Energy Scenario and Vision 2020 in India

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Abstract: India is a country with more than 1.2 billion people accounting for more than 17% of world's population. It is the seventh largest country in the world with total land area of 3,287,263 sq kilometers. India measures 3214 km from north to south and 2993 km from east to west. It has a land frontier of 15,200 km and coastline of 7,517 km. India has 28 states and 7 union territories. It faces a formidable challenge in providing adequate energy supplies to users at a reasonable cost. It is anticipated that India's nominal GDP will exceed US $ 2 trillion by March 2012. India's nominal GDP crossed the US $ 1 trillion mark in 2007-2008 which means that the annual growth rate of nominal GDP during the period is stupendous 18 percent. Thus the energy challenge is of fundamental importance. In the last six decades, India's energy use has increased 16 times and the installed electricity capacity by 84 times. In 2008, India's energy use was the fifth highest in the world.

Nevertheless, India as a country suffers from significant energy poverty and pervasive electricity deficits. In recent years, India's energy consumption has been increasing at a relatively fast rate due to population growth and economic development, even though the base rate may be somewhat low. With an economy projected to grow at 8-9% per annum, rapid urbanization and improving standards of living for millions of Indian households, the demand is likely to grow significantly. As per the estimates made in the Integrated Energy Policy Report of Planning Commission of India, 2006, if the country is to progress on the path of this sustained GDP growth rate during the next 25 years, it would imply quadrupling of its energy needs over 2003-04 levels with a six-fold increase in the requirement of electricity and a quadrupling in the requirement of crude oil. The supply challenge is of such magnitude that there are reasonable apprehensions that severe shortages may occur.

1. Introduction to Energy

In recent years availability of power in India has both increased and improved but demand has consistently outstripped supply and substantial energy and peak shortages prevailed in 2009-10. There are also various estimates of 25000 to 35000 MW of power being produced by diesel generation to meet the deficits [1]. Electricity shortage is not the only problem. Its spread is an equally serious issue. In the past, the selection of an energy resource for electricity generation was dominated by finding the least expensive power generating plant. Although such an approach is essential, there is growing concern about other aspects of power generation such as social, environmental and technological benefits and consequences of the energy source selection. Figure 1 shows a comparison of different energy sources for life cycle emissions [2]. It can be observed that coal has the maximum global warming potential followed by Natural Gas and others. Further, it needs to be re-emphasized that for India, like most developing countries, the cost of producing electricity is of paramount concern while planning for the type of plant to be installed and commissioned and more so with abundant supply of coal. However, in the long run if we take the effect of the pollutants on human health and environment and cost as well as efforts needed to improve or alter the path of degradation, the initial higher cost of using renewable resources for producing energy may not be too big. A high degree of caution is also needed as emerging economies like India may not at present have financial resources to leapfrog directly to cleaner mechanisms of energy. Since global warming is an international phenomenon and it has no boundaries there is an urgent need for the transfer of technology and development of appropriate financial instruments from developed the world to nations who are still trying to find their rightful places [3]. No argument is needed to understand that the world is today facing the problem of global warming due to rapid industrialization and urbanization followed by the western world. In terms of per capita equity India is 145th in the world with a release of 1.25 t CO_2 per annum [4].

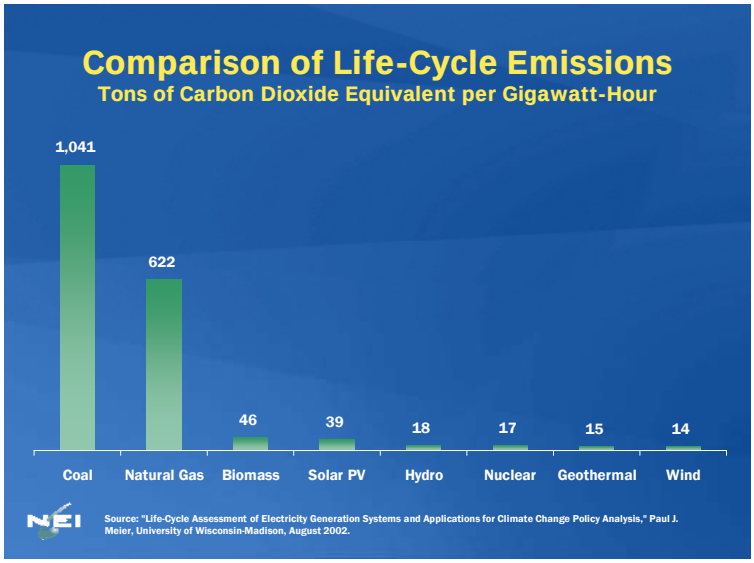

Figure1. Comparison of Life- Cycle Emissions (Source: University of Wisconsin).

