Analysis of Energy Efficiency in India

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Abstract: Energy is the most fundamental requirement of every society or nation as it progresses through the ladder of development. Energy is critical, directly or indirectly, in the entire process of evolution, growth and survival of all living beings. Achieving the goals of poverty eradication, improved living standard and increased economic output imply increasing energy. Energy has come to be known as strategic commodity and any uncertainty about its supply can threaten the functioning of the economy, particularly the developing countries like India. So the paper makes an attempt to analyze the issues and energy situation in India. The paper comprises of the following sections- section 1- Introduction, section 2-energy scenario in India, section 3-energy history, section 4- current energy scenario, section 5-energy planning exercise, section 6 – energy efficiency and section 7-references.

Section 1

INTRODUCTION

Role of energy in an economy

Energy in the Past

The term 'energy' is the capacity to do work as coined by Thomas Young (1737-1829).The two laws of thermodynamics describes the behavior of energy-the first law states that energy can be transformed from one form to another, but cannot be created or destroyed. The second law states that some energy is always dispersed into unavailable heat energy. History of human existence is related with ever increasing energy needs of man. In the ancient time only source of energy was muscular energy and replenished through the intake of food. Through his progress from primitive to modern technological man and demand of energy for cooking and warming newer pathways of energy flow in nature were discovered by converting wood into fire. In agriculture sector the grass was turned into muscular energy of livestock to plough his fields and to transport materials. Further progress led to the development of energy from wind and water. The advent of steam engine led to the industrial revolution and later on energy needs for the various sectors household, transport, industry and agriculture were met by the exploration of fossils-petroleum, coal and natural gas. For the millennia of human existence it was available in plenty but in the present scenario the there is huge gap in demand and supply of energy.

Energy in the Present Scenario

Energy is the prime mover of growth. It is not an end itself, but it fuels the economy and provides the basic infrastructure from extraction of natural resources to availability of technology. Energy is the most fundamental requirement of every society or nation as it progresses through the ladder of development. Energy is critical, directly or indirectly, in the entire process of evolution, growth and survival of all living beings. Achieving the goals of poverty eradication, improved living standard and increased economic output imply increasing energy. Energy has come to be known as strategic commodity and any

uncertainty about its supply can threaten the functioning of the economy, particularly the developing. Of course, once a nation reaches a relative degree of development, the energy demands becomes more stable but today as a result of the structural and technological changes there is also change in use and availability of energy resources. In past the industrial revolution was fueled by coal which was considered a concentrated fuel and led to increase in productivity and development than the wood fuels used earlier. But now the characteristics of modern global economy are distinct than the past, as today the major changes are:

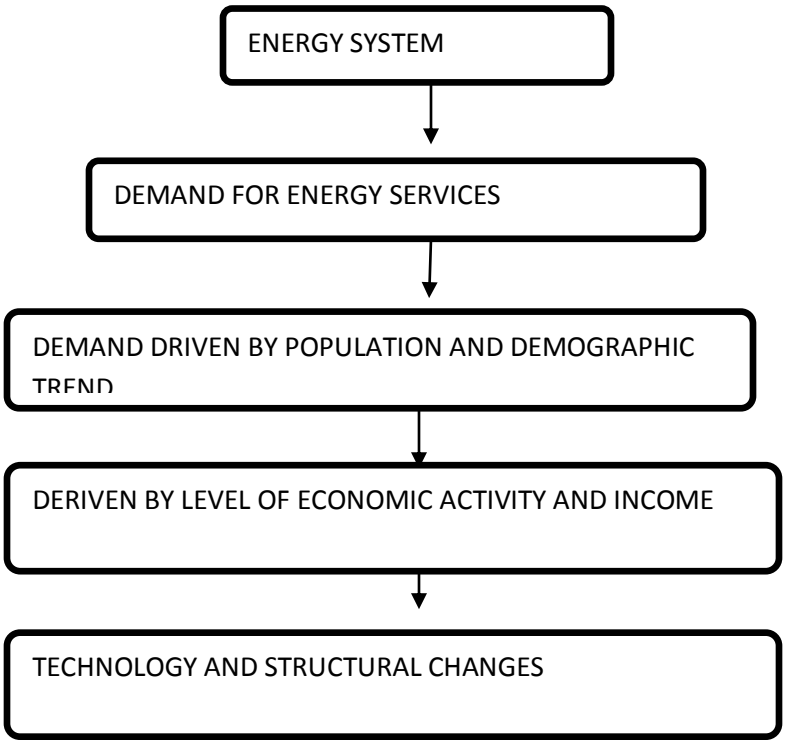
i) Increasing age of population in developed countries, so they shift more to techno advance products which leads to more increase in energy demand.

ii) The developing countries in their race to development are emerging fast in the global scenario, which leads to increase in their labour participation, more investment; more productivity in developing countries all these further needs more energy.

iii) Another change observed is the increase in urbanization in the developing countries which further accelerates the demand for energy.

If we look around us every step of progress has come with an additional demand for energy-cars, ships and aircraft to move, hospitals to give quality health care, production of more and better goods, irrigation for better farming. In fact every element of our lives is increasingly going to become energy intensive-that is a necessary prerequisite for development. The three most basic drivers of energy demand are economic activity, population and technology as shown below in chart:

Figure 1

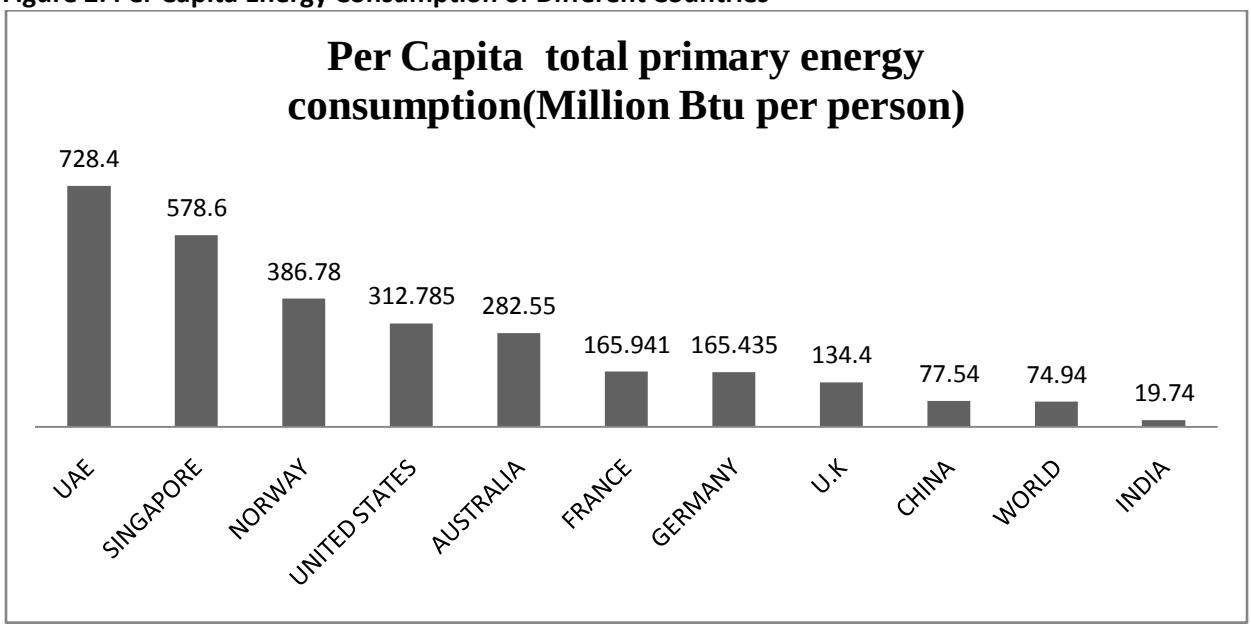


Source: Global Energy Assessment: Towards a Sustainable Future (2012), Chapter 6, Energy and Economy, Cambridge University Press

