Energy Intensity Trends in Karnataka State, India: Need for the Environmentally Sound Alternatives?

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Abstract

The present energy situation in Karnataka state, India is plagued with constant power cuts, fuelwood scarcity and demands for strategic and integrated planning with emphasis on renewable resources and improvement of enduse efficiency. This paper discusses the energy consumption pattern in Karnataka and compares with 56 countries across the globe to explore the level of energy consumption and efficiency. Energy intensity (energy consumption per GDP) and GDP per capita data reveals that India and Karnataka state have high energy intensities compared to other developed industrialised countries. This clearly shows that Karnataka state and India have good potential in energy conservation.

Introduction

Energy utilisation in Karnataka state, India differs radically from that of other, industrialised countries. Non commercial sources of energy such as firewood and agricultural residues constitute the main source of energy in rural areas. There are enormous variations in the amount of energy used within India in different states and regions. There exist regional disparities both in terms of energy supply and demand. Linkages between various energy sub sectors such as coal, oil, electricity and non commercial energy sources are non existent. Energy planning in our country is not an integrated activity. The plans for electricity, oil, coal, and firewood are separate exercises. Secondly, the planning activity considers only the demand and projects the demand over a period of years. The efficiency in utilisation has not been investigated. The primary goal of planners is for supply expansions based on the assumption of linkage between energy consumption and the economic growth of a region. With this approach, energy becomes an end in itself and the focus shifts on meeting increased energy consumption through energy supply expansion alone. This supply and demand based planning for each individual energy form has resulted in problems like inefficiency, losses, more conversions and other environmental problems. This conflict between energy demand and environmental quality goals can be solved by an integrated approach to the problem of energy planning with emphasis to minimise the consumption of non renewable sources of energy such as coal, oil, etc., to maximise the efficiency of end use devices in all sectors and to organise an approach towards optimal use of renewable sources. This path would certainly help in boosting economic growth of a region and equally important, it promotes structural changes that are conducive to overall development. In order to get an idea of Karnataka and India's level of energy consumption with other countries, we have carried out energy analyses and compared with energy consumption data from 56 countries.

The energy use per capita and GDP per capita data of 56 countries reveals that Karnataka state and India has very low per capita energy consumption. There are only small differences in per capita energy consumption between the developing countries. For high income countries, the difference is much larger. That is energy use per capita increases with higher income, but cross country comparisons can be misleading and inappropriate due to large variations among countries in terms of economic structure, climate, geographic location, etc. Energy intensity (energy consumption per GDP) and GDP per capita data reveals that India and Karnataka state have high energy intensities compared to other developed industrialised countries. Which clearly shows that Karnataka state and India have good potential in energy conservation.

A comparative study of energy use, mainly electrical, in industries in Karnataka and in those of some other industrialised countries reveals that Karnataka consumes 6.13 times the energy consumed in the Switzerland, 5.28 times the energy consumed in Japan, 3.35 times the energy consumed in the U.K. and 1.98 times the energy consumed in U.S.A. for the same GDP (Gross Domestic Product).

A sectoral analysis of electricity users in Karnataka shows that the growth of connected loads is mainly in two categories - AEH (All Electric Homes) and Small Scale (LT) Industries. The growth rate is 19.46% for the former and 27.33% for the latter. The growth increases in the past four years are 67.4% and 55% respectively. If we look at the annual increases in the number of installations again the LT industries sector has a very high rate of 38.66% followed by AEH with a rate of 19.15%. More than 50% of our industries are clustered in and around Bangalore. Barring a few exceptions, there is only limited industrial activity in other parts of Karnataka. Energy consumption patterns show that Bangalore uses 26.67% of HT energy. A few industries like Indian Aluminum at Belgaum, VISL at Bhadravathi, etc. show higher energy consumption values for some divisions. Belgaum consumes 21.6% of total HT energy in the State. Sector wise commercial energy consumption data shows that the industrial sector with 51.4% of total consumption constitutes the major energy consumer in Karnataka. This paper discusses about energy utilisation pattern and energy intensity trends among 56 countries and the energy scenario of Karnataka.

Karnataka State: Location and Demographic Details

Karnataka state extends over an area of 1.92 lakh sq.kms, It occupies about 5.84%.of the total geographical area of the country. The state is situated in the West-Central part of the deccan peninsula of the Indian union and is stretched between 13^{o} 3' and 18^{o} 45' north latitudes & 74^{o} 12' and 78^{o} 40' east longitudes. The major portion of Karnataka lies in the elevation range between 450 and 900 metres above the mean sea level. With a population of 4,49,77,201, it accounts for 5.4% of the country's population. For administrative purpose, the state has been divided into divisions, districts and taluks. There are 27,024 villages spread over 175 taluks. 69.07% of the population resides in rural area (3,10,69,413 people).

Karnataka's Energy Scene

Karnataka does not have any coal deposits. It gets its coal from outside. The electrical energy for Karnataka was purely hydro, and with the commissioning of Raichur thermal power station, it gets electrical energy from coal also. The other major source of commercial energy - oil - is also not available in Karnataka. Hence, the main source of commercial energy for the state comes from hydroelectric plants.

Karnataka state depends both on commercial and non commercial forms of energy. Non commercial energy constitutes 53.2%, met mainly by sources like firewood, agricultural residues, charcoal and cowdung, while commercial energy's share is 46.8%, met mainly by electricity, oil, coal etc. The data is compiled from various agencies shows that the commercial energy sources like coal, oil, electricity provides only a small part of the energy scene of Karnataka. The major energy share comes from firewood. Electricity represents 55.67% of commercial energy for 1990-91. There has been an increase in the per cent share for electricity in the last ten years. Firewood consumption is around 7.44 million tons of oil equivalent. Agro wastes are also used for energy purposes. Figures 1 and 2 are pictorial presentation of sourcewise consumption. From Figure 2, it is seen that firewood constitutes 43.0%, while electricity is 26.1%, followed by oil (11.6%), agricultural residues (8.7%). This demonstrates that we depend mainly on biomass to meet our energy needs. Figure 3 illustrates the sector wise consumption of commercial energy in Karnataka during 1990-91. This showed that industrial sector, with 51.4% share, formed the major consumer of commercial energy, followed by the transport sector (23.0%), household (11.2%), and agriculture (3.5%). [1,2,3].

Electrical Energy Use in Karnataka

The share of industries in total electrical energy consumption is around 44%. The state generated 12,430 million units of electrical energy in 1990-91 and 12,887 million units during 1991-92. The share of industries in electricity consumption is 4,482 million units in 1990-91 and 4,316 million units in 1991-92. Transmission and distribution losses during 1991-92 are about 19.32%. Electric energy requirement and available data compiled from the Karnataka Electricity Board for the last six years shows that, there is a deficit of electrical energy of the order of 26.88% during 1988-89, 23.57% during 1989-90, 22.90% during 1990-91, and 23.59% during 1991-92. Sector wise electric energy consumption shows that during 1989-90, the industrial sector consumed 4780 million units, constituting a share of 44.86%, followed by irrigation pumpsets with a share of 28.63%. It is seen that the share of irrigation pumpsets is gradually increasing. 8.82% of pumpsets energised through 1991-92, is already guzzling 36.26% of the total electrical energy. The share of the agriculture sector in electrical energy scene has gone up to 36.3% in 1991-92 from 28.6% (during 1989-90). The industries share is 34.3%, followed by domestic sector (15.3%).