Table1. Energy Scenario for World and India.

Countries/ Regions	**Population (millions)**	**GDP Per Capita (PPP) 2000USD**	**TPES Per Capita (kgoe)**	**TPES/GDP (kgoe-2000USD)**	**Elec. Cons/capita (kwh)**	**Kwh/ $-2000 PPP**
World	6688	9549	1803	0.19	2782	0.29
OECD	1190	27620	4560	0.17	8486	0.31
Middle East	199	8191	2990	0.37	3384	0.41
Former USSR	285	8996	3650	0.41	4660	0.52
Non OECD Europe	53	10471	2010	0.19	3378	0.32
China	1333	8311	1600	0.19	2471	0.30
Asia***	2183	4013	650	0.16	719	0.18
Latin America	462	8522	1240	0.15	1956	0.23
Africa	984	2540	670	0.26	571	0.22
India	1139.97	3781	540	0.14	566	0.15

(Source: 2010 Key World Energy Statistics: IEA)

*** Asia excludes China but includes India

2. The Energy Scenario

Table 1 gives the comparison of India with other regions of the world with regards to Total Primary Energy Supply which has been normalized with respect to GDP and population for the year 2008 [5]. From Table 1 it can be seen that per capita consumption of energy in India is one of the lowest in the world. India consumed 540 kgoe in 2008 compared to 1803 kgoe by the world, 4560 kgoe by OECD countries, 1600 kgoe by China. India's energy use efficiency for generating Gross Domestic Product in Purchasing Power Parity is better than many countries and even compared to the world average. It is expected that with a growth rate of 9% TPES requirement for India in 2021-22 will be around 1192 Mtoe which will further increase to around 2043 Mtoe by the year 2031-32.

The electricity consumption per capita for India is just 566 KWh and is far below most other countries or regions in the world. Even though 85% of villages are considered electrified, around 57% of the rural households and 12% of urban households, i.e. 84 million households in the country, do not have access to electricity. Electricity consumption in India is expected to rise to around 2280 BkWh by 2021-22 and around 4500 BkWh by 2031-32. Figure 2 shows the Human Development Index (HDI) which is calculated from the literacy rate, infant mortality rate and GDP plotted against per capita electricity consumption [6-7].

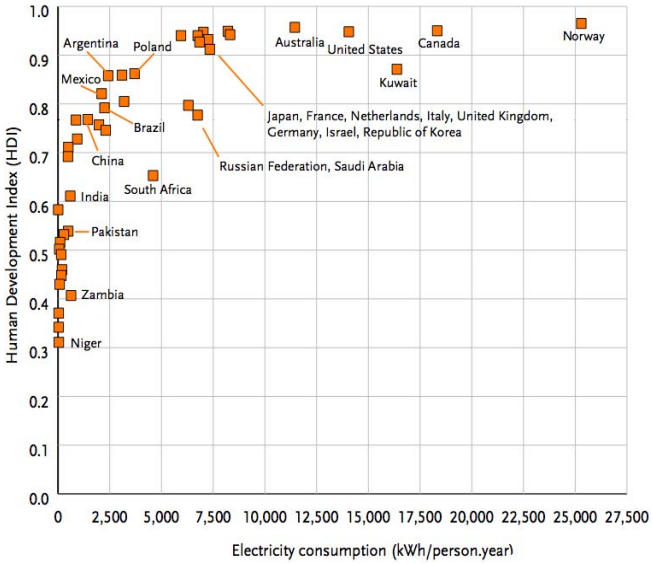

Figure 2. Graph of HDI and Electricity Consumption/ Person.