The whole energy system is governed by the technological and structural changes in an economy.There exists a two-way relationship between economic development and energy consumption. On the one

hand, growth of an economy, with its global competitiveness, depends on the availability of cost-effective and environmentally safe energy sources, and on the other hand, the level of economic development derives the level of energy demand. Thus as the economy undergo changes there is change in energy system. If we see the energy consumption per person across nations also reflects that along with development the demand for energy goes on increasing-for e.g. an average American consumes more than 16 times the energy consumed by an average Indian as clear from the figure given below:

Figure 2: Per Capita Energy Consumption of Different Countries



Source: Energy Information Administration (EIA), U.S international energy statistics (2011).
Btu-British thermal unit

Note: Total primary energy consumption reported in this table includes the consumption of petroleum, dry natural gas, coal, and net nuclear, hydroelectric, and non-hydroelectric renewable electricity. Total primary energy consumption for each country also includes net electricity imports (electricity imports minus electricity exports)

From the figure above we see that per capita energy consumption of the developed countries like Singapore, Norway, U.S, Australia, France and Germany is quite high than the developing i.e. India and China. As a nation progresses on the ladder of development the per capita energy consumption also increases. Thus higher energy consumption per capita too is an index of development as it widens the choices of people and improves their standard of living.

Table 1: Per Capita Primary Energy Consumption (2005-2011)

Total Primary Energy Consumption per Capita (Million Btu per Person)							
Countries ↓ Years →	2005	2006	2007	2008	2009	2010	2011
United States	339.34	333.89	336.34	326.51	308.36	316.86	312.78
France	180.42	179.67	175.73	176.20	166.50	169.78	165.94
Germany	170.97	173.78	167.83	171.76	161.42	171.73	165.43
Norway	428.55	392.17	418.85	418.19	408.67	393.98	386.78
United Kingdom	162.26	159.58	152.99	150.20	140.88	143.07	134.48
United Arab Emirates	632.88	640.04	688.55	747.07	717.24	719.10	728.42
Singapore	469.24	503.27	530.05	519.99	512.54	559.03	578.60
China	49.64	53.96	57.11	59.93	64.96	71.36	77.54
Australia	287.82	287.85	285.84	285.08	283.33	276.28	282.55
India	15.10	15.94	16.95	17.26	18.64	19.13	19.74
World	70.29	71.35	72.19	72.38	70.71	73.99	74.94

Source: Energy Information Administrator (EIA), U.S international energy statistics (2011).
Note: unit of measurement is million British thermal units (mbtu)

The table shows the total primary energy consumption per capita of the world and some countries from 2005 to 2011.From table it is reflected that the primary energy consumption per capita of developed countries is either consistent or declining slowly whereas in case of developing economies like India and China it is increasing and in absolute amount the energy consumption is less as compared to the developed which shows the future sign of increase in demand of energy in the developing countries. The 2009 World Energy Outlook of the International Energy Agency (IEA,2009) estimated that US $ 20 trillion will be required over next 25 years just to meet the projected increase in global energy demand by 2030 which raises a question of energy security and sustainability for the world especially the developing. Energy security and sustainability in 21st century depend less on global population than on income of population and how is income generated, for e.g. the members of Organization of Economic Cooperation and Development(OECD) currently account for 18% of world's population and ¾ of global GDP. By comparison, China and India represent some 37% of world's population and 11% global GDP in terms of Market Exchange Rate (MER) (World Bank, 2011). It might be expected that as the economy matures and achieves a certain level of development the demand for energy stabilize but what happens actually is the energy intensity declines and the per capita consumption increases. This happens due to the rebound effect i.e. as more efficient technology is employed it reduces the amount of energy for operating the appliances and equipments, the energy is saved and the cost decreases, but it leads to more increase in demand for energy as there is increase in disposable income due to low cost. The link between energy and economy can be explained as with the help of following equation as:

E= $(Pop \times \frac{GDP}{POP} \times \frac{E}{GDP})$

Where E is the demand for energy, which is function of population (pop) of an economy, per capita income ($\frac{GDP}{POP}$) and energy intensity ($\frac{E}{GDP}$) (Energy and Economy, Chapter 6, Global Energy Assessment). For all the countries generally, the energy demand increases with increase in population, but in case of

per capita income the developing countries show more positive response, as a slighter increase in income leads to more increase in the demand of energy. The intensity effect differs for the all countries according to the level of development and regional disparities. The developed countries use less energy per unit of economic output and more energy per capita than the poor countries do. Organization of Economic Cooperation and Development (OECD) countries have generally lower energy intensities than developing and transition economies. The developing and transition economies are less efficient in their economic production, which indicates a large potential for efficiency improvements as this region industrialize and adopt best available technologies. Thus, the main concern is for the developing economies as they would require now energy in massive amount for the path they are leading, because the global world today is driven by manufacturing sector, as the industrialized world have high percentage share of manufacturing in value added (UNIDO, 2001). Also the manufacturing sector consumes more than one- fourth of the total energy consumed in an economy. Thus there are many challenges in front of the developing economies, as they have not only to focus on the need of energy for industrialization, apart from these the issue of sustainability because industrialization is governed by fossil fuels-a finite and non-renewable energy source, for long term availability of energy resource transition is necessary. Secondly the environmental concerns due to increase of emissions in the world economy and third is the safe cleaner and easily available energy i.e. energy security, because still a large chunk of masses is there who depends on non-commercial, traditional energy sources for their basic needs which have their own limitations. A lot of time is wasted in collection of the fuel wood, increase in pollutants and also the people are exposed to health hazards. Thus to connect these people with modern energy carriers too is required for development. The globalization and market liberalization have changed the global scenario and standard of life, but we cannot ignore the crucial role played by energy. Without light, power and heat we cannot run or build the factories that provides good jobs and homes nor enjoy the amenities that make life more comfortable and enjoyable. So there is need to examine the energy situation in the developing economies and the future prospects of energy security. We discuss the emerging economy-India.

Section 2

India's Energy Scenario

India an emerging economy is not free from the challenges discussed above, finds itself going through a phase of rapid ascent in economic empowerment. Industries are evolving at a significantly higher rate since liberalization. India has achieved rapid and remarkable economic development in past two decades and became the world's tenth largest economy in 2011 (World Bank,2011) .With its relatively young population, India is expected to take over China as the world's most populous nation around 2025 (based on IEA population growth projection in WEO,2011). The country has thus achieved dynamic economic powers in the world, yet there exist contradictions and complexities that posit considerable challenges to the economy. India ranks 134 out of 187 countries in United Nations HDI due to poor performance in education and health indicators (UN HDI, 2013). Recent rapid growth reduces the number of people living in poverty, but failed to achieve balanced growth between rural and urban areas. For e.g. 37.2% of national population is below poverty line of USD 1.25 purchasing power parity (ppp), whereas 26% urban population is considered BPL and 42% of rural population. So along with economic development India needs to alleviate imbalances in economic wealth and living conditions. Economic growth in India has led to alarming increase in the demand for energy. Despite the skyrocketing demand, access to energy is still preserve to small minority of the population and a large chunk of population still lack access to the modern sources of energy and depend on biomass and other sources of energy. Uneven access to energy has a direct impact on economic growth and represses poverty alleviation. Thus India has to face the twin challenge of providing energy access to all the section

