Considering that in the Indian economy context the structural break was taken place during 1990, we have introduced another variable a dummy for this regression. Again with the help of the multiplicative dummy we have tried to get the structural stability in the regression using the following equation:

$$\ln Y_t = \alpha_1 + \alpha_2 D_t + \ln \beta_1 X_t + \beta_2 \left(D_t X_t \right) + u_t$$

Where lnY = Log of total Primary energy consumption from 1980 to 2005

lnX = Log of GDP from 1980 to 2005

t = time

D = 1 for observations in 1991-2005

= 0, otherwise (i.e., for observations in 1980-1990

Intercept Dummy (D_t)

As mentioned above the intercept dummy (D) is equal to 1 for observation from 1991 to 2005 and equal to 0 for observations from 1980 to 1990.

Slope Dummy (D_tX_t)

The slope dummy for the above regression equation is defined as the intercept dummy multiplied with the log of GDP. The necessity of taking this dummy is to investigate the nature of the regression with a structural break.

Assuming that $E(u_i) = 0$, we obtain

Mean energy consumption function for 1980-1990:

$$E(Y_t / D_t = 0, X_t) = \alpha_1 + \beta_1 X_t$$

Mean energy Consumption function for 1991-2005

$$E(Y_t / D_t = 1, X_t) = (\alpha_1 + \alpha_2) + (\beta_1 + \beta_2) X_t$$

Table 16: Regression result 3

	Variables	Coefficient	t value	R^2	$\bar{R}^2$
Model3	Constant	-18.19	-19.79	0.94	0.93
	lnGDP	3.01	21.70 *		
Intercept	dummy1	3.92	3.42*		
Slope	dummy2	-0.57	-3.38*		

* relates significant at 1% level

The result of the above regression is given in table 16. We have tried two models for the above equation 1. In the first case we have tried to regress taking the log of consumption with two dummy variables [(D = 1 for observations in 1991-2005, D = 0, otherwise (i.e., for observations in 1980-1990)] and log of GDP as the dependent variable. As the regression result show, both the differential intercept and slope coefficients are statistically significant. As given in the table shows, ceteris paribus, the annual consumption of energy resources has increased to 3.92 units from 1980-1990 where as the annual consumption of energy resources

has declined to 0.57 units from 1991-2005. However the log of GDP in the model has turned out to be statistically significant with high t value and from the result we can assume that one unit change in log GDP leads to 3.01 unit change in log of annual primary energy consumption. From the above result we can however say that as the slope dummy coefficient has taken a negative sign it means the rate of growth of the energy consumption has been slower down from 1991-2005 compared to the previous period. How ever the slope dummy has a positive sign and gives a clear picture that the rate of growth of the energy consumption with GDP was more than from 1991-2005. The same kind of result was attained from the trend analysis, where as now we able to relate the two time frames and can see how the energy consumption has changed in due time period.

Model 4

From the trend analysis we can see that both primary energy consumption as well as the population of the country are rising in real term, where as the growth rate is decreasing, hence there might be a relationship between both of them. To verify that we have calculated the correlation coefficient between them and found that they are highly positively correlated. Again it should be noted that the growth rate of the two variables are more from 1980-1990 compared to 1991-2005.

Table 17: Correlation between TPEC Population

lnTPEC	1.0000	
lnpopulation	0.9954	1.0000

(obs=26)

Hence in this case we tried to find out the structural break in the regression using the following equation:

$$\ln Y_t = \alpha_1 + \alpha_2 D_t + \ln \beta_1 X_t + \beta_2 \left(D_t X_t \right) + u_t$$

Where lnY = Log of total Primary energy consumption from 1980 to 2005

lnX = Log of population from 1980 to 2005

t = time

D = 1 for observations in 1991-2005

= 0, otherwise (i.e., for observations in 1980-1990

Intercept Dummy (D_t)

As mentioned above the intercept dummy (D) is equal to 1 for observation from 1991 to 2005 and equal to 0 for observations from 1980 to 1990.

Slope Dummy (D_tX_t)

The slope dummy for the above regression equation is defined as the intercept dummy multiplied with the log of population.

Assuming that $E(u_i) = 0$, we obtain

Mean energy consumption function for 1980-1990:

$$E(Y_t / D_t = 0, X_t) = \alpha_1 + \beta_1 X_t$$

Mean energy Consumption function for 1991-2005

$$E(Y_t / D_t = 1, X_t) = (\alpha_1 + \alpha_2) + (\beta_1 + \beta_2) X_t$$

Table 18: Regression result 4

	Variables	Coefficient	t value	R^2	$\bar{R}^2$
Model4	Constant	-19.28	-19.13	0.96	0.95
	Lnpopulation	3.17	20.88*		
Intercept	dummy1	4.39	3.50*		
Slope	dummy2	-0.64	-3.46*		

* relates significant at 1% level

Adding the log of population as a dependent variable we have tried to estimate the double log regression model using the dummy as described above. However the population variable has turned up to be positive in the model and turned up to be highly significant. From the coefficient value of the log of population we can assume that one unit change in log of population leads to 3.17 unit change in the log of energy consumption. As given in the table 18, ceteris paribus, the annual consumption of energy resources has increased to 4.93 units from 1980-1990 where as the annual consumption of energy resources has declined to 0.64 units from 1991-2005 which is quite similar with the result of Model 3. The population growth rate from the trend analysis shows that it is increasing at a diminishing rate. More specifically the growth rate of population is less in 1991-2005 compared to the 1980-1990 as

well the primary consumption of energy resources. From the above regression result it is seen that the slope dummy of the regression has turned out to be negative but significant. Which reflects that the energy use of the country; has slowed down after the 1991 compared to the previous period from 1980-1990. Rapid growth of industrialization and population leads to more demand of the energy resources, as from 1990-2005 the rate of growth of population has declined, so as the rate of growth of energy demand. But still the real value of the population as well as the energy need are growing. Even the slope of the regression has became flatter from 1991-2005 compared to 1980-1990, we are in need of more energy resources sue to the rapid development as well as increase in the population.

6 Discussion

From the trend analysis as well as the regression analysis it is now clear that there is positive relationship between total primary energy consumption to GDP, population, and per capita energy consumption, however a negative relationship do exist between the energy use and the production of the energy resources in case of India. From the study one can summarize that total primary energy use is one of the key components of the GDP. Population is an important factor for the total primary energy consumption and one of the major contributors for the demand of more energy resources. Per capita energy consumption in the economy has a positive relationship with the total energy use. Hence it is one of the important factors of the total energy consumption. As evidence from the developing countries more the nation develops economically, the demand for energy resources also increases. Our findings also suggests in the same way, as increase in GDP, Population, Per capita consumption leads to more demand of energy resources.

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