It is observed that for consumption over 4000 kWh/per person the curve plateaus out and straightens. Even those who have access to power suffer from shortages and quality of power. Consumers and the economy bear a large burden due to the poor quality of power supply. Industries maintain diesel powered generators and households have invertors with batteries as backup for unscheduled power cuts, low voltages or variable frequency. Equipment is frequently damaged [due to the erratic electricity supply]. Added to these is the cost of idle manpower and loss of production when power supply is interrupted. Power capacity has risen at a rate of 5.87% per annum over last 25 years. The total supply of electricity has risen at the rate of 7.2% per annum over the same period. This reflects an improvement in Plant Load Factor (PLF) [8]. However, the consumption is still constrained as power shortages continue to plague the country. Availability Based Tariffs (ABT) and unscheduled interchange charges of power introduced since 2003 for interstate sale of power has reduced voltage and frequency fluctuations. The shortages are also attributed to inadequate investments in distribution and transmission. Increasing the generation capacity has attracted the bulk of investment. Aggregate Technical & Commercial (AT&C) losses which include theft, non billing, incorrect billing, inefficiency in collection and transmission and distribution losses exceeded 40% for the country as a whole in 2005. Consequently, the State Electricity Boards remain financially sick and are unable to attract finances for investment. The extent of power shortage varies from state to state. Table 2 gives the comparative status of power supply in various states and union territories from April 2010 till February 2011 [9]. It also provides an insight into the peak demand for power and the shortages in peak power.

The Planning Commission of India has set a target of adding more than 78000MW in a five year plan beginning 2007. Historically the plan targets have been missed and even for this five year plan the target is likely going to be missed as capacity addition till February 2011 was only 40,000 MW. Finally, the history of emphasis on investment in power generation results in loading more and more power on an inadequate transmission and distribution (T&D) network. Since T&D investments have not kept pace with investments in generation, power cannot be easily moved from areas of surplus to those in deficit. Industrial and commercial establishments have been forced to seek captive and standby generation to meet demand or provide quality supply on a 24X7 basis to support critical processes and provide peaking support. Table 3 gives the figure for growth of the transmission sector since the end of the sixth five year plan (In India planning commission is formulating plans in block of five years) [9].

The sector is dominated by large state monopolies both at federal and state level. Private distribution has been introduced but is limited to very few areas. An uneven playing field permeates the market place wherein the Central Power Sector PSUs get guaranteed post-tax returns of 14-16% with full payment backed by the GOI. State Power Sector Utilities (SPSUs) are

given zero or low returns by Regulators who are under constant pressure not to raise tariffs, which are already among the highest in the world in PPP terms for industrial, commercial and household consumers. Power tariffs are structured on the basis of industrial and commercial users cross subsidizing agricultural and domestic power consumption. The agricultural sector is supplied with un-metered power in almost all states and the farmers pay a highly subsidized lump sum based on the declared horse power of their pumps. This leads to a zero marginal cost of power which promotes inefficient use and over exploitation of ground water. The domestic sector also has a range of subsidies based on the level of consumption including heavily subsidized power for the poorest segment wherein households pay a low lump sum monthly charge. With the rising cost of supply, the burden of these cross-subsidies has increased and is disproportionately loaded on the paying industrial, commercial and large household consumers. Additionally, the tariff structure has created incentives for high paying consumers to pilfer power under the cover provided by unmetered power. The habit of stealing power is now widespread. A vested interest lobby has been created and what are euphemistically called AT&C losses remain stubbornly high.

Table2. Base and Peak Demand Deficit in India.

States/UT/Region	Requirement	Availability	Surplus /Deficit (%)	Requirement	Availability	Surplus /Deficit (%)
	Power Supply (in MU)			Peak Demand (in MW)		
Chandigarh	1413	1413	0	301	301	0
Delhi	23863	23800	-0.3	4810	4739	-1.5
Haryana	31762	29912	-5.8	6142	5574	-9.2
Himachal Pradesh	6964	6713	-3.6	1278	1187	-7.1
Jammu & Kashmir	12427	9268	-25.4	2500	1690	-32.4
Punjab	41226	38649	-6.3	9399	7938	-15.5
Rajasthan	40956	40552	-1.0	7582	7408	-2.3
Uttar Pradesh	70098	59306	-15.4	11082	10672	-3.7
Uttrakhand	9022	8451	-6.3	1520	1520	0
Chhatisgarh	9250	9096	-1.7	2913	2759	-5.3
Gujarat	65217	61199	-6.2	10786	9947	-7.8
Madhya Pradesh	43873	35018	-20.2	8864	8068	-9.0
Maharashtra	115824	96566	-16.6	19766	15479	-21.7
Daman & Diu	1987	1822	-8.3	353	328	-7.1
Dadar Nagar & Haveli	4047	4044	-0.1	594	594	0
Goa	2856	2806	-1.8	544	460	-15.4
Andhra Pradesh	70860	68577	-3.2	12018	11232	-6.5
Karnataka	44970	41600	-7.5	8137	7815	-4.0
Kerala	16275	16052	-1.4	3295	2946	-10.6
Tamil Nadu	72712	68140	-6.3	11728	10436	-11
Puducherry	1929	1847	-4.3	319	300	-6
Lakshwadweep	22	22	0	6	6	0
Bihar	11621	10007	-13.9	2073	1659	-20
DVC	15045	13777	-8.4	2206	2046	-7.3
Jharkhand	5651	5482	-3.0	1012	1012	0
Orissa	20429	20368	-0.3	3505	3468	-1.1
West Bengal	33349	32715	-1.9	6162	6112	-0.8
Sikkim	361	361	0	100	99	-1
Andaman & Nicobar	220	165	-25	40	32	-20
Arunachal Pradesh	463	394	-14.9	101	85	-15.8
Assam	4992	4669	-6.5	971	937	-3.5
Manipur	522	464	-11.1	118	115	-2.5
Meghalaya	1405	1225	-12.8	294	284	-3.4
Mizoram	332	282	-15.1	76	70	-7.9
Nagaland	543	485	-10.7	118	110	-6.8
Tripura	813	735	-9.6	220	197	-10.5
India	783057	715795	-8.6	120575	108212	-10.3

(Source: Central Electricity Authority, Government of India)

Table3. Development of Transmission Sector in India.

At the end of	400 KV Transmission line ckm	220 KV Transmission line ckm	765 KV Transmission line ckm	+/- 500 KV HVDC Converter ckm
6th Plan (1980-1985)	6029	46005		
7th Plan (1985-1990)	19824	59631		
8th Plan (1992-1997)	36142	79600		
9th Plan (1997-2002)	49378	96993		
10th Plan (2002-2007)	75722	114629		
11th Plan up to 1.2.2011 (2007-2012)	104798	133787	4423	8924

(Source: Central Electricity Authority, Government of India)

3. Supply Options for Non Renewable Energy

Strategies to meet India's energy requirement are constrained by country's energy resources and import possibilities. Unfortunately, India is not well endowed with natural energy resources. Reserves of oil, gas and Uranium are meager though India has large reserves of thorium. While coal is abundant, it is regionally concentrated and is of low calorie and high ash content, though it has the advantage of low sulfur content. The extractable reserves, based on current extraction technology, remain limited. Hydro potential is significant, but small compared to India's needs and its contribution in terms of energy is likely to remain small. Further, the need to mitigate environmental and social impacts of storage schemes often delays hydro development thereby causing huge cost overruns.

Coal: It is the most important and abundant fossil fuel in India. It accounts for 55% of the country's energy need. The country's industrial heritage has been built upon indigenous coal. Commercial primary energy consumption in India has grown by about 700% in the last four decades. Considering the limited reserve potentiality of petroleum & natural gas, eco-conservation restriction on hydro projects and geo-political perception of nuclear power, coal will continue to occupy centre-stage of India's energy [production??] [10]. With hard coal reserves around 246 billion tonnes, of which 92 billion tonnes are proven, Indian coal offers a unique eco friendly fuel source for the domestic energy market for the next century and beyond. Hard coal deposits, spread over 27 major coalfields, are mainly confined to eastern and south central parts of India. Lignite reserves stand at around 36 billion tonnes, of which 90% occur in the southern State of Tamil Nadu. Out of a total of 171926 MW of electricity generated, coal powered thermal power plants accounted for 92418 MW as of February, 2011 indicating that most of India's electricity needs are dependent on coal. It has been estimated that at current levels of consumption the proven reserves of coal will last for 80 years and if all the inferred reserves also materialize it can last for over 140 years at the current rate of extraction. However, the coal consumption will increase as India tries to meet its energy requirements and thus the reserves will last for fewer years. If domestic coal production continues to increase at a rate of 5% the extractable reserve will run out in around 45 years. Further, it is difficult to predict the long term demand for coal owing to rapid changes in the prices and relative availability of other fuels as well as the technological advancements and new policies in the end use sector. Further, the coal deposits in India are concentrated in the Eastern regions. The setting up of a coal fired power plant in Western or North-west India, entails transporting coal over distances exceeding 1000 Km. and at such distances the economics of coal power become unfavorable.