of population and meeting the goal of economic growth. All this would need massive energy. The government of India aims to achieve a GDP growth rate of 9% in the 12th five year (Planning Commission: Twelth Five Year Plan Document) plan and maintain average growth rate of about 8% in the next fifteen years. In formulating its growth strategy, India has placed emphasis on growth of its manufacturing sector. The objective of Indian planners is to achieve accelerated growth in the industrial sector with a view to increase industry's share in GDP as well as India's share in world industrial output. However energy being a vital component of production such an ambitious vision would adventerly call for rapid increase in commercial energy demand at the rate of 5.2 per cent per year (Planning Commission: Twelth Five Year Plan Document) in the near future. So, the biggest challenge to India today which is the third largest consumer of energy after U.S, China and ahead of Russia in the world energy consumption (2009, IEA), is the management of energy demand and supply because India does not possess the energy resources in abundance and to fulfill the target of 9% growth rate, India had to meet its development needs by available coal, oil, hydro and renewable energy resources and rely on the imports. Today, we have reached a point where not only future growth, but even current production and employment are threatened by the possibility of a cut back in the availability of imported crude oil and the oil products. Thus, it becomes necessary to reduce the vulnerability of the economy by increasing energy efficiency measures to contain the domestic demand for energy and reduce the imports at a reasonable level. The most conventional and traditional measure for energy efficiency is energy intensity (Energy input associated with a unit of GDP).The energy intensity of Indian economy is declining over the time. Declining energy intensity implies that energy required for per unit of output is decreasing.

Table: 2: Energy Intensity for Total Primary Energy Use

Period	Energy Intensity* (kgoe/US$)**
1981	1.09
1991	.99
2001	.85
2011	.62

Source: Planning Commission, 12th Five Year Plan Document

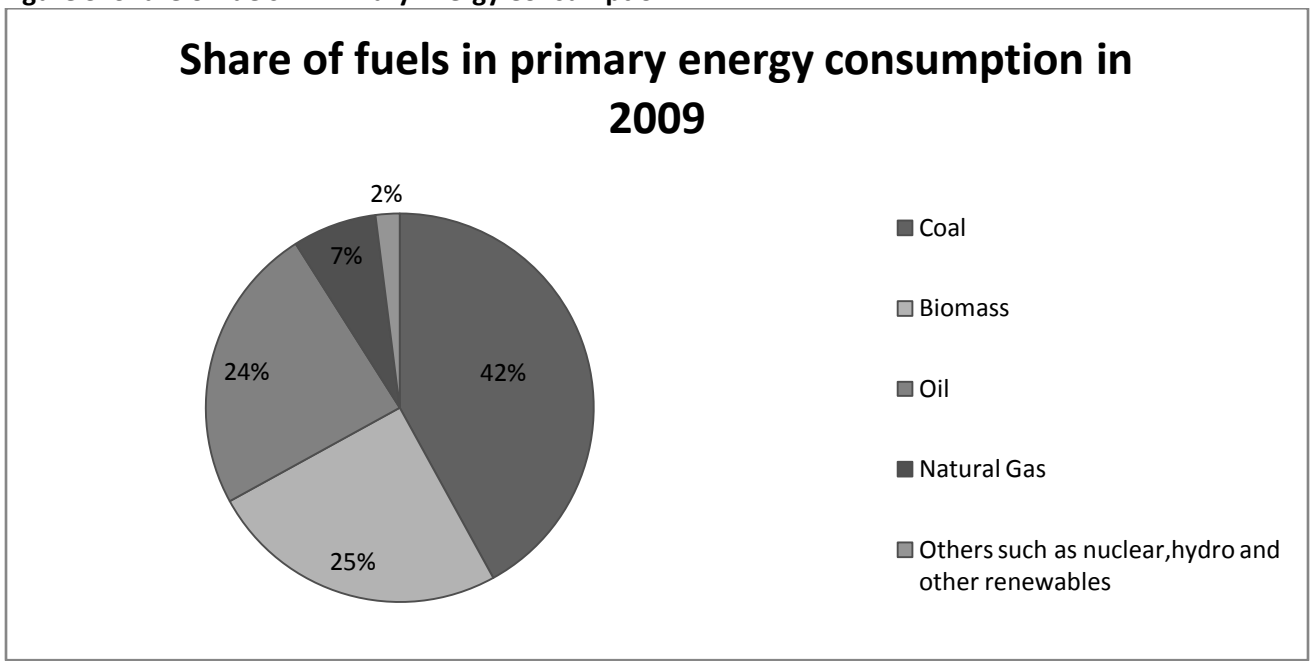
*Energy intensity indicated as energy required to produce one unit of output.

**Kilogram of oil equivalent (kgoe)

Thus we see that the energy intensity of primary energy has declined from 1.09 in 1981 to .62 in 2011.But the elasticity of income of commercial sources of energy has been higher than the energy intensity for total primary energy as a result of ongoing shift from non-commercial sources of energy to commercial sources of energy. Thus there exists a wide scope for improvement in energy intensity through energy efficiency measures. India's per capita consumption is .58(toe/capita),compared of world average of 1.8,OECD of 4.28,China 1.7 (IEA,2011).The low per capita energy consumption level indicates that India's energy demand still has a long way to reach saturation. Since economic reforms in 1991, India has experienced a major transformation of its energy mix as there is shift from biomass to other energy sources, particularly coal. The reduction of biomass consumption considerably coincides with India's economic development and urbanization over past decades. But still biomass and fuel wood are widely used in rural areas by low income households. In 2009, primary energy source was coal,

followed by biomass, oil and natural gas. Thus the consumption pattern totally depends upon the non renewable source of energy and renewable occupies a very small percentage.

Figure 3: Share of fuels in Primary Energy Consumption



Source: International Energy Agency (IEA, 2012), Understanding Energy Challenges in India.

Considering India's energy demand growth at CAGR of 4% for period 1990-2009 (IEA,2009),domestic supply could not cope up with the demand as most of volume of production comes from coal and natural gas and crude oil constitutes a very small percentage. To see how India can best address the challenge before it, it is necessary to examine the country's energy history and overview of production and distribution of energy.

Section 3

Energy History

To understand the current state of India's energy sector, it is necessary to analyze the past events and policy decisions that shaped today's energy sector. Prior to independence in 1947 the production and consumption of energy was mostly British owned and had three principal characteristics (Ebinger, 2013, Energy and Security in South Asia)

a) Urban - rural population with divergent consumption patterns.

b) A private sector which controlled energy production.

c) Limited distribution of electricity resources.

More than 80% of population lived in rural areas and dependent primarily on non-commercial sources of energy. Coal was consumed primarily in electricity and transportation sectors, its production and use was limited to British private firms that left Indian firms with poor quality deposits and inferior technology and production methods. Domestic oil production capacity was also limited and the demand of oil for transportation, cooking, heating and lighting was met exclusively by imports. The inefficiencies of coal sector and the minimal production of oil spurred the government interest in developing its hydropower resources as there was no fuel cost and hydropower was cheaper to produce. But even then the electricity distribution was minimal. Thus, the picture of energy sector before independence was very grave. Shortly after Independence, India's first Prime Minister, Pt Jawaharlal Nehru established

the parameters for public and private sector involvement in Industry through Industry Policy Resolutions (IPRs) of 1948 and 1956. Because the private sector was too small prior to independence and it does not possess the capability to support such a robust industrialization, so the responsibility to develop the energy industry was fell on the public sector. Despite of establishment of National Coal Development Corporation and expansion of Geological Survey of India, public sector production fell short of the target decided. Similar difficulties were faced in the oil sector too; despite of the exploration and the production facilities the public sector performance was very dismal. Sluggish production, coupled with increasing demand forced a significant rise in the import of the oil. In addition to the costly import bill, the Nation's balance sheet was further dwindling by heavy subsidies for petroleum and natural gas production. By mid 1980's India's electricity sector had also become grossly inefficient and unprofitable. Further by 1990's the LPG reforms were introduced and there was a dire need for private sector involvement in energy to reduce the import bill. To encourage the private sector participation the government introduced the New Exploration and Licensing Policy (NELP), which helped in bringing much needed technology, expertise and a significant amount of investment. At the start of the eighth five year plan, the Planning Commission of India called for the construction of facilities' to generate an additional 30,000 Megawatt (MW) by 1997.In order to reach the goal, a number of changes were made to existing electricity framework including the amendment to the Indian Electricity act allowing for great authority and autonomy to the regional dispatch centre. Recognizing the importance of the coherent energy plan for economic, social and political development, In 2004 the Prime Minister Dr. Manmohan Singh commissioned an expert committee "to prepare an integrated energy policy linked with sustainable development that covers all sources of energy and addresses all aspects of energy use and supply including energy security, access and availability, affordability and pricing, as well as efficiency and environmental concerns" (Planning Commission, 2006). The committee was set up in 2004, the draft report was released in August 2006, and, the cabinet finally approved the report in December 2008. One of the salient features of IEP is the focus on ensuring transition to market economy where private companies compete on a fair footy with public companies ensuring level playing field to all players and also stresses on transparent and targeted subsidies and proper energy pricing to send right signal to producers and consumers. The report stated that to sustain the growth rate of 8% a year and over 25 years the country's average annual energy growth would have to rise 4.3% a year in the most energy efficient scenario and 5.1% a year in a business-as-usual (BAU) .

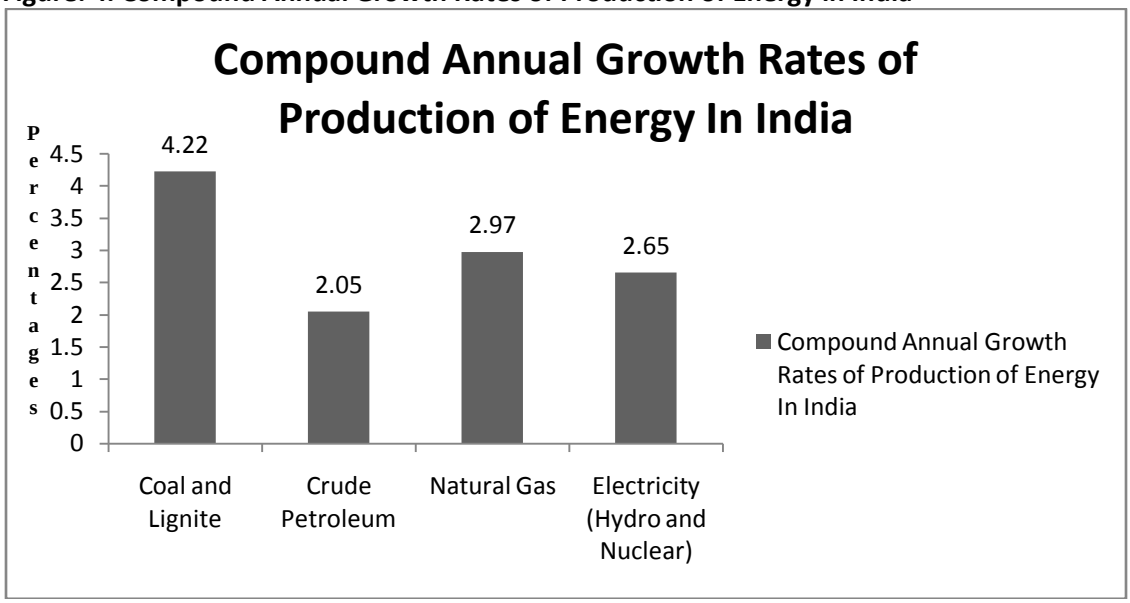
Section 4

Current Energy scenario

India is the third largest consumer of energy after U.S, China and ahead of Russia in the world energy consumption (2009, IEA), and its need for energy supply continues to climb as a result of the country's dynamic economic growth and modernization over the past several years. India's economy has grown at an average annual rate of approximately 7% since 2000, and it proved relatively resilient following the 2008 global financial crisis. At the same time, India's per capita energy consumption is one-third of the global average, according to the International Energy Agency (IEA), indicating potentially higher energy demand in the long term as the country continues its path of economic development. In the International Energy Outlook 2013, EIA projects India and China will account for about half of global energy demand growth through 2040, with India's energy demand growing at 2.8% per year.

The current energy system of India is governed by coal. In total energy consumption largest percentage share is of coal followed by the other energy sources. If we look at the production side, we find that the compound annual growth rate of production of coal and lignite is more as comparison to other fuels of energy from the primary sources, we observe from the figure above that coal account for major share in rate of production followed by biomass, natural gas, electricity and crude petroleum .

Figure: 4. Compound Annual Growth Rates of Production of Energy in India

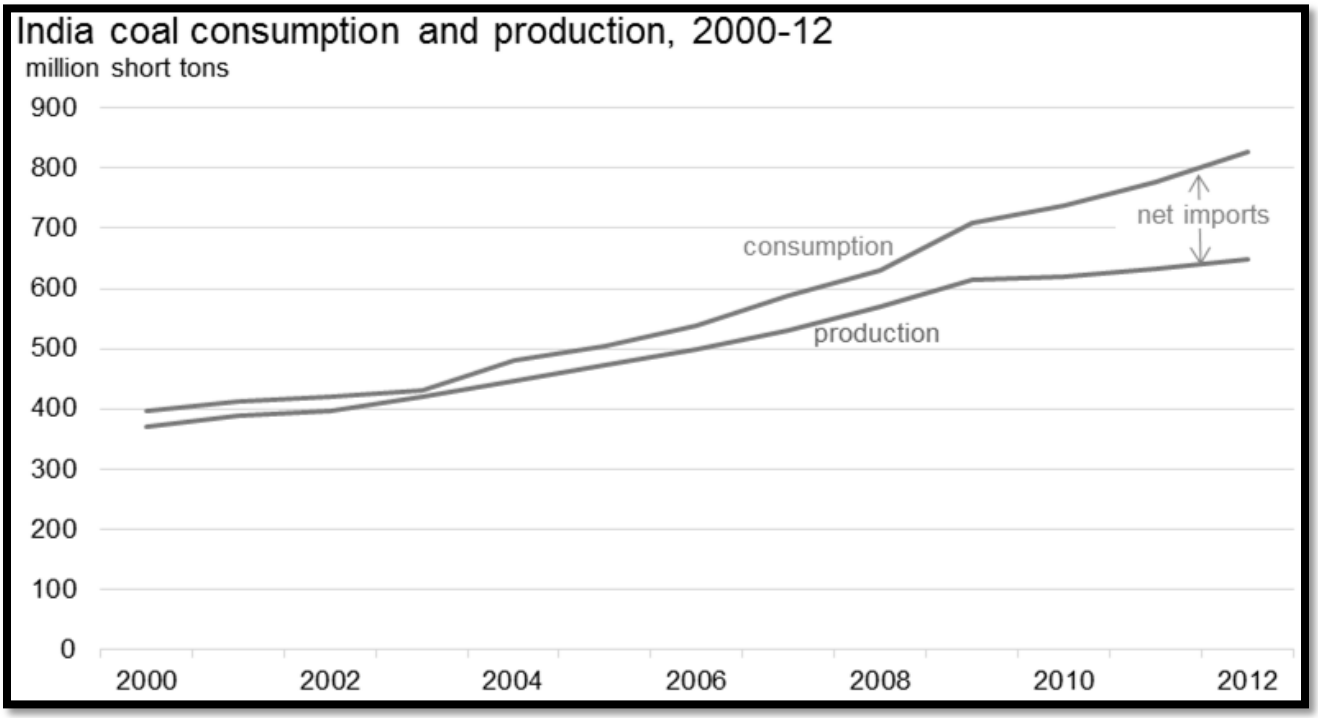


Source: Energy statistics (2014), CSO, Ministry of statistic and programme implementation of India.

Coal: Coal is India's primary source of energy. The country has the world's fifth-largest coal reserves, and ranked third largest in terms of both production and consumption in 2012. The state retains a near-monopoly on the coal sector. The power sector makes up the majority of coal consumption. Coal is India's primary source of energy, and the country was the third-largest global consumer in 2012.Coal has remained critical to India's infrastructure and development trajectory than any other fuel source. Coal being an indigenous source of power, but its production was modest at the time of Independence because of lack of access to technology, expertise and adequate data. But as a result of the reforms introduced in the coal sector led to increase in demand and supply of the coal. The government 2006 Integrated Energy Policy report stated that the coal blocks held by Coal India Limited that are not brought into production by 2016-17 should be made available to other eligible candidates for development. Along with this other reforms include recommendations that Indian coal producers adhere to the international norm of preparing coal ,introduction of independent regulatory body to oversee the competitiveness of auctions, construction of power generation fascilities close to the coast. With the introduction of international expertise and advanced technologies, India's coal producers will gain access to hard to mine underground coal and will able to enhance cost competitiveness through the implementation of advanced processes such as in –situ gasification, which gasifies the coal underground making it cheaper to produce coal based energy and technologically easier to capture Co_2 emissions.No doubt a number of reforms undertaken for development of coal but there is uncertainity regarding the reserves of coal deposits. A large amount of India's reserves of thermal and coking coal are found in forest sites and tribal areas, which the government is reluctant to exploit. Coal deposits are mainly confined to eastern and south central parts of the country. The states of Jharkhand, Odisha, Chhattisgarh, West Bengal, Andhra Pradesh, Maharashtra and Madhya Pradesh account for more than 99% of the total coal reserves in the country. The State of Jharkhand had the maximum share (27.0%) in the overall reserves of coal in the country as on 31st March 2013 followed by the State of Odisha (24.7%) (Energy Statistics (2014).The unrest among the coal workers of Jharkhand, Bihar and West Bengal and some percentage of mining revenue is allocated to people affected by mining make it difficult for foreign investors to operate in India. Thus, despite the vast amount of untapped coal deposits, India is becoming more and more reliant on coal imports for its power and industrial needs.

The figure given below shows the trend of divergence in production and consumption of coal and the gap is fulfilled by the increasing imports.

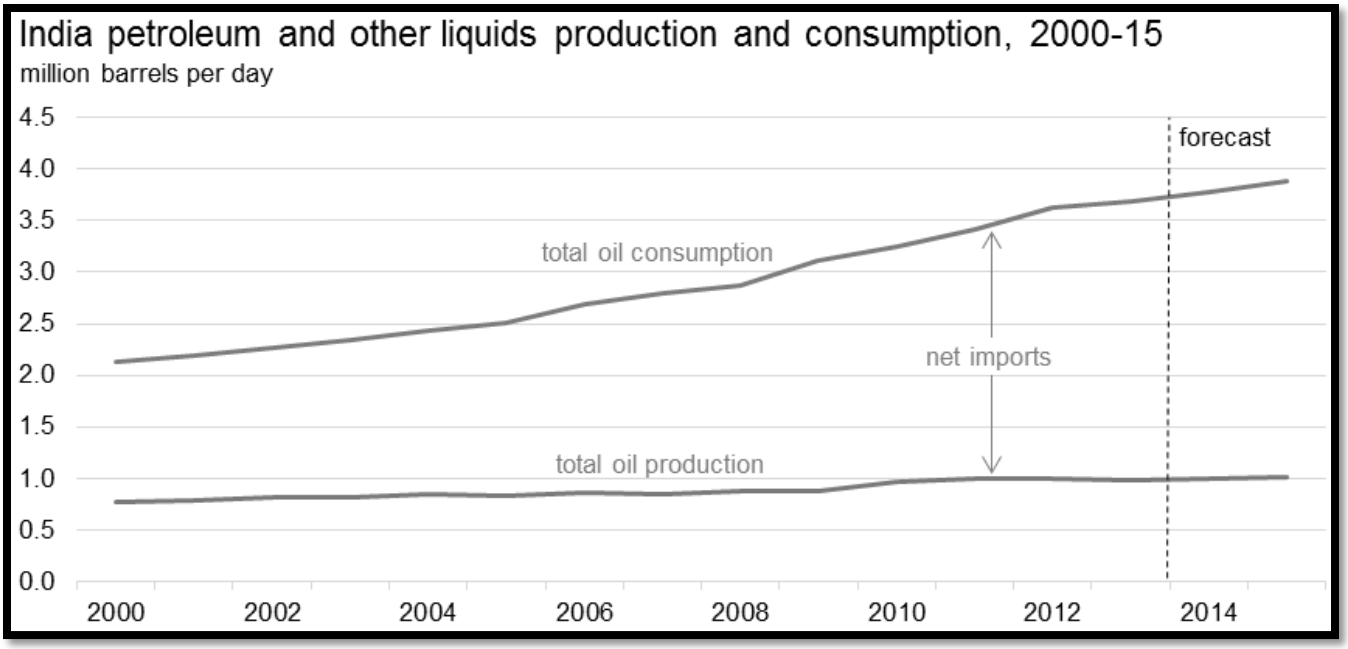
Figure 5 Consumption and Production of Coal



Source: U.S Energy Information Administration (2012)

Petroleum: In 2009, petroleum consumption in India totaled to 3.11 million barrels a day (mmbd) of which 877,000 barrels a day was domestically produced. The remaining 70% came through imports. India's impressive economic growth during the last decade has intensified the country's thrust for oil. The International Energy Agency forecasts a demand increase of nearly of 4% a year over the next several decades, reaching 5.1 million barrels a day(mmbd) by 2025 and 7.5 mmbd by 2035.Another driver of growth in the demand for oil in India is the transportation sector where demand for both petrol and aviation fuel is sky rocketing. India has about 5.6 billion barrels of crude oil reserves, according to Energy Information Agency. The majority of India's domestic oil production is from the offshore Mumbai High field and in the Onshore Cambay Basin in India's North-West and Assam Arakan basin in India's North-East. Despite the efforts over the past decade to encourage foreign investment in the domestic oil sector, including the NELP licensing rounds implemented in 1999, India's oil production has not increased as quickly as its demand for oil. Gasoline and diesel prices have been depressed to a low level that discouraged the private sector investment and forced major state run companies like Oil and Natural Gas Corporation, Oil India Limited and Gas Authority of India Limited to run finance starved projects. As a result, India's domestic oil sector depends on aging and declining fields, while new fields have not developed owing to a lack of adequate exploration technology and seismic data.

Figure 6: Production and Consumption of Petroleum and Other Liquids

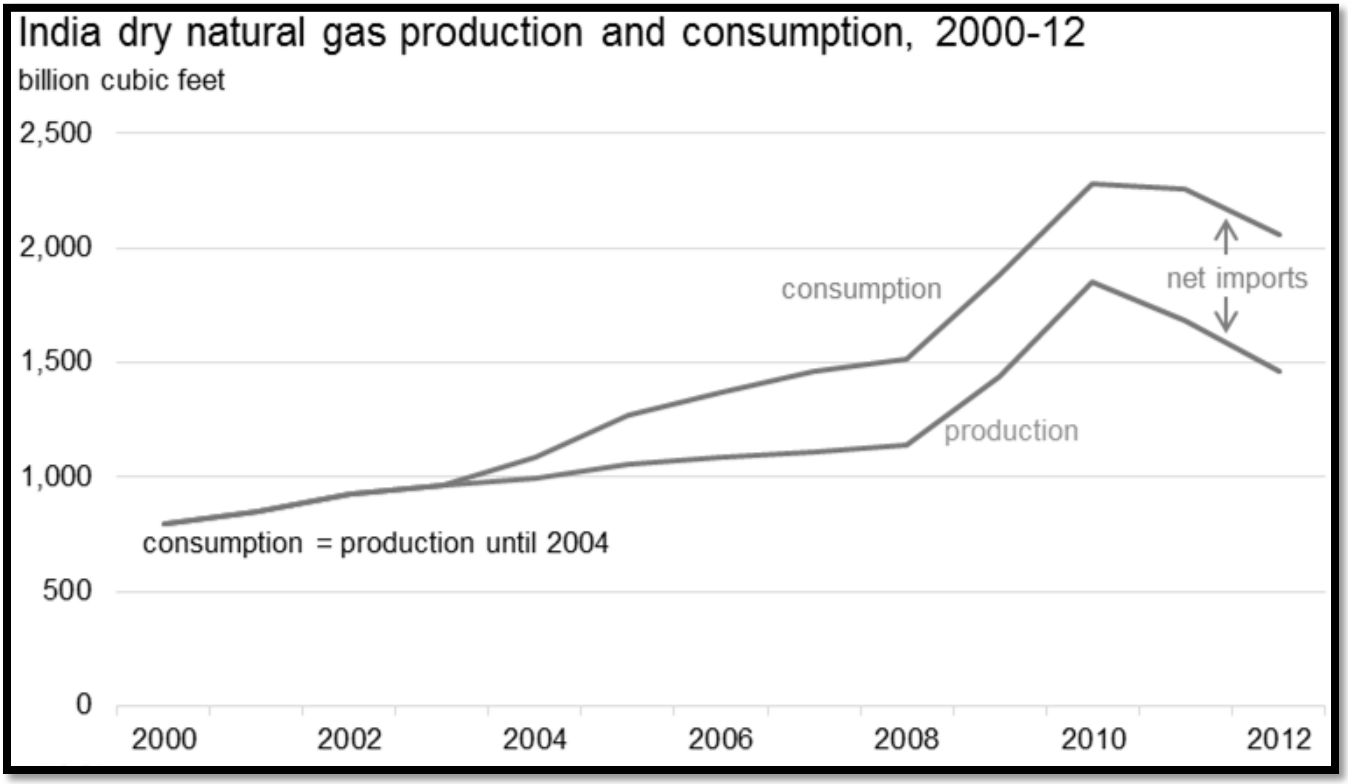


Source: U.S Energy Information Administrator, International energy statistics and short term energy outlook, June 2014**.**

Thus we see from the above figure that there is wide disparity in the consumption and production of petroleum in India. The dependence on the imports is continually growing which calls for necessary action to switch to other energy sources or design another measures.

Natural Gas: India's Natural gas sector presents a more optimistic story than its oil sector. Since the 1980's, domestic natural gas production has increased steadily. In 2009 India produced about 1.4 trillion cubic feet (tcf) of natural gas while domestic consumption was 1.8 tcf. The remaining 400 billion cubic feet (bcf) was imported via liquefied natural gas shipments as India does not have any pipeline connection with foreign country. Natural gas mainly serves as a substitute for coal for electricity generation and as an alternative for LPG and other petroleum products in the fertilizer and other sectors. The country was self-sufficient in natural gas until 2004, when it began to import liquefied natural gas (LNG) from Qatar. Natural gas consumption has grown at an annual rate of 8% from 2000 and 2012, although supply disruptions starting in 2011 resulted in declining consumption. In 2012, India consumed 2.1 trillion cubic feet (tcf) of natural gas. LNG imports accounted for about 29% of 2012 demand.

Figure7:Production and Consumption of Natural Gas



Source: U.S Energy Information Agency, International energy statistics and short term energy outlook, June 2014**.**

Domestic production in India is concentrated offshore with Mumbai high field and the Krishna-Godavari (KG) Basin as the primary domestic production regions. The current Indian gas market is accounted by the power and fertilizer industries using 40% and 29% respectively. Because the fertilizer is heavily subsidized and the gas fired power sector is also subsidized it does not provide an incentive to gas producers to engage in exploration. In the oil sector NELP licensing round created interest in developing gas fields in India and led to discovery of the KG-D6 field in the KG basin off the eastern coast of India. The field 90% owned by the Reliance Industries Limited is the second largest gas producing field in India. Demand for gas is expected to increase over time. The bulk of increase in demand is from India's strategy for generating electricity and in India's transportation sector. Delhi is pursuing a path of power generation diversification and is vigorously supporting increased use of natural gas to displace coal and oil fired generation, as natural gas is more efficient and cleaner than both coal and oil.

Shale Gas: The shale gas revolution that has swept the United States is gathering momentum in India. Through a process known as hydraulic fracturing-natural gas producers can now access previously unattainable reserves of natural gas trapped inside shale rock formations. In only few years' shale rock has transformed the United States from a likely major importer of natural gas to a self sufficient natural gas consumer. And now producers in U.S are also cooperating with India and oil and Natural Gas Corporation (ONGC) completed drilling its first shale gas well in Damodar Valley in West Bengal. The company has also announced other investments in shale gas production elsewhere in West Bengal and Jharkhand. In its 2013 assessment of global shale gas reserves, U.S, Energy Information Administration (EIA) estimates India has 96 trillion cubic feet (tcf) of technically recoverable shale gas reserves.

Renewable Energy Sources

Hydroelectricity: Hydropower has played a significant role in India's electricity mix. The government of India has expressed interest in re energizing the hydropower sector, most notably through its 50,000-MW hydropower initiative launched in 2003. India was the world's seventh-largest producer of hydroelectric power in 2012, with 115 billion kilowatt-hours generated. India benefits from a tropical climate, which gives the country increased hydropower potential, particularly during the summer months. In particular, states with significant river systems such as Himachal Pradesh, Jammu, Kashmir, and Uttarakhand benefit from energy surpluses as a result of abundant precipitation during the monsoon period. But there are a number of obstacles in the growth of hydroelectricity. The melting of Himalayan Glaciers is placing strains on the availability of water supplies, in addition to this the scarcity of available land also creates political opposition to new projects as problem regarding the displacement of the population .Also, there is impact on local and regional flora and fauna including fisheries.

Nuclear Energy: As a part of its effort to diversify its economy from fossil fuels, India has pursued the development of both conventional and advanced nuclear energy technologies since early 1950's.While the capacity of nuclear power was expected to grow fivefold by 2030 and the signing of the nuclear deal has led to even more optimistic forecast of up to 63,000 Mega Watt (MW) of nuclear power by 2032(www.world-nuclear.org) . The U.S-India Agreement on Civil Nuclear Cooperation, which was signed into law in Dec.2008, provides India with access to the International market for civilian nuclear technologies. Since the signing, a no. of nuclear companies has entered into agreements with the Nuclear Power Corporation of India for the construction of nuclear reactors. However in wake of Fukushima nuclear accident in northern Japan in March 2011, the achievements of these targets may prove more challenging as public opposition may be stronger. But in response to public concerns, India indicated that it will seek to establish a new independent regulatory to oversee the nuclear industry.

Solar Energy: In recent years, India has created a dynamic domestic solar power market, emerging as a formidable competitor in the international market. Recently New Delhi announced the Jawaharlal Nehru National Solar Mission, a mid and long term commitment to the significant generation of solar power. The mission proposes a solar generating capacity of 20,000 MW by 2022.While there is access to consistent and intense sunlight averaging 250 to 300 days a year encourages the growth of solar sector, but high cost threatens the industry's growth.

Wind Energy: With an installed capacity of 10.24 giga watts as of March 2009, India is the world's fifth largest wind power generator behind U.S, Germany, Spain and China. The Wind Resource Assessment Programme a project of the centre for wind energy potential, having set up 1050 wind monitoring stations through-out twenty five states of India and with a plan to extend to include seven more. State Electricity Regulatory Commission have implemented a no. of prefential tax schemes and accelerated depreciation to promote the installation of wind generation facilities within their territories.

Biomass Energy: It is another important fuel for India. Rural areas of India tend to rely on traditional biomass (including firewood, animal dung, and agricultural residue) for cooking, heating, and lighting because they lack access to other energy supplies. These sources can be burned directly to produce heat and electricity. Large parts of India rely on biomass as the primary fuel for cooking. According to the 2011 India census, 62.5% of rural households use firewood as the primary fuel for cooking, 12.3% use crop residue as the primary cooking fuel, and 10.9% use dung. By contrast, more than 3% of urban households use crop residue and dung, and only 20% use firewood as the primary fuel source for cooking. These uses can cause health problems from exposure to waste products and pollution or environmental problems when forests or crops are harvested unsustainably. On the whole, about 66% of India's total population used traditional biomass for cooking purposes in 2011, according to the International Energy Agency (IEA).Biomass is not as important for power generation, but its potential for

electricity generation is high. Through increased application of currently available technology, it is projected that 16 giga watt of power could be produced from rice husks and other residues currently being left to rot.

Section 5

Energy Planning Exercise in India

Until 1992 country's entire energy apparatus operated under the purview of the Power Ministry. Subsequent restructuring of the sector lead to the formation of Ministry of Power, the Ministry of oil and Natural Gas, the Ministry of Coal, the Ministry of New and Renewable Energy and the Department of Atomic Energy. The main thrust towards framing the policies and programmes for the energy planning started in 1970's after the energy crisis, due to scarcity of fossil fuels, growing global climate concerns and finally for achieving cost effectiveness because of rising prices of commercial sources. As, India do not possess the energy resources in abundance so different initiatives were taken to save the country from energy crisis. While the early energy policy initiative in India revolved around on energy conservation and only recent concerns on climate change have captulated policies to move faster towards energy efficiency. Till 1970's the planning exercise focused on puritanical ideals of development. The five year plan focused on the goals of poverty alleviation and economic growth with importance to self reliance in the economy. In 1970's the 'Fuel Policy Committee' (FPC) was constituted for assessing the energy demand and supply gap for next 15 years against the backdrop for growing concerns on scarcity of fossil fuels. In 1974 the committee submitted its report, at that time world oil market was going through major upheavals and the committee suggested various recommendations for substituting oil by coal, efficiency in electricity generation and special attention to hydro power generation. Then 'Petroleum Conservation Action Group' (PCAG) was formed in 1976 for creating awareness on the importance, methods and benefits of conserving petroleum products, promote R&D in the field and promote conservation of oil and substituting petroleum products by alternate sources of energy. The 'Working Group on Energy Policy' (WGEP) 1979 was formed to carry out comprehensive review of energy situation. It highlighted the need for integrated energy policy and demand management should form most important element of oil policy. The sixth Five Year plan (1980-85) marked the beginning of economic liberalization in Indian Economy and the Government of India instituted in 1981 'Inter-ministerial working group' on energy policy. It came with first concrete proposal for reduction in energy consumption in India and showed that there is immense scope of saving energy in Industry, transport and agriculture. The key outcome of the report was it proposed creation of an apex body to initiate, coordinate integrate and monitor the progress and implementation of various energy conservation measures in India. Advisory Board on Energy (ABE) was set up on the eve of seventh Five Year Plan (1985-1989) to provide energy policy input directly to Prime Minister's Office. The ABE also made detailed projections of energy demand in different regions till 2004 under the assumptions of different macro-economic scenarios. In 1990's Government of India introduced an array of innovative initiatives and programmes aimed towards energy conservation. The Government declared 14th of December (every year) as 'The National Energy Conservation day' and 'National Energy Conservation Award' was started by Ministry of Power for industrial units which have taken exceptional initiatives on energy conservation. Eco-Mark was started in 1991 as part of the bureau of Indian Standards (BIS) was aimed at essentially labeling of environmentally friendly products. In 21st century concern on sustainable supply of conventional sources of energy increased to meet the growing demand for energy. It was realized that the path and policies pursued in context of energy use had led to inefficiency in production, transportation and utilization of energy. So need was felt for developing alternate sources of energy to meet the rising demand, but it takes time to develop alternate sources of energy and make them commercially viable. So, India had to pursue the policies that aggressively promote the efficient use of energy resources. In 2001 the Energy Conservation bill was passed as an act

by parliament. It stressed on energy consumption norms and required designated consumers .i.e. the energy intensive industries and other establishments notified so by the government, to adhere to these. It facilitated the creation of new body in the name of 'Bureau of Energy Efficiency. Since its inception, the BEE has been successful by providing greater thrust on promoting the idea of energy efficiency as a means of attaining competitiveness. Despite the perceptible focus on promoting energy efficiency, India continue to face barriers-one of the barriers was energy pricing keeping the electricity rates low to promote spread of electricity especially in rural areas. Low agriculture tariffs and high subsidies resulted in overuse of both ground water and electricity. The challenge was not only to ensure energy efficiency but also to provide clean energy created the need to develop an effective and comprehensive energy policy. In 2006 'Integrated Energy Policy' was framed that involves a system of coordinated decision making and that brings various energy activities and decision making in a common framework. One of the goals of integrated energy policy was to ensure that technologies that maximize energy efficiency and demand side management are pursued. The policy lays strong emphasis on making the energy sector efficient and competitive. It argues for relative prices and taxes that reflect the true social cost of different fuels and forms of energy as the best way to encourage right choice of fuels and technologies; for competitive markets wherever possible; transparent and targeted subsidies when needed. The direction of Eleventh Five-Year plan was influenced by the integrated energy policy. One of the critical vision put forth by plan was to increase energy efficiency by 20 percentage points by 2016-17 (Planning Commission,2007).The impact of these all policies and programmes was that India was able to reduce its energy intensity by significant amount. But while calculating the energy intensity only the commercial sources of energy is taken into account, while a large part of population still rely on the non-commercial sources of energy. Thus the challenge is to take into account both the commercial and non-commercial sources of energy into the energy intensity and provide the population with safer, clean and modern sources of energy. All this is possible only through the energy efficiency measures.

Section 6

Energy Efficiency

The present energy scenario in India as examined above have the following features:

i) The present energy system is coal dominated and because of high dependence on dirty fuels pollution is rising.

ii) Since Independence the energy sector has been operating under the ownership of government sector, after 1990's private sector participation has been allowed to ensure level playing field but domination of public sector still continues.

iii) There is skewed demand pattern as Indian energy consumption shows a large income bias.

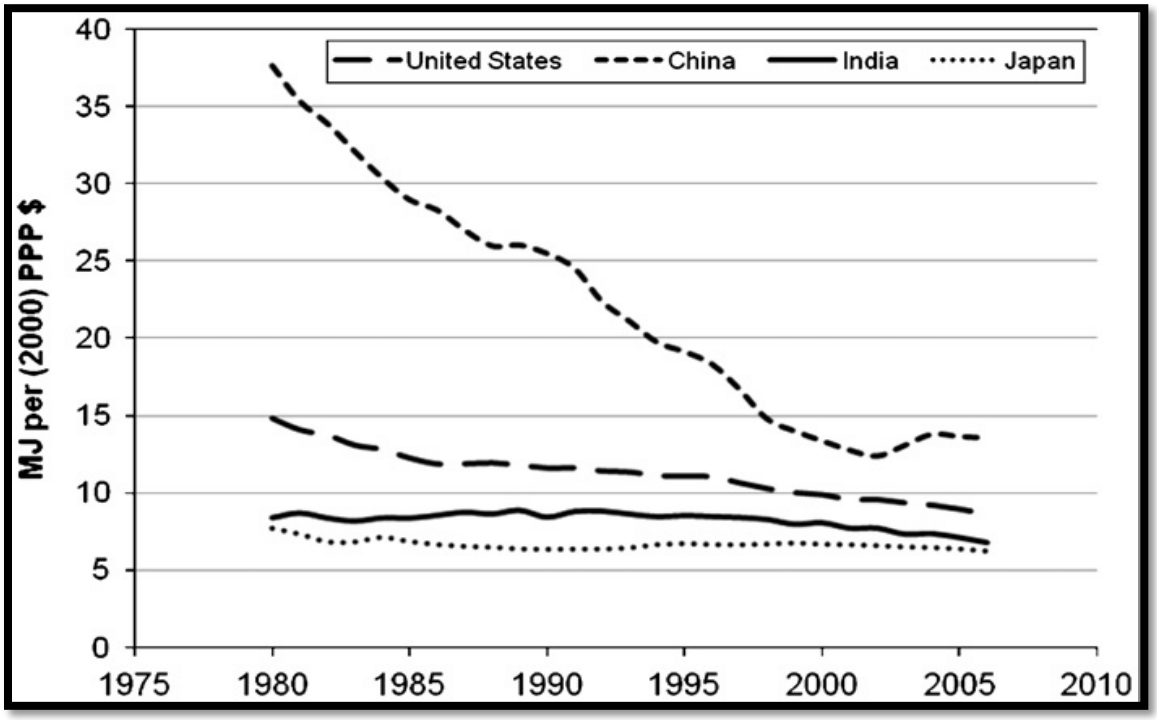
iv) There exists a wide gap in patterns of energy consumption in urban and rural India.

v) The country still face a significant access issue of providing clean energy to large section of population.

Thus India needs a shift and break –away from the present unsustainable path at all levels and adopt energy efficient way of life. There exists a vast amount of literature that focuses on changing habits of energy consumption by different countries and also focuses on switching to another alternate, as the fossil fuels are limited and causes environmental hazard and growth cannot be sustained solely on basis of fossil fuels. Some of the notable studies are Rangarao(1974),Pendse(1980),Ghosh(1991),Mitra(1992),Goldemberg(2001),Russi Daniela(2007),all the studies focus on the issue of energy security and energy efficiencies. The challenge before the global economy is twin fold i.e. to keep sustaining the development path with environmental concern, and to make access clean and affordable fuel supply to the growing population. Today energy security is not just the oil security rather it encompasses another dimensions like safe, affordable and clean fuel too. Moreover it must be recognized that energy security does not stand

by itself but is lodged in the larger relations among nations.(Daniel Yergin,2006).The energy modeling exercise done in developed countries cannot be adopted in the developing as both differ in nature, resources and many other geographical features. In this stage it is comfortable for the developing to transform the energy system. Now a country like India enjoys an advantage of renewable energy resources that can be easily tapped according to its geo-climatic conditions. But totally switching to renewable is an arduous task and it will take time, so the best solution for the emerging Indian economy is energy efficiency. It is necessary to look at the different concepts of efficiency. The most common efficiency concept is technical efficiency: the conversion of physical inputs (such as the services of employees and machines) into outputs relative to best practice. In other words, given current technology, there is no wastage of inputs whatsoever in producing the given quantity of output.. This is the measure through which India will be able to sustain its growth of 9% and also be able to connect a large part of people to switch from non-commercial energy resources to modern and clean energy carriers. Energy intensity is the most common indicator used for measuring energy use efficiency of the economy. The energy intensity have improved over a period from 1980-2007 .i.e. over a period of 27 years (Balachandra P et al,Energy Policy,2010) The rate of improvement observed in energy intensity is higher if measured in current monetary units as compared to measured in terms of constant monetary units. In term of current rupees, the energy intensity has come down from 3.1MJ/Rs. in 1980 to 0.37/Rs. in 2007 exhibiting a reduction of nearly 88%.On the other hand rate of reduction measured in constant terms is 20.5%.Thus while reporting energy efficiency improvements in form of energy intensity one has to take into account the depreciation in monetary values. The energy intensity of India in 2007 was 0.77toe/thousand dollar at constant 2000 prices whereas Japan had an intensity of 0.1 toe/thousand dollars at 2000 constant prices, U.K had an intensity of 0.12 and U.S.A had an intensity of 0.2 toe/thousand dollars at constant 2000 prices (Bhattacharyya, 2010).

Figure 8: Trend in energy intensity of GDP- comparison with major countries.



Source: Estimates based on BP (2008), RBI (2009), EIA (2008), Balachandra P et al (2009), Energy Policy.

The figure presents comparison of trend of India's progress in energy efficiency with that of other major countries. The progress in terms of reduction in energy intensity is highest in case of China and USA mainly because of higher starting bases. Japan is only country in this figure whose energy intensities are lower than of India. The trend above is showing some improvement in energy efficiency in India but, if we examine sectoral energy consumption in Indian Economy, we may find that improvement in energy efficiency may be attributed to the structural change in the Indian economy i.e. contribution of energy light service sector to GDP. If we examine the energy consumption across the various sectors of economy we find that industrial sector is the major consumer of energy than any other sector.

Table 6: Final Commercial Energy Consumption in India by Sector (in MTOE)*

Sector	1990/91	1995/96	2000/01	2005/06	2010/11
Agriculture	4.9 (3.9%)	8.4 (5.3%)	15.2 (7.9%)	15.1 (6.9%)	23.14 (7.32%)
Industry	62.9 (50.4%)	77.5 (48.6%)	77.4 (40.4%)	96.2 (44.4%)	137.98 (43.62%)
Transport	28 (22.4%)	37.2 (23.4%)	33.5 (17.5%)	36.5 (16.8%)	55.34 (17.5%)
Residential and Commercial	12.6 (10.1%)	15.3 (9.6%)	24.1 (12.6%)	32.6 (15.1%)	43.43 (13.73%)
Other Energy uses	3.9 (3.1%)	6.8 (4.3%)	13.4 (7%)	18.7 (8.6%)	30.25 (9.56%)
Non-Energy Uses	12.6 (10.9%)	14.1 (8.8%)	28 (14.6%)	17.5 (8.1%)	26.15 (8.27%)
Total	124.9 (100%)	159.3(100 %)	191.6 (100%)	216.6 (100%)	316.29 (100%)

Source: TERI Energy Data Directory Yearbook 2012-13,*Million Ton of Oil Equivalent

Note: Figures in parentheses indicates percentage share of each sector.

The figure above shows that industrial sector occupies major place in commercial energy consumption and the present focus is on 'Make in India' which in turn will need more energy, so the energy intensity level of Indian Industrial sector should be brought down to continue reduction in energy intensity and along with assuring its large deprived section of population migrates into energy mainstream.

Section 7

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