

Energy Intensity in India and its Impact on GDP

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Abstract: *Energy has been acknowledged as one of the most important inputs for economic growth and human development. It is becoming progressively strong that energy efficiency needs to be crucial in energy policies around the world. The economic development of an economy rests on the availability of cost-effective and non-threatening energy sources since the level of economic development has been observed to be dependent on the energy demand. As the energy sector plays an important role in the process of economic development, it is relevant to study energy consumption levels in the various sectors, their energy intensities and other characteristics of energy consumption. Here we require an understanding about past energy-use trends and the identification of opportunities for energy savings and improved efficiency today. Energy Intensity, an important indicator shows how efficiently energy is used in the economy. We measure energy intensity by the ratio of intermediate energy input to gross value added. Energy intensity has decreased over the last decade. The energy intensity of India has been over twice that of the developed economies, claimed by the OECD (Organization of Economic Co-operation and Development) member countries. India's energy intensity is also much higher than the emerging economies, which include many Asian countries. However, since 1999, India's energy intensity has been decreasing and is expected to continue to decrease. In the present study, we have analysed energy-use data for all sectors of the Indian economy and have used energy to GDP ratio as efficiency indicators. The purpose of this paper is to analyse the relationship between energy consumption and economic growth in India for the period of 2006-2013. The energy consumption for sectors such as primary, secondary and tertiary measured in peta joules has been taken for the mentioned time period, and GDP (Rs. crores) at 2004-05 prices have been considered. The study also throws light in analyzing the relationship between total energy consumption in India with respect to energy use in industry, transport, residential and commercial sectors which are most energy intensive.*

Key words: *Energy Intensity, GDP, Energy Efficiency Indicators, Energy Consumption, Mega Joules, Peta Joules*

I. Introduction

India's energy intensity has been much higher than the emerging economies, which include many Asian countries and the ASEAN member countries as well as China. However, since 1999, India's energy intensity has been decreasing and is expected to continue to decrease.

India's contribution towards climate change has been proven in a well-documented fact that India's energy intensity has been remarkably low and has continued to be steadily declining since the mid-nineties. The overall trend of falling energy intensity can be attributed to a number of factors, such as structural shifts in economic activity towards the service sector which by its very nature has a very low energy intensity, also efficiency improvements in energy-intensive sectors like industry and transportation.

Objectives of the Study:

1. To understand the consumption of energy in the important sectors of the economy such as agriculture, industry and services and compare with the overall energy consumption in India.
2. To study the energy intensities pattern in different sectors in India.
3. To analyse the impact of the use of energy in different sectors on the Gross Domestic Product (GDP).

II. Methodology

The data analysed has been collected from The Energy Statistics and The Energy and Resources Institute (TERI) reports. We have calculated the energy intensities for the sectors studied to make a comparison with the energy intensities at the all-India level. A multiple regression model has been built to understand the impact of use of energy in different sectors on the GDP and the correlation between the energy intensities in the service sector and at the all-India level has been found.

III. Review of Literature

Christopher and Rodney (2005) have focused on energy conservation policies and have used a macro economic model-based analysis on multiple model estimation to understand the causality between energy consumption and economic growth. An interdependent causation between energy consumption and GDP was found in the study.

Stephane de la Rue du Can (2009) described the underlying residential and transport sector end use energy consumption in India. The report looks at energy used over the period 1990 to 2005 and develops a baseline scenario to 2020. They focused on developing a comprehensive strategy of national energy demand management required for developing countries like India.

The report by The Climate Institute (2013) examined the causal relationship between energy efficiency and economic growth using advanced statistical methods for countries like Australia, France, Japan, Poland, Spain, United Kingdom and United States. It provides evidence that energy efficiency measures are not unfavourable to the growth but actually contribute towards it.

Jacobo Campo and Viviana Sarmiento (2013), in their paper discussed the energy dependence of some countries and described potential implementation of energy conservation policies in others. The authors presented empirical evidence on the long-run relationship between energy consumption and real GDP through the application of a co-integration panel test and estimation methods in both directions, i.e., energy consumption to GDP and GDP to energy consumption.

Jakovac (2013) in his paper examined the relationship between economic growth and total energy consumption in Croatia using the annual data covering the period 1952–2010. He concluded that there is a bidirectional short-run causality and a unidirectional long-run causality running from total energy consumption to economic growth suggesting that energy consumption comes as a leading factor of the economy.

Renjish and Vimala (2016) in their paper analyzed the use of energy in different sectors of the economy and studied its direct impact on the economic growth of India, besides examining the influence of various forms of energy consumption growth on growth of private consumption and private investment as different components of GDP growth. The study suggested, reducing oil and natural gas consumption especially in the consumption sectors of the economy, thereby conserving energy and reduce its requirements by demand-side management and by adopting more energy efficient technologies in all sectors.

Energy Intensity in Agriculture Sector

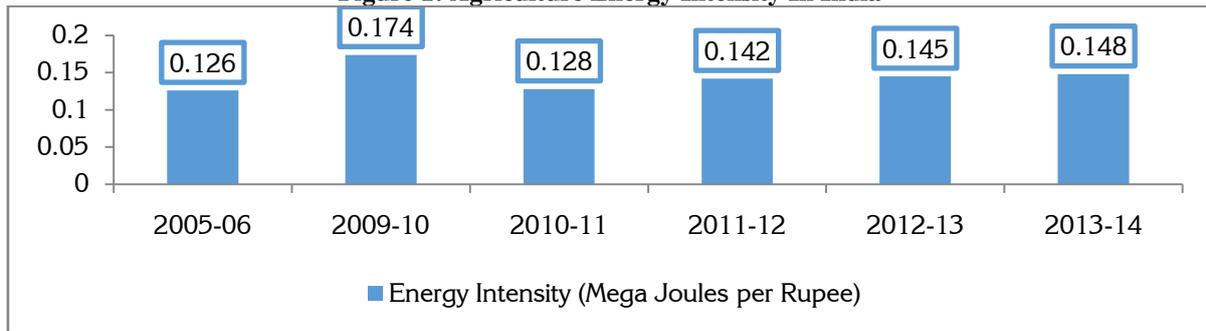
Agriculture in India occupies a significant position in the country, as it provides livelihood and employment to over 54% of the population (Census of India, 2011) and constitutes around 14% of the GDP. Use of energy in agriculture at the farm level is classified into direct energy use of diesel and electricity to operate mobile and stationary equipment/machinery to prepare fields, plant and harvest crops and transport inputs and outputs to and from markets. The consumption of energy indirectly is in the form of fertilizers and pesticides. As reported by TERI (2015), there has been an increase in the consumption of high-speed diesel (HSD) in the agriculture sector in India since the sale of tractors and agricultural machinery and implements have increased with the joint effort of the government and the private sector. The sector is a major consumer of diesel in India; it accounted for 13% of the total consumption in 2012-13. The energy intensities in this sector have increased from 0.126 in 2005-06 to 0.148 in 2013-14 (Table 1, and Figure 1) which implies that the energy use per rupee towards GDP has increased significantly since the total energy consumption in the agricultural sector has increased from 632.21 peta joules to 1004.83 peta joules for the period mentioned.

Table 1: Agriculture Energy Intensity In India

Years	Energy Intensity (Mega Joules per Rupee)
2005-06	0.126
2009-10	0.174
2010-11	0.128
2011-12	0.142
2012-13	0.145
2013-14	0.148

Source :TERI, 2015

Figure 1: Agriculture Energy Intensity In India



Source:TERI, 2015

Energy Intensity in IndustrySector

The Indian industrial sector is a major energy user accounting for around 43.6 per cent of the commercial energy consumption in 2010-11. The rapid increase in energy consumption in the industry sector during the past few years is partly due to investments in basic and energy-intensive industries, following the emphasis laid on achieving self-reliance in the past development plans. (TERI, 2015). The industrial sector contributed about 19 per cent to India’s GDP in 2009 which has increased to 27.23 percent at current prices in the year 2014. (Statistics Times, 2017).