It is estimated that the coal deficit in India will increase to 400 million tonnes in Financial Year (FY) 2017 from around 50 million tonnes in FY11, according to a Credit Suisse report. Further, as per the Planning Commission report it is expected that demand for coal will rise to around 937 million tonnes by 2021-22 and to more than 1415 million tonnes by 2031-32. This will compel power generation companies to look at offshore coal, either through mine acquisitions or buying coal from international markets. Also the experts say offshore coal is not an easy alternative for power companies to meet their requirements. "Technically, the dependence on imported coal is not viable as old power stations cannot take the heat generated from more than 10-12% international coal blending" [11]. Mine acquisition is not easy for India as most of the deals have been sealed by China leaving India with very few options. Besides, mines abroad, as in India, face government and environment clearance issues. Also, reserve-rich countries such as Indonesia, Australia, and South Africa are considering giving priority to their local needs. Indonesia, for instance, has implemented the Domestic Market Obligation and will restrict the export of coal after 2014. Transportation of imported coal to the respective power projects has its own challenges as India does not have sufficient infrastructure such as ports and rail network. Trebling of port capacity to 3 billion from 1 billion by FY15 would give some relief in the coming years but the rail capacity would continue to be a concern. At present, the total cost of power generation using domestic coal is INR 2.1 per kWh. But with imported coal, the cost shoots up to INR 3.6 per kWh, due to high international coal prices, port handling charges, and customs duty. Coal based generation remains constrained in India due to materialization of the requirement of coal. As of 28 February 2011, 32 power stations [were down to] had critical stock [levels] including 18 stations with super critical stock, i.e. stock for less than 4 days. This poses a challenge to the power industry to maintain capacity utilization at high levels. India continues to suffer from power outages as state electricity boards are unable to buy power at high prices due to their weak financial health. The industry has received some support from the environment ministry, which has reduced the number of "no-go" areas (where mining is not allowed). But, the dependence of the sector on imported coal will remain high for some years to come. Also, large investment is required to spruce up the infrastructure. Further, The Directorate General of Hydrocarbons has estimated the country's resource base for Coal Bed Methane (CBM) to be between 1400 BCM (1260 Mtoe) and 2600 BCM (2340 Mtoe). To give impetus to exploration and production, the government has formulated the CBM policy.

Petroleum/Oil: India has total reserves (proved and indicated) of 1201 million metric tonnes of crude oil. Crude oil production during 2009-10 at 33.69 million metric tonnes was 0.55% higher than the 33.51 million metric tonnes produced during 2008-09. The consumption of petroleum products during 2009-10 was 138.196 million metric tonnes (including sales through private imports) which is 3.60% higher than the sales of 133.400 million metric tonnes during 2008-09 [12]. Long-term growth in demand of petroleum products depends upon a number of factors such as economic growth (GDP), elasticity of demand for petroleum products with respect to GDP growth, relative price levels of substitute products particularly LNG/CNG, saturation of LPG demand, and the impact of energy conservation measures. The demand for petrol and diesel is dependent on the growth of road infrastructure, the price of oil, the future efficiency of vehicles, the growth of alternate modes of transport and the emergence of substitutes like bio-fuels and/or technologies such as hybrids. Naphtha demand is dependent on the growth plans for fertilizer and petro-chemicals and its price relative to the price and availability of natural gas. The production of automobiles has greatly increased in the last decade in India as indicated in Table 4 [13]. It passed the 1 million mark during 2003-2004 and has more than doubled since then. Due to rapid growth of [the number of] automobiles the demand for petroleum products will witness a growth in demand and it is expected to rise to more than 240 million metric tonnes by 2021-22 which will further increase to around 465 million metric tonnes by 2031-32 considering a high output growth.

Besides this two-wheeler production capacity is expected to reach 22.31 million units in 2011-12 compared with 10.78 million in 2006-07 which will further add to the increase in consumption of petroleum products [14]. Similarly, LPG has witnessed a growth of 8% per year and it is one of the primary sources of domestic fuel. The total demand for LPG in 2009-2010 stood at 12747 TMT while the domestic production was

only 10323 TMT. As awareness grows about [LPG being a] cleaner fuel along with the increase in purchasing power and improved literacy levels it is anticipated that this sector will see exponential growth. It is expected that the demand of LPG will increase to 18680 TMT by 2014-2015 and this will require massive investment in infrastructure and upgrading the ports to cater for increased imports. India has a total installed capacity of 1199.75 MW of oil based power plants which is not substantial and the price per unit of kwh ranges from INR 7.60 to INR 8.00. In 2009-10, the total expenditure incurred on import of 159.2 million tonne of crude oil was $79,552 million and this is increasing each year putting substantial pressure on Indian economy leading to continuous increase in import dependence in this sector.

Natural Gas: India has total reserves (proved and indicated) of 437 billion cubic meters of natural gas as of 1st April 2010**.** Gross Production of Natural Gas in the country at 47.51 billion cubic meters during 2009-10 was 44.63% higher than the production of 32.85 billion cubic meters during 2008-09. The total installed capacity of gas fired plants as of February 2011 stood at 17706 MW. The flaring of Natural Gas in 2009-10 at 2.09% of gross production is lower than the 3.29% in 2008-09 [15]. Natural gas can replace existing fuels in various sectors both for feedstock as well as for energy purposes. However, this substitution will depend upon the relative price of gas with respect to other fuels. Therefore, it may be stated that the demand for gas will depend upon the price of natural gas relative to that of alternatives, mainly Naphtha for fertilizer and petrochemicals and coal for power. With domestic production of just over 140 million standard cubic meters per day meeting barely half the demand, India is importing 10 million tons of liquefied natural gas per annum and is looking at unconventional sources like shale gas. One of the major issues with use of natural gas in India is that of the discriminatory pricing and fiscal policy adopted for oil and gas where oil produced from domestic fields is priced at international rates while the government caps natural gas price at artificially low levels. This is due to the fact that the Indian fertilizer sector, which is a dominant user of natural gas, is highly subsidized.

The cost of power obtained by using natural gas varies from INR 2.90 to INR 4.60 per KWh and power obtained through natural gas is mainly used as peaking power. Besides this India has around 0.5 million vehicles running on auto gas and per vehicle consumption is 451 Kg per annum compared to the world average of 1428 kg per annum. This is, however, constrained by a lack of appropriate distribution networks. Natural gas has been recognized as a bridge between the more polluting fuels based on hydrocarbons and cleaner renewable sources of energy. India Vision 2020 has estimated the demand for gas to be between 65 and 71 Billion Cubic Metres (BCM) for the year 2020. IRADe-PWC has projected demand of natural gas and natural gas equivalent of Naphtha at 243 BCM under the business-as usual scenario and 405.7 BCM under a High Output Growth scenario for the year 2030.

Nuclear Energy: Nuclear power is the fourth-largest source of electricity in India after thermal, hydroelectric and renewable sources of electricity. As of 2010, India has 20 nuclear reactors in operation in six nuclear power plants, generating 4,780 MW while 5 other plants are under construction and are expected to generate an additional 2,720 MW. India's nuclear power industry is undergoing rapid expansion with plans to increase nuclear power output to 64,000 MW by 2032 [16]. The country is involved in the development of nuclear fusion reactors through its participation in the ITER project and is a global leader in the development of thorium-based fast breeder reactors (FBR). India is poorly endowed with Uranium. Available Uranium supply can only fuel 10,000 MW of the Pressurized Heavy Water Reactors (PHWR). FBR technology is critical to developing stage two of India's nuclear power program. Without developing the wide-scale use of FBR technology, India will find it difficult to go beyond 10,000 MW of nuclear capacity based on known indigenous Uranium resources. India aims to supply 25% of electricity from nuclear power by 2050. Because India is outside the Nuclear Non-Proliