



Assessment of Energy Infrastructure in India: Is it Sustainable.....

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Abstract

Energy is one of the important building blocks in human development and act as a key factor in determining the economic development of any country. To meeting the demands of a developing nation, Energy requirement in the Form of Coal, Gas, oil and most important Electricity is necessary. This paper attempts to present full picture of Indian energy sector which is growing rapidly. However since, resource allocation and growth in energy supply have failed to meet the demands exerted by the increasing population, rapid urbanization and growing economy. First we identify factor of energy shortage in India, forcing it to rely heavily on imports.

Second, we develop a multiple linear regression model which includes all independent variables (Population, Inflation, and GDP) to determine energy consumption in India. India is a developing economy. Energy requirement in India are basically electricity, oil, coal, biomass and gas. India's energy-mix comprises both non-renewable (coal, lignite, petroleum and natural gas) and renewable energy sources (wind, solar, small hydro, biomass, cogeneration biogases etc.). Based on these model we give conclusion such that which independent variable (population, Inflation and GDP) is more impacting coal, oil, gas and electricity consumption in India as well as Current patterns of energy use and assumptions about future trends in economic activity, we constructed an activity driven model to forecast what would be the natural short term evolution of energy use in India for each end use segment by. Through analysis of current patterns of energy use, drivers of energy use were collected at the sub-sector level. We connected drivers of model with evolution of GDP to determine what would be the impact of economic growth on drivers of energy use. It also includes fuel or technology switching in the forecast.

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Introduction

World is currently facing three fold global crises– the energy crisis, the economic crisis and the environment/climate crisis. India is a developing country with fast economic growth rate, for a sustainable growth rate India needs to address its need of energy. In recent years, India has emerged as one of the leading destinations for investors from developed countries. This attraction is partially due to the lower cost of manpower and good quality production. The expansion of investments has brought benefits of employment, development, and growth in the quality of life, but only to the major cities which represents only a small portion of the total population. The remaining population still lives in very poor conditions. India is now poised to make tremendous economic strides over the next ten years, with significant development already in the planning stages. This study gives an overview of the energy demand in India. We look at the current status of energy mix in India, the energy needs of the country, forecasts of consumption and production, and we assess whether India can power its growth and its society with existing energy resources.

To better understand the current situation in India and the future of the energy demand and supply, it is important to look at the trends in energy consumption, growth of the current grid, and the availability of resources as well as GDP of the country. India relies heavily on coal energy to produce electricity. A strong second is hydro power, followed by natural gas. The consumption of all renewable energies represents fully one third of the total consumption. This is a significant figure, and we will see later that this sector has a great future. Nearly 85% of the villages have been electrified, and there is a nationwide grid for the transmission and distribution of power.

Literature Review

India's energy-mix comprises both non-renewable (coal, lignite, petroleum and natural gas) and renewable energy sources (wind, solar, small hydro, biomass, cogeneration bagasse etc.).

Information on reserves of non-renewable sources of energy like coal, lignite, petroleum, natural gas and the potential for generation of renewable energy sources is a pre-requisite for assessing the country's potential for meeting its future energy needs. The changes in the reserves over time indicate the research and development going into the discovery of new reserves and the pace of their exploitation. They also facilitate in devising effective conservation and management strategies for optimal utilization of these resources.

India's energy needs can be met entirely by solar and other renewable sources, says a new study by two professors at the Indian Institute of Science (IISc) in Bangalore . Their report published in the journal Current Science may add ammunition to the anti-nuclear

agitation in India. The analysis by Hiremath Mitavachan and Jayaraman Srinivasan of IISc's Divecha Centre for Climate Change overturns the argument that nuclear power is essential for India because the country does not have enough land to exploit the potential of solar energy in India.

NCAER (1960) made demand forecasts for energy for various years both at all-India level and regional level. The total energy as well as electricity consumption was projected by relating them to the hypothesis of economic development. Coefficients for elasticity of demand for energy were obtained at the aggregate level and used for forecasting demand for future periods.

The Energy Survey Committee (1965) made demand forecasts at macro level, by using relation between national income and consumption and at sector level by estimating energy demand by various types e.g. coal, oil and electricity by assuming them to grow at given rates. Dhar and Sastri (1967) related observed input output coefficients with the desired level of production in different sectors for forecasting demand.

The Report of the Fuel Policy Committee (1974) considered three methods for forecasting energy demand and found that trend method provided a reliable means of forecasting energy demand only in developed market economies. The committee preferred regression model to trend method. Parikh (1976) modified slightly the approach used by the Fuel Policy Committee and projected demand for energy under two scenarios- one optimistic and the other pessimistic - for the period 1991- 2001. He also developed a simulation model based on Cross-country regression for energy demand to forecast commercial, non-commercial and electrical energy demand in developing countries. Pachauri (1977) too developed a simulation model for projecting the demand for electricity in the state of Andhra Pradesh in India.

Reddy and Prasad (1977) selected a number of countries, both developed and underdeveloped to find out the relationship between consumption of energy and economic growth and they found a strong correlation between the two.

The Central Electricity Authority (CEA) uses three methods for long-term projections of demand for electricity. These are trend method, the end use method and Scheer's formula. The Task Force Report on Electricity (Rao 2004) suggests that demand forecasts made by CEA must take into account the elasticity of demand since the next few years are likely to see rebalancing of tariffs and reduction of thefts, resulting in variations in demand therefore demand forecasts will require much better information based on Transmission and Distribution losses and other matters than is presently available. Prayas (2004) also points out a drawback in CEA's methodology of forecasting. The authority does not make any attempt to influence power consumption and reduce power requirement. Trends are studied and it is assumed that they will continue.

Objectives of the Study:

To analyse the factors that affect demand for energy which include, oil, gas, coal and power in Indian scenario.

Research Methodology: Research Methods which have been used for this study are as follow: This study is based on both exploratory and quantitative methodology.

Exploratory research method: In this research data has been explored from various sources as mentioned in the next section. This study provide a comprehensive insight into a newly developed situation. The research primarily relies on secondary sources of data.

Quantitative Research Method: Quantitative methodology is based on the measurement of quantity or amount. In this study we developed a multiple linear regression model to calculate Energy consumption in India.

Source of Data: In this research secondary data is used:

- a) Secondary Source of Data: For this research several source of secondary data have been used.
 - Annual Report of various organizations such as Planning Commission ,Central Electricity Authority (CEA) etc
 - Research paper publish on world /India energy market
 - Report published on Future trade of energy.

Multi Linear Regression Model:

The dependent variable, in our study, demand for electricity, is expressed as a function of various economic factors. These variables could be population, income per capita or value added or output (in industry or commercial sectors), price of power, price(s) of alternative fuels (that could be used as substitutes), proxies for penetration of appliances/equipment (capture technology effect in case of industries) etc. Thus, one would have

$ED = f(Y, P_i, P_j, POP, T)$ where,

ED = electricity demand

Y = output or income

P_i = own price

P_j = price of related fuels

POP = population

T = technology

Several functional forms and combinations of these variables and other relevant variables may have to be tried till the basic assumptions of the model are met and the relationship is found statistically significant.

End Use Model:

The end-use approach attempts to capture the impact of energy usage patterns of various devices and systems. The end-use models for electricity demand focus on its various uses in the residential, commercial, agriculture and industrial sectors of the economy. For example, in the residential sector electricity is used for cooking, air conditioning, refrigeration, lighting, and in agriculture for lift irrigation. The end-use method is based on the premise that energy is required for the service that it delivers and not as a final good.

$$E = S \times N \times P \times H$$

E = energy consumption of an appliance in kWh

S = penetration level in terms of number of such appliances per customer

N = number of customers

P = power required by the appliance in kW

H = hours of appliance use.

We have two models one is multiple regression model and other is End use model. Data analyses from End use model require accurate variable to calculate consumption which may not possible always. Therefore, it is difficult and not feasible to calculate variables for end use model. So multiple linear regression model we use for calculate energy consumption in India.

Future Consumption of Electricity In India

Electricity consumption and demand of any country majorly depend on population of the country and income of the household. Econometric method can be used to forecast demand of electricity, in which electricity consumption is dependent variable where as population, inflation and GDP per capita taken as independent variable.

$$EC = \alpha + (\beta \times \text{population}) + (\gamma \times \text{GDP Per capita}) + (\delta \times \text{Inflation Rate})$$

Electricity consumption: This entry consists of total electricity generated annually plus imports and minus exports, expressed in kilowatt-hours. The discrepancy between the amount of electricity generated and/or imported and the amount consumed and/or exported is accounted for as loss in transmission and distribution.

Population: This is an independent variable to calculate electricity consumption of India. Electricity consumption of any country depends upon population, so as population of country increase, their consumption of electricity should also increase. India's population continuously increasing such that demand of electricity as well as oil and other consumable energy may also increase.

Average Inflation Rate: Average Inflation Rate will be used in the study

GDP Per capita: This is an independent variable to calculate electricity consumption of India. Electricity consumption of any country depends upon per capita income, so as per capita income of country increase, there is a possibility of increasing electricity consumption. In India GDP per capita are continuously increasing such that demand of electricity as well as oil and other consumables energy may also increase.

Table 1: India's electricity consumption from 1980 to 2012

Sources Data from World Economic Outlook IMF and British petroleum statistical review 2012

Year	Consumption	GDP	Population	Inflation
1990	97.898	2090.83	682.25	11.37
1991	107.442	2436.6	696	13.12
1992	113.695	2694.88	711.75	7.887
1993	117.213	3044.48	727	11.87
1994	130.42	3366.78	743	8.322
1995	140.645	3713.45	759	5.556
1996	154.717	4076.37	775.25	8.731
1997	166.86	4518	792.25	8.799
1998	185.924	5197.45	809.25	9.385
2001	202.681	5889.69	826.25	6.159
2001	219.877	6715.51	843.25	8.971
2002	240.201	7595.78	860	13.87
2003	255.683	8561.77	877	11.79
2004	275.666	9633.74	896.5	6.362
2005	297.961	11031.52	914.5	10.21
2006	318.278	12693.33	932.5	10.23
2007	323.009	14024.03	950.5	8.949
2008	344.406	15781.88	968.75	7.399
2009	360.393	17732.11	987.5	13.24
2010	365.352	19426.61	1005.5	4.658
2011	375.394	20900.64	1024.25	3.906
2012	384.906	22048.31	1044	3.671
2013	403.74	23409.49	1060	4.469
2014	428.18	25578.27	1076.25	3.713
2015	457.027	28549.16	1093.25	3.891
2016	483.256	32128.1	1110	3.97
2017	525.372	36553.93	1126	6.268
2018	587.9	41747.69	1142	6.373
2019	517.2	47038.23	1158	8.349
2020	517.2	51714.45	1174	10.88
2021	568	61784	1190.52	11.99

a) Net Electricity Consumption billion Kilowatt hour per year.

a) Population In million

- b) GDP per capita, current prices National currency
- c) Inflation, average consumer prices Percent change

Data analyses and Interpretation for electricity consumption in India

Regression Statistics

Multiple R 0.992974626

R Square 0.985998608

Adjusted R Square 0.984550188

Standard Error 19.88137875

Multiple Linear Regression Model: This model include all of the potential independent variables that have identified. The model obtained is:

$$EC = \alpha + (\beta \times \text{population}) + (\gamma \times \text{GDP per capita at current price}) + (\delta \times \text{Inflation Rate index})$$

$EC = -552.76 + (.0003673 \times \text{population}) + (1.0540 \times \text{GDP}) + (.9085 \times \text{Inflation Rate})$

- Electricity Consumption in Billion KWh per Annum in India.
- GDP in Billion Rupees.
- Population in Million.
- Inflation rate Index in %.

Finding:

R Square: The value of R square in following model is 98.59 showing that about 98.59% of total variation in electricity consumption in India can be explained by Independent variables Population, GDP per capita of country at current Price and Inflation Index.

F Value: Since calculated F value is greater than Critical value of F hence this model is accepted. It can be concluded that ratio of explained variance by this model to the unexplained variance is very high. Thus the regression variable is significant in explaining the dependent variable.

P value:

- Population has influence on electricity consumption in India as it is statistically significant. Population P value is less than 0 .01 i.e. at 1% level of significance..

- Inflation variable is not significance at 1 % level of Inflation variable did not affect Electricity consumption. Hence it shows electricity consumption has not influenced by inflation.
- GDP per capita variable is not significance at 1 % level so GDP per capita variable did not affect Electricity consumption. Hence it shows electricity consumption has not been influenced by GDP per capita.

Coefficients:

- Coefficient of population parameter is .908 that tells about dependence of electricity consumption on population of country, if population parameter changes by one unit then electricity consumption of India will increase by 0.908 i.e. ninety one percent.
- Coefficient of inflation Index is 1.054 that tells about dependability of electricity consumption on inflation rate (CPI), if Consumer price index of substitute product changes by one unit then electricity consumption of India will increase by 1.054 i.e. around hundred percent. Price of substitute product means all the energy products which can be used as a substitute for electricity. So if price of substitute good increase than consumer will prefer electricity to consume.
- Coefficient of GDP per capita is .0003673 that tells about dependability of electricity consumption on GDP per capita. GDP per capita at Current price does not affect that much amount of electricity consumption, while correlation between prices also there.

Correlation between Variable:

- Correlation between electricity consumption and population is 99.23 which show very high level of positive correlation between these two variables.
- Correlation between electricity consumption and GDP per capita is 90.91 showing a very high correlation.
- Negative Correlation between electricity consumption and Average inflation of consumer price index is 28.08 showing that price rise inversely affects electricity consumption.

Oil Consumption in India:

Oil consumption in India Basically comes from Transportation, electricity generation and heating purpose. The above graph shows consumption oil in India in billion barrels per day per thousand people. This is taken as in dependent variable to predict

the consumption of electricity in India. Consumption of oil basically comes from transportation such as when population increase consumption also increases.

Oil Consumption

$$= \alpha + (\beta \times \text{population}) + (\gamma \times \text{GDP current price}) \\ + (\delta \times \text{Inflation Rate index})$$

Table 2: India's Oil consumption from 1980 to 2011
Sources Data from World Economic Outlook IMF and British petroleum statistical review 2012

Year	Consumption	GDP	Population	Inflation
1980	31.633	2090.83	682.25	11.37
1981	34.036	2436.6	696	13.12
1982	35.403	2694.88	711.75	7.887
1983	37.223	3044.48	727	11.87
1984	39.934	3366.78	743	8.322
1985	43.333	3713.45	759	5.556
1986	45.53	4076.37	775.25	8.731
1987	46.995	4518	792.25	8.799
1988	51.53	5197.45	809.25	9.385
1989	55.801	5889.69	826.25	6.159
1990	57.943	6715.51	843.25	8.971
1991	58.903	7595.78	860	13.87
1992	62.075	8561.77	877	11.79
1993	62.662	9633.74	896.5	6.362
1994	67.384	11031.52	914.5	10.21
1995	75.232	12693.33	932.5	10.23
1996	81.062	14024.03	950.5	8.949
1997	86.503	15781.88	968.75	7.399
1998	92.527	17732.11	987.5	13.24
1999	100.303	19426.61	1005.5	4.658
2000	106.147	20900.64	1024.25	3.906
2001	106.964	22048.31	1044	3.671
2002	111.262	23409.49	1060	4.469
2003	113.066	25578.27	1076.25	3.713
2004	120.153	28549.16	1093.25	3.891
2005	119.576	32128.1	1110	3.97
2006	120.407	36553.93	1126	6.268
2007	133.448	41747.69	1142	6.373
2008	144.134	47038.23	1158	8.349

2009	153.70878	51714.45	1174	10.88
2010	156.17803	61784	1190.52	11.99
2011	162.2	70653.91	1206.92	8.628

a) Total Oil Consumption Million Tonne per annum.

a) Population In million

b) GDP per capita, current prices National currency

Inflation, average consumer prices Percent change

Data analyses and Interpretation for Oil consumption in India

Regression Statistics

Multiple R 0.996119486

R Square 0.99225403

Adjusted R Square 0.991424104

Standard Error 3.710349874

Observations 32

Multiple Linear Regression Model: This model include all of the potential independent variables that have identified. The model obtained is:

Oil Consumption

$$= \alpha + (\beta \times \text{population}) + (\gamma \times \text{GDP current price}) + (\delta \times \text{Inflation Rate index})$$

$$\text{oil consumption} = -79.64 + (.161 \times \text{population}) + (.0007780 \times \text{GDP}) + (-0.308 \times \text{Inflation Rate})$$

Here:

- Oil Consumption in million tonne per Annum in India.
- GDP in Billion Rupees.
- Population in Million.
- Inflation rate Index in %.

Finding:

R Square: The value of R square in following model is 99.22%, showing that about 99.22% of total variation in Oil consumption in India can be explained by Independent variables Population, GDP of country at current Price and Inflation Index.

F Value: Since calculated F value is greater than Critical value of F hence this model is accepted. It can be concluded that ratio of explained variance by this model to the unexplained variance is very high. Thus the regression variable is significant in explaining the dependent variable oil Consumption.

P value:

- Population has influence on oil consumption in India as it is statistically significant. Population P value is less than 0 .01 i.e. at 1% level of significance.
- Inflation variable is not significance at 1 % level of Inflation variable did not affect oil consumption. Hence it shows electricity consumption has not influenced by inflation.
- GDP has influence on oil consumption in India as it is statistically significant. GDP, P value is less than 0 .01 i.e. at 1% level of significance.

Coefficients:

- Coefficient of population parameter is 0.161 that tells about dependability of Oil consumption on population of country, if population parameter changes by one unit then Oil consumption of India will increase by 0.161 i.e. sixteen percent.
- Coefficient of inflation Index is -0.308 that tells about negative impact of Oil consumption on inflation rate (CPI), if Consumer price index of substitute product changes by one unit then Oil consumption of India will decrease by - 0.308. Price of substitute product means all the good which can be used as a substitute for oil. So if price of substitute good increase then consumer will prefer Oil to consume.
- Coefficient of GDP is .000778005 that tells about dependability of Oil consumption on GDP. GDP at Current price does not affect that much amount in Oil consumption, while correlation between prices also there.

Correlation between Variable:

- Correlation between Oil consumption and population is 98.61 which show very high level of positive correlation between these two variables.

- Correlation between Oil consumption and GDP is 95.42. Showing a very high correlation.
- Negative Correlation between Oil consumption and Average inflation of consumer price index is 30.17% .showing that price rise inversely affects oil consumption.

Natural gas consumption:

Natural gas is a substitute of oil, coal and other renewable sources such as to produce electricity. Natural gas consumption basically depends on population, per capita income and price of substitute product.

Natural Gas Consumption

$$= \alpha + (\beta \times \text{population}) + (\gamma \times \text{GDP current price}) + (\delta \times \text{Inflation Rate index})$$

Table 3: India's Natural Gas consumption from 1980 to 2011

Sources Data from World Economic Outlook IMF and British petroleum statistical review 2012

Year	Consumption	GDP	Population	Inflation
1980	1.1	2090.83	682.25	11.37
1981	1.8	2436.6	696	13.12
1982	2.4	2694.88	711.75	7.887
1983	2.9	3044.48	727	11.87
1984	3.3	3366.78	743	8.322
1985	4.0	3713.45	759	5.556
1986	5.6	4076.37	775.25	8.731
1987	6.5	4518	792.25	8.799
1988	7.6	5197.45	809.25	9.385
1989	9.1	5889.69	826.25	6.159
1990	10.8	6715.51	843.25	8.971
1991	12.1	7595.78	860	13.87
1992	13.5	8561.77	877	11.79
1993	13.7	9633.74	896.5	6.362
1994	14.8	11031.52	914.5	10.21
1995	16.9	12693.33	932.5	10.23
1996	18.5	14024.03	950.5	8.949
1997	20.1	15781.88	968.75	7.399

1998	22.0	17732.11	987.5	13.24
1999	22.6	19426.61	1005.5	4.658
2000	23.7	20900.64	1024.25	3.906
2001	23.8	22048.31	1044	3.671
2002	24.8	23409.49	1060	4.469
2003	26.6	25578.27	1076.25	3.713
2004	28.7	28549.16	1093.25	3.891
2005	32.1	32128.1	1110	3.97
2006	33.5	36553.93	1126	6.268
2007	36.1	41747.69	1142	6.373
2008	37.2	47038.23	1158	8.349
2009	45.9	51714.45	1174	10.88
2010	55.7	61784	1190.52	11.99
2011	55.0067	70653.91	1206.92	8.628

a) Total Natural Gas Consumption MTOE per annum.

a) Population In million

b) GDP per capita, current prices National currency

c) Inflation, average consumer prices Percent change

Data analyses and Interpretation for Natural Gas consumption in India

Multiple Linear Regression Model: This model include all of the potential independent variables that have identified. The model obtained is:

Natural Gas Consumption

$$= \alpha + (\beta \times \text{population}) + (\gamma \times \text{GDP current price}) + (\delta \times \text{Inflation Rate index})$$

$$\text{Natural Gas Consumption} = -31.23 + (0.04175 \times \text{population}) + (0.00047317 \times \text{GDP current price}) + (0.2962 \times \text{Inflation Rate})$$

Here:

- Natural Gas Consumption in MTOE per Annum in India.
- GDP in Billion Rupees.
- Population in Million.
- Inflation rate Index in %.

Finding:

R Square: The value of R square in following model is 99.13%, showing that about 99.13% of total variation in Natural Gas consumption in India can be explained by Independent variables - Population, GDP of country at current Price and Inflation Index.

F- Value: Since calculated F value is greater than Critical value of F hence this model is accepted. It can be concluded that ratio of explained variance by this model to the unexplained variance is very high. Thus the regression variables are significant in explaining the dependent variable, Natural Gas Consumption.

P value:

- Population has influence on Natural Gas consumption in India as it is statistically significant. Population P value is less than 0 .01 i.e. at 1% level of significance.
- GDP show 1% levels of significance that show population has statistically influence on Natural Gas consumption in India. GDP, P value is less than 0.01%.
- Inflation has influence on Natural gas consumption in India as it is statistically significant. Inflation P value is less than 0 .01 i.e. at 1% level of significance.

Coefficients:

- Coefficient of population parameter is 0.041751 that tells about dependability of Natural Gas consumption on population of country, if population parameter changes by one unit then Natural Gas consumption of India will increase by 4 %.
- Coefficient of inflation Index is 0.2962 that tells about dependability of Natural Gas consumption on inflation rate (CPI), if Consumer price index of substitute product changes by one unit then Natural Gas consumption of India will increase by 0.2962. Price of substitute product means all the good which can be used as a substitute for electricity. So if price of substitute good increase than consumer will prefer Natural Gas to consume.
- Coefficient of GDP is .00047317 that tells about dependability of Natural Gas consumption on GDP. GDP at Current price does not affect that much amount in Natural Gas consumption, while correlation between prices also there.

Correlation between Variable:

- Correlation between Natural Gas consumption and population is 95.7861 which show very high level of positive correlation between these two variables.
- Correlation between Natural Gas consumption and GDP is 98.18. Showing a very high correlation.
- Negative Correlation between Natural Gas consumption and Average inflation of consumer price index is 0.1791%. Showing that price rise inversely affects Natural Gas consumption.

Consumption of Coal in India:

Coal account for almost 60% of Indian electricity production and are likely to meet the majority of additional power generation. Consumption of Coal basically comes from power plant, to analyze coal consumption use of dependent variable is not feasible because of less amount of coal consume by population for cooking purpose as per the total consumption in India. Gas is the main competing energy source for coal, due to lower investment needs for gas power plants with respect to coal-fired power plants. Increasing gas prices can therefore make coal-fired power generation more competitive and allow for increases in coal prices. But because of in India Gas power plant is very less and domestic price of coal is also regulate by government so it is not feasible to take natural gas price as variable of coal consumption.

Table 4

India's Coal consumption from 1980 to 2011

Sources Data from World Economic Outlook IMF and British petroleum statistical review 2012

Year	Consumption	GDP	Population	Inflation
1980	56.71238028	2090.83	682.25	11.37
1981	63.24911668	2436.6	696	13.12
1982	63.06230312	2694.88	711.75	7.887
1983	66.15882074	3044.48	727	11.87
1984	69.4585048	3366.78	743	8.322
1985	72.54391644	3713.45	759	5.556
1986	78.01044929	4076.37	775.25	8.731
1987	85.92151412	4518	792.25	8.799
1988	91.65669846	5197.45	809.25	9.385
1989	99.9551009	5889.69	826.25	6.159
1990	95.4575093	6715.51	843.25	8.971

1991	101.7607658	7595.78	860	13.87
1992	108.2183607	8561.77	877	11.79
1993	112.5073058	9633.74	896.5	6.362
1994	115.8290594	11031.52	914.5	10.21
1995	124.952927	12693.33	932.5	10.23
1996	134.3949026	14024.03	950.5	8.949
1997	135.8988391	15781.88	968.75	7.399
1998	136.0645463	17732.11	987.5	13.24
1999	135.7521351	19426.61	1005.5	4.658
2000	144.2432145	20900.64	1024.25	3.906
2001	145.1892237	22048.31	1044	3.671
2002	151.8475412	23409.49	1060	4.469
2003	156.8018514	25578.27	1076.25	3.713
2004	172.2584572	28549.16	1093.25	3.891
2005	184.4377164	32128.1	1110	3.97
2006	195.4427498	36553.93	1126	6.268
2007	210.2713291	41747.69	1142	6.373
2008	230.3763975	47038.23	1158	8.349
2009	253.8237972	51714.45	1174	10.88
2010	270.8112794	61784	1190.52	11.99
2011	295.6150832	70653.91	1206.92	8.628

a) Total Coal Consumption Million Tonne of Oil equivalent per annum.

a) Population In million

b) GDP per capita, current prices National currency

c) Inflation, average consumer prices Percent change

Data analyses and Interpretation for Coal consumption in India: IN this method of Study two models will be used to analyses.

Multiple Linear Regression Model: This model include all of the potential independent variables that have identified. The model obtained is:

Model (1)

Coal Consumption

$$= \alpha + (\beta \times \text{population}) + (\gamma \times \text{GDP current Price}) + (\delta \times \text{Inflation Rate index})$$

Coal Consumption

$$\begin{aligned} &= -46.0525 + (0.1356 \times \text{population}) \\ &+ (0.002337 \times \text{GDP current Price}) \\ &+ (1.092358 \times \text{Inflation Rate index}) \end{aligned}$$

Here:

- GDP in Billion Rupees.
- Population in Million.
- Inflation rate in %.
- Coal Consumption in MTOE.

Finding:

R Square: The value of R square in following model is 99.30%, showing that about 99.30% of total variation in Coal consumption in India can be explained by Independent variables Population, GDP of country at current Price and Inflation Index.

F Value Since calculated F value is greater than Critical value of F hence this model is accepted. It can be concluded that ratio of explained variance by this model to the unexplained variance is very high. Thus the regression variables are significant in explaining the dependent variable, Coal Consumption.

P value:

- Population has influence on Coal consumption in India as it is statistically significant. Population P value is less than 0 .01 i.e. at 1% level of significance.
- GDP has influence on Coal consumption in India as it is statistically significant. GDP P value is less than 0 .01 i.e. at 1% level of significance.
- Inflation has influence on Coal consumption in India as it is statistically significant. Inflation P value is less than 0 .01 i.e. at 1% level of significance.

Coefficients:

- Coefficient of population parameter is 0.1356 that tells about dependability of Coal consumption on population of country, if population parameter changes by one unit then Coal consumption of India will increase by 0.1356 i.e. thirteen percent
- Coefficient of Inflation parameter is 1.092358 that tells about dependability of Coal consumption on Inflation Index of country, if Inflation Index parameter changes by one unit then Coal consumption of India will increase by 1.092358.
- Coefficient of GDP parameter is 0.002337 that tells about dependability of Coal consumption on GDP of country, if GDP parameter changes by one unit then Coal consumption of India will increase by 0.002337.

Correlation between Variable:

- Correlation between Coal consumption and population is 94.74% which show very high level of positive correlation between these two variables.
- Correlation between Coal Consumption and GDP is 98.85%. That mean 98.85% of the times when income of house hold increase Coal consumption of India also increase.
- Negative Correlation between Coal consumption and Average inflation of consumer price index is 0.16513%. Showing that price rise inversely affects Coal consumption.

Model (2) let take coal consumption is a function of electricity consumption. In India major portion of electricity generation is basically comes from Coal based Thermal Power Plants.

Table 4

India's Coal consumption from 1980 to 2011

Sources Data from World Economic Outlook IMF and British petroleum statistical review 2012

Year	Coal Consumption	Electricity Generation(TWH)
1980	56.71238028	119.26
1981	63.24911668	131.12
1982	63.06230312	139.41
1983	66.15882074	144.987
1984	69.4585048	161.739

1985	72.54391644	179.8438
1986	78.01044929	196.806
1987	85.92151412	214.5568
1988	91.65669846	235.0098
1989	99.9551009	261.586
1990	95.4575093	284.246
1991	101.7607658	309.0833
1992	108.2183607	328.4425
1993	112.5073058	350.4295
1994	115.8290594	378.2515
1995	124.952927	409.9215
1996	134.3949026	432.0583
1997	135.8988391	458.5513
1998	136.0645463	489.1418
1999	135.7521351	526.5675
2000	144.2432145	554.7445
2001	145.1892237	574.5505
2002	151.8475412	592.1873
2003	156.8018514	624.092
2004	172.2584572	657.7235
2005	184.4377164	689.5625
2006	195.4427498	738.7053
2007	210.2713291	797.94
2008	230.3763975	824.4501
2009	253.8237972	869.7999
2010	270.8112794	922.24883
2011	295.6150832	1006.173474

a) Total Coal Consumption Million Tonne of Oil
equivalent per annum.

b) Electricity Generation in Tetra watt hour.

$$\text{Coal Consumption} = \alpha + (\beta \times \text{Power Generation in India})$$

$$\text{Coal Consumption} = 26.434 + (0.24054 \times \text{Power Generation in India})$$

Here:

- Power Generation Tetra watt hour

- Coal Consumption in MTOE.

Finding:

R Square: The value of R square in following model is 96.75 %, showing that about 96.75 % of total variation in Coal consumption in India can be explained by Net power generation in India.

F Value: Since calculated F value is greater than Critical value of F hence this model is accepted. It can be concluded that ratio of explained variance by this model to the unexplained variance is very high. Thus the regression variable is significant in explaining the dependent variable Coal Consumption.

P value:

- Power Generation show 1% levels of significance that show power generation has statistically influence on Coal consumption in India. Power Generation P value is less than 0.01%.

Coefficients:

- Coefficient of Power Generation parameter is 0.24054 that tells about dependability of Coal consumption on electricity Generation of country, if Electricity Generation changes by one unit then Coal consumption of India will increase by 0.1356.

Correlation between Variable:

- Correlation between Coal consumption and electricity Generation is 98.36% which show very high level of positive correlation between these two variables.

Conclusion of The Study

We have analyzed several factors that affect energy demand in India. These factors were chosen carefully based on previous literature on energy demand. The variable which affect the demand for energy in India significantly are GDP at current price, population, and inflation index and power generation. It has been found in our analysis that all these variables which are mentioned above significantly affect the energy demand and consumption in India. In our studies we have analyzed the different factors affecting oil consumption, electricity consumption, coal consumption, and natural gas consumption. These factors are relevant for any future policy to be designed for deterring the demand for energy as well as the factors affecting demand pattern.

Suggestion:

- Electricity consumption is majorly affected by inflation and population of India as it is clear from our regression analysis. So, this independent variable has a great impact on the dependent variable (electricity consumption).
- Oil consumption is majorly affected by population of India. This is a major factor that affects the consumption of the oil.
- Natural gas consumption is majorly affected by inflation.
- Coal consumption is majorly affected by electricity generation and inflation.

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