Comparisons of Energy Use

Since energy consumption plays an important role in indicating the life style or quality, there are many indicators to compare life styles in various countries. Initially, energy consumption was compared with a country's gross domestic product (GDP). It was found from 56 countries data, that there is a strong correlation existing between national output per capita and energy per capita. The basic gross domestic product and energy data used in this research are from the UN

Energy Statistics Yearbook [4] and from the report -Current Energy Scene in India, [5]. The energy data are measured in tons of oil equivalent (toe), the GDP data are measured in local currencies, but have been adjusted for price changes. Population of various countries is from the World Population Data sheet 1994, Published annually by Population Reference Bureau, Inc. Washington [6].

In order to make a quantitative estimate of the response of energy consumption per capita to GDP per capita a regression analyses is carried out for a set of data pertaining to 56 countries. Both linear and nonlinear regression analyses were carried out (about 25 types of equations were tried). Based on the lowest percentage of error and best correlation coefficient , the best fit relationship for this set of data was found to be power law of the form

$En_{œ}= A*GDP_{œ}B$ ----------------------- (1)

Where $En_{œ}$ = energy consumption per capita in kg's oil equivalent, GDP_{pc}= gross domestic product per capita in US$.

$En_{œ}= (0.9184)*GDP_{œ}^{0.8938}$

with correlation coeff. "R" = 0.90, R^2 = 0.8119, std error of Y est. = 0.05792 The relationship between En (Energy consumption) and GDP (gross domestic product) could be written is

Log(En)= A +B*Log(GDP) ----------------------- (2)

with R^2 in all cases being greater than 0.8. Even though the statistical reliability of the regression is uniformly high, the striking substantive result is that the relationship between economic growth and energy consumption differs widely among various countries in terms of exponent "B". Exponent "B" in equation (1) is also referred to as the income elasticity of energy consumption and is, in part influenced by a country's stage in economic development. "B" is less than one for countries like Japan (0.9605), USA (0.9588), France (0.8788), UK (0.4780), Germany (0.6612) while for countries like India (1.8925), Thailand (1.9341), Mexico (1.3328), Italy (1.7662) and Phillipines (2.0696), it is greater than one. This shows that the energy consumptions is in part influenced by a country's stage of economic development. Apart from this, the structure of energy consumption exerts an important influence on the elasticities depending on the efficiency, price of predominant energy sources, economic structure and climate.

In developing countries like India, Nigeria and Pakistan, the share of non commercial energy is more than 50%. It is noticed that the energy consumption per capita accelerates as GDP per capita gets beyond $500. In terms of per capita GDP there is wide spectrum ranging from $92 for Mozambique, $288 for India, $22,219 for USA,$24,824 for Norway and $34,304 for Switzerland. Apart from this they also differ in terms of economic characteristics such as level of industrialisation, rate of economic growth etc. From data it appears that per capita energy use increases with higher incomes at a higher rate than the linear growth. There are only small differences in per capita energy between the developing countries. For most Asian countries barring Japan the per capita energy consumption 1 toe. For high income countries, the differences in energy use per capita are larger. For example the difference between USA and France or Japan is a factor of two. Among industrialised countries, Spain and Italy have relatively low per capita energy consumption. Further disaggregation of source wise data shows that Japan, Sweden and Switzerland have a high share of primary electricity, in the order of 90 to 96%, which contributes to the high energy use per capita and per GDP. Other factors explaining the difference between countries include industrial composition, end use efficiencies and geography. It is essential to include these factors in accounting for per capita energy consumption, otherwise cross country comparisons of aggregate measures such as energy use per capita or energy intensities could be misleading. Karnataka has a figure of 0.180 (Per Capita Energy Consumption), While for India it is 0.231 during the year 1990-91. The Energy analysis is carried out by incorporating non commercial energy sources in computing Per Capita Energy Consumption, which constitutes the significant portion in total energy consumption in countries like India, Nigeria, etc. Incorporating non commercial energy sources also, per capita energy consumption becomes 0.379 for Karnataka and 0.469 for India. These are low compared to U.K. (3.646), Australia (5.206), Sweden (6.347), U.S.A (7.722) and Norway (8.134). This means that per capita energy consumption in industrialised countries like U.K. and U.S.A are higher (9.62 - 20.63) compared to that of Karnataka. This illustrates that Karnataka State has very low energy/capita and GDP/capita values, but these do not reveal the true state of energy use; one would like to know how the energy is used and what the level of efficiency is. Normally, it is said that, since our energy use/person is very low compared to that for advanced countries, we should increase our energy production so as to reach the level of "advanced" societies. It is wrongly assumed that energy/capita reflects a true state of development in a country. If this argument is accepted, then we should increase energy consumption rates in our country and our state.

Recently, there has been a shift in the thinking even in the industrial nations. The index to be used is not energy/person, but energy/GDP i.e. the amount of energy consumed for producing 1 unit of GDP (energy/GDP in tons oil equivalent per million dollars). This index also reflects the efficiency of energy use at a macro level. The value for Canada, 464.218, Norway, 365.896 and for U.S.A. 352.041 on the high side. Japan, France and Italy with values 132.041, 182.634 and 138.880 respectively, are on the low side. Energy/GDP is computed with the USA value equal to 100 shows that India has an energy intensity value of 754.12 toe/million dollars and Karnataka State has a value of 696.729 toe/million dollars. With inclusion of the non commercial energy share India's energy intensity increases to 1628.47 while for Karnataka it is 1468.99. Compared to the USA, India and Karnataka consumes 2.33 and 2.77 times (exclusion of non commercial sources), 4.85 and 6.00 times (with inclusion of non commercial sources of energy), while compared to France 4 times and Japan 6 times more energy for the same output. However, these calculations does not include animate energy share such as human and animal energy. If these are quantified and included then energy/GDP for India would shoot up further. These analyses shows that Karnataka state and India have good potential in energy conservation.

During 1994, India's energy intensity was 838 toe/m$ compared to USA's 344, Japan's 133 and Sweden's 172. This shows the increase in energy intensity for India while a decline for Japan, USA and Sweden. An explanation for the differences in energy intensities between these countries cannot be done based on this aggregate analysis. That would require each region/country's sectoral energy use, industrial composition, etc. This necessitates a detailed look at energy scenario and energy auditing.

The second factor seen is that the energy/SDP is increasing for Karnataka. One possible conclusion is that the energy efficiency (of use) is decreasing and not increasing. Post oil crisis situations saw considerable reductions in energy/GDP. For instance, West Germany showed a decrease from 1,080 to 1,010; Similar decreases were evident for U.K. and Netherlands. United States has shown a steady value for a period of nearly 20 years (1961-1974) varying from 1,400 to 1,480 (a max. of 5% difference) whereas Karnataka has shown an increase of about 10% in 5 years. Hence, it is desirable to actively pursue the introduction of energy efficient methods. The reasons why the U.S. has a flat curve for the 15 years period may be: frequent updating of technology; efficient methods due to competition; stability in the system due to many years of energy use.

In order to see which sector consumes more energy in Karnataka, sector wise GDP and energy have been calculated. The index here is the energy consumption in tons of oil equivalent per crore rupees of the sector's contribution to SDP. The value for agriculture is very low - 371.90 whereas, the value for transport is very high (9115.24). Industry sector has an energy/SDP values of 7989.32 for 1990-91.

Efficient use of energy implies proper pricing strategies. Subsidies to industries on the tariff or fuel charges or low tariffs result in larger wastage of energy instead of lower costs of production. The electricity tariff for Karnataka is the cheapest (second only to the U.S.). Many other countries like West Germany, U.K. and France have tariffs which are more than twice our rate. One cannot say more on this because it also depends on income levels. One point deserves mention here with low costs of energy charges, labour and raw materials, many of our industrial products - engineering, chemical etc. should be highly competitive in international markets, but it is not so, one of the factors may be inefficient use of energy.

Energy Planning

Currently, energy planning in our country is not an integrated activity. Since there are many energy sources and end uses, there are many organisations and agencies that deal with different aspects of energy. The plans for electricity, coal, oil and fuelwood are made by respective organisations mainly based on the projection of energy demand. The primary goal of this approach is for energy supply expansions on the assumption that there is a correlation between energy use and gross domestic product. With this approach, energy becomes an end in itself, and the focus shifts on meeting increased energy consumption through energy supply expansion alone. This supply and demand based planning approach for each individual energy form has resulted in problems like more losses, more conversions and low efficiencies. This is evident from the disappearance of forests, village wood lots, roadside trees, construction of giant hydro electric dams, fossil fuel based power plants and controversial nuclear plants. This conflict between the energy demand and environmental quality goals can be solved by having an integrated approach to the problem of energy planning with a view to minimise consumption of non renewable resources of energy, to maximise efficiency of energy usage and to harness renewable sources of energy in an ecologically sound way [7,8]. Another aspect that has to be considered in the planning process is that of matching energy resources and end uses. Because of convenience, the current usage of high quality energy such as electricity for low quality activities like bath water heating is to be discouraged. Hence, strategies for integrated energy planning should include a) Improvements in efficiencies of end use devices and/or conversion equipments, b) optimising energy source - enduse matching, c) an organised approach towards optimal use of renewable resources, d) proper exploitation of biomass energy resources and e) discourage use of depletable resources (by penalising) [9,10].

Our earlier studies brings out vast scope for energy conservation in the energy sectors. Highlights of these studies are

1. The domestic sector in rural areas shows that there is scope for savings of 42% in the quantity of fuelwood used by switching over from traditional stoves to improved stoves [11,12],
2. In electro metallurgical industry, efficiencies of 14% in welding sets, 10.4% in furnaces, 24% in cranes and 36.5% in diesel engines shows vast possibility for improvement in enduse efficiencies in all sectors [13],
3. Energy analyses carried out for the food processing sector revealed that most of the industries are utilising less than 50% of installed production capacity. The low power factor when motor is under loaded, leads to inefficiency. It is estimated that 23- 38% of the energy could be saved at improved efficiency due to full utilisation of installed production capacity [14],
4. Usage of solar water heaters, for water heating (bathing and washing purposes) could bring down electricity consumption in urban area and fuelwood consumption in rural areas [15,16].
5. Harnessing hydro potential in ecologically sound way by means of mini/micro/small hydro potential in hilly districts. It is estimated that about 1250 million units per year could be generated in the Bedthi and Aghnashini river catchment alone in Uttara Kannada district [17] and
6. Harnessing solar and wind energy in coastal regions of Karnataka [18,19]. Our estimate shows that, coastal taluks and arid zones in Karnataka have good potential to install solar devices.

Conclusions

Karnataka state depends both on commercial and non commercial forms of energy. Non commercial energy constitutes 53.2%, met mainly by sources like firewood, agricultural residues, charcoal, cowdung. While commercial energy's share is 46.8% met mainly by electricity, oil coal etc. Energy intensity (energy consumption per GDP) and GDP per capita data reveals that India and Karnataka state have high energy intensities compared to other developed industrialised countries. Which clearly shows that Karnataka state and India have good potential in energy conservation. A comparative study of energy use, mainly electrical, in industries in Karnataka and in those of some industrialised countries reveals that Karnataka consumes 6.13 times the energy consumed in the Switzerland, 5.28 times the energy consumed in Japan, 3.35 times the energy consumed in U.K., 1.98 times the energy consumed in U.S.A. for the same GDP (Gross Domestic Product). The growing environmental degradation demands for review of energy policy. The energy policy should emphasis on energy conservation, development and exploitation of renewable resources of energy, accerlate the development of energy sources in an environmentally sound way and optimum utilisation of the existing capacity.

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