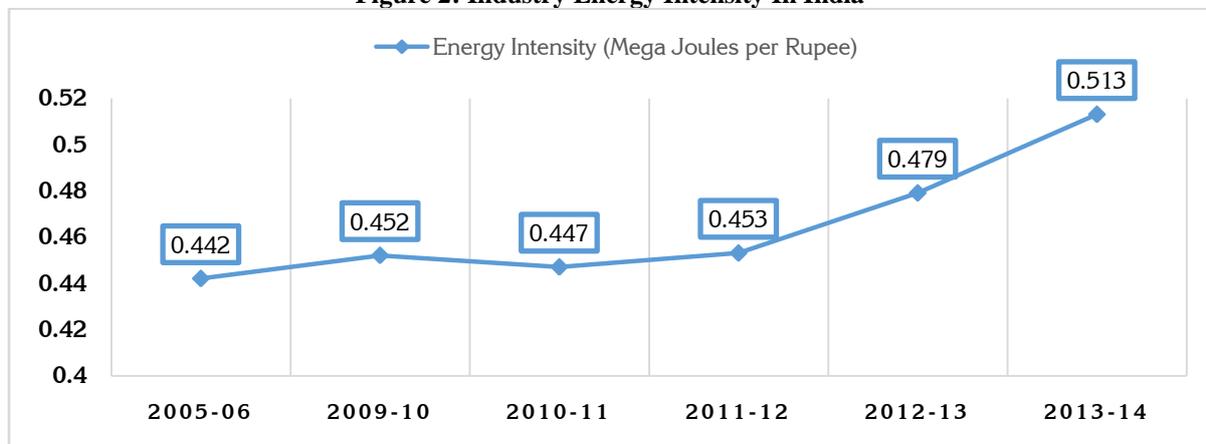
In India, the energy intensive industries are iron and steel, aluminum, cement, fertilizer, refining, and pulp and paper. The industries such as food processing, textiles, wood products, printing and publishing, and metal processing account for a lesser final energy consumption. The energy use per rupee GDP earned has increased from 0.442 Mega Joules per rupee in 2005-06 to 0.513 Mega joules per rupee in 2013-14 (Table 2, and Figure 2) and can be attributed to more energy intensive industries. At the same time there is a need to improve the efficiency to have much more reduced intensities.

Table 2:Industry Energy Intensity In India

Years	Energy Intensity (Mega Joules per Rupee)
2005-06	0.442
2009-10	0.452
2010-11	0.447
2011-12	0.453
2012-13	0.479
2013-14	0.513

Source :TERI, 2015

Figure 2: Industry Energy Intensity In India



Source:TERI, 2015

Energy Intensity in Service Sector

Given the structural changes in the economy, especially in the post-liberalization period, the services sector now accounts for a high share in the total national income—about 50 per cent in the aggregate GDP (TERI, 2015). Economic growth has paved the way for the increasing demand for services, driven by rising

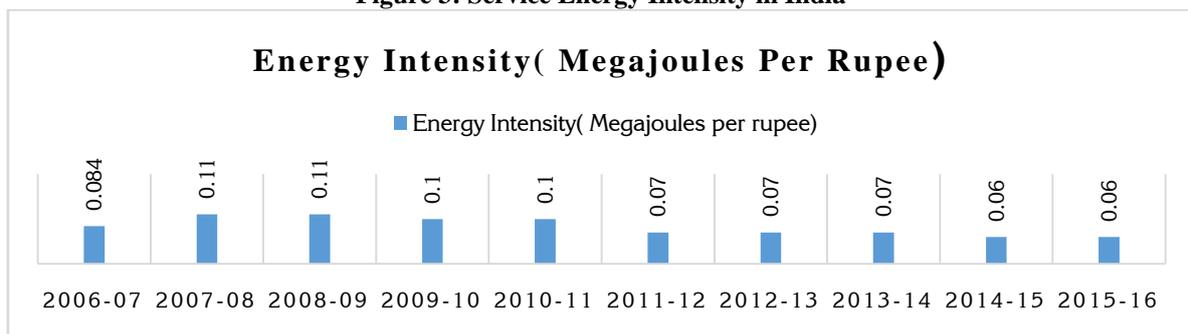
personal disposable incomes and greater purchasing power in the hands of people. Moreover, structural reforms in the banking sector have led to lower interest rates and resulted in the real estate boom (encompassing the construction of large-scale commercial buildings, shopping malls, etc. especially in urban centers), and increased government spending on the provision of public services. All these have provided an impetus to the growth of the service sector.

Table 3:Service Energy Intensity in India

YEARS	Energy Intensity (Mega Joules per rupee)
2006-07	0.084
2007-08	0.11
2008-09	0.11
2009-10	0.1
2010-11	0.1
2011-12	0.07
2012-13	0.07
2013-14	0.07
2014-15	0.06
2015-16	0.06

Source :TERI, 2015

Figure 3: Service Energy Intensity in India



Source:TERI, 2015

During 2007-2008 and 2008-2009 period energy consumption in this sector has increased rapidly. However, the energy intensity for the period studied has more or less remained steady at the level 0.06 Mega Joules per rupee. The reason being that, the contribution of the service sector in terms of GDP is more than the use of energy due to the basic nature of service sector being less energy intensive and also better energy efficiency programmes adopted in this sector.

Trends in Energy Intensity in India

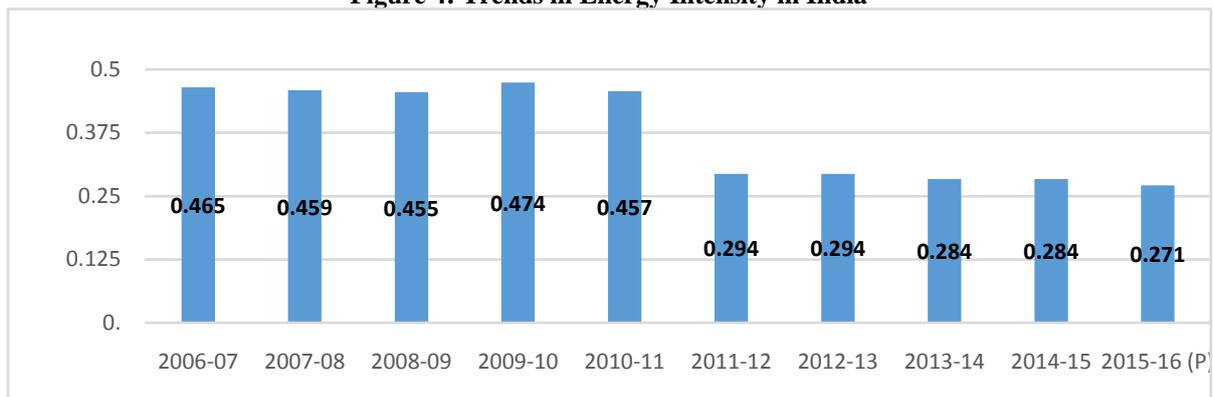
Energy Intensity is defined as the amount of energy consumed for generating one unit of Gross Domestic Product (at 2004-05 constant prices). The total consumption of energy at all India level has increased from 16571 petajoules during 2006-07 to 28258 petajoules during 2015-16. The Energy Intensity decreased from 0.465 Mega Joules per rupee in 2006-07 to 0.271 Mega Joules per rupee in 2015-16. It is observed that the Energy intensity has decreased over the last decade. This decline may be attributed to faster growth of GDP than energy demand since the services sector having a growing share of the economy and use of energy efficiency programmes, etc.).

Table 4: Trends in Energy Intensity in India

Year	Energy Intensity (Mega Joules per Rupee)
2006-07	0.465
2007-08	0.459
2008-09	0.455
2009-10	0.474
2010-11	0.457
2011-12	0.294
2012-13	0.294
2013-14	0.284
2014-15	0.284
2015-16 (P)	0.271

Source: TERI, 2015

Figure 4: Trends in Energy Intensity in India



Source:TERI, 2015

Electricity use in India

The Indian electricity sector is at present going through a major transformation since the demand has had an improved energy security policy leading to an increased use of renewable electricity, especially from wind and solar energy. It is predicted to grow much faster in the years to come. Also, the demand pattern has experienced changes due to urbanization, increased space conditioning loads, and adoption of energy efficiency initiatives.

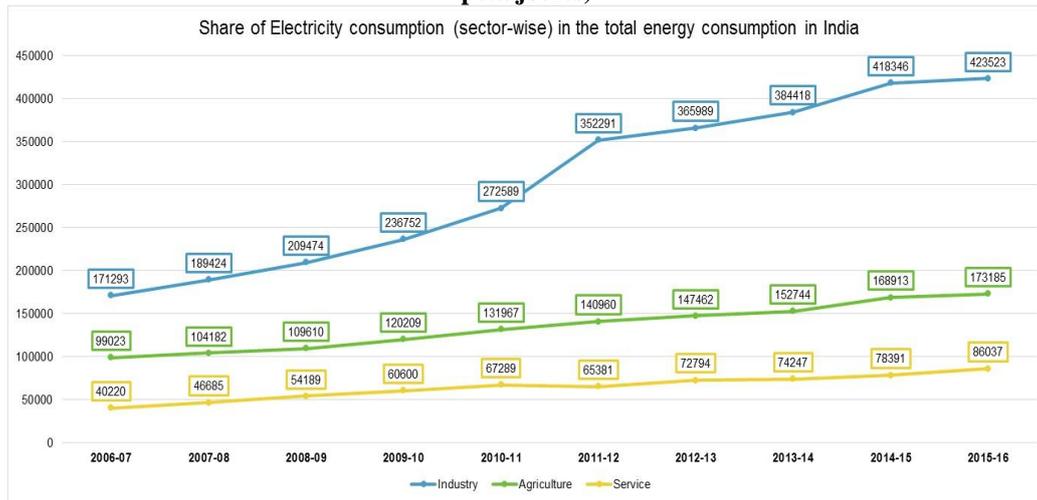
Based on the study initiated by The Energy and Resources Institute (TERI), electricity demand is likely to increase from 1115 BU in 2015–16 to 1692 BU in 2022, 2509 BU in 2027, and 3175 BU in 2030. Apparent from data available, electricity sector in India has experienced considerable growth in the last two decades combining all sectors from agricultural to residential to industrial. With growing urbanization levels, improved incomes and electricity access, larger economic activity, and superior electrification giving rise to increased end use demand, enhanced use in agriculture have led to changing patterns in electricity consumption all over the country. Added to this, during the last few years there have been several energy efficiency improvements giving rise to reduced energy intensities over the last decade, as recorded in various reports of TERI. As reported in TERI, the total electricity consumption in the country grew at a CAGR of more than 7% between 2001 and 2015 which is in line with GDP growth which grew at a CAGR of 7.3% over this period. As seen in the below table and graph the share of industry has been the highest in terms of electricity use followed by agriculture and service growing at a moderate rate.

Table 5:Share of Electricity consumption (sector-wise) in the total energy consumption in India (in peta joules)

Year	Industry	Agriculture	Services
2006-07	171293	99023	40220
2007-08	189424	104182	46685
2008-09	209474	109610	54189
2009-10	236752	120209	60600
2010-11	272589	131967	67289
2011-12	352291	140960	65381
2012-13	365989	147462	72794
2013-14	384418	152744	74247
2014-15	418346	168913	78391
2015-16	423523	173185	86037

Source :TERI, 2015

Figure 5 Share of Electricity consumption (sector-wise) in the total energy consumption in India (in peta joules)



Source: TERI, 2015

Multiple Regression Model

A multiple regression model has been fitted to understand the use of energy in the three major energy intensive sectors in India such as Industry, transport, residential and commercial. Here GDP at 2004-05 constant prices for the period 2009-10 to 2013-14 has been taken as the dependent variable and energy consumption for industry, transport and residential and commercial sectors in peta joules for the period 2009-10 to 2013-14 have been taken as independent variables. The regression equation so derived is:

$$Y = -3508385 - 1927.41 * X_1 + 5476.865 * X_2 + 3403.824 * X_3$$

where X_1 is industry energy consumption, X_2 is transport energy consumption and X_3 is residential and commercial energy consumption. It can be seen that the transport sector energy consumption has the highest impact on GDP.

Another regression model has been fitted to understand the impact of energy consumption of the major sectors such as agriculture, industry and services on the GDP. The GDP has been taken as the dependent variable (GDP at 2004-05 constant prices) and the energy consumption in all the three sectors agriculture, industry and services measured in peta joules have been taken as independent variables. The data has been taken for the time period 2006-07 to 2015-16. The regression equation so derived is:

$$Y = -1008483 + 32.59892 * X_1 + 15.01467 * X_2 - 64.7143 * X_3$$

where X_1 refers to industry, X_2 refers to agriculture and X_3 refers to services sector. We find that the industrial and agricultural sectors energy consumption have positive values means a high price to convert energy into GDP, which is much more in the industrial sector. Whereas, services sector has a negative value indicating a lower price or cost of converting energy to GDP.

We have used correlation between the energy intensities (calculated in Mega joules per rupee) at the all-India level and that of the services sector. Value of $r = .92$ signifies that energy intensity for the services sector is well correlated to that of the all-India level. The falling energy intensities for the services sector contribute well to the falling energy intensity at the all-India level.

IV. Conclusion

The multiple regression model developed to understand the use of energy in the three major energy intensive sectors in India like, industry, transport, residential and commercial and its impact on the GDP lead us to conclude that there is an urgent need to use energy in a more efficient manner in the transport sector when compared to that of industry, residential and commercial sector. Therefore, we need more energy efficient transport equipment where there can be use of electric vehicles in place of vehicles run on petroleum products and natural gas.

The second regression model enables us to understand the impact of energy consumption of the major sectors such as agriculture, industry and service on the GDP and find that the industrial and agricultural sectors energy consumption have positive values, whereas service sector has a negative value indicating a lower price or cost of converting energy to GDP. We can therefore conclude that there is a need to improve the energy

efficiency in the industrial sector followed by that of the agricultural sector and encourage growth of services sector which uses less energy by its very nature, leading to more environmentally friendly growth.

The present research paper can be concluded by giving an outline of the energy efficiency policies of the government as follows:

As a part of the Energy efficiency policies of the Government of India, the emphasis has been laid on energy efficiency techniques that involves efficient utilisation of resources, to reduce Green House Gas emission and thermal pollution. In promoting energy efficiency, Industry Associations in India are focusing on technology developments and encouraging the development of self-regulation process.

The planning authorities in addition to the above suggest demand-side management specifically in the transport sector. The Indian government recognized the importance of energy efficiency in passing the Energy Conservation Act of 2001. The implementation of energy efficiency programmes, however, has accelerated in the last few years through the efforts of the Bureau of Energy Efficiency (BEE) under the Ministry of Power (MOP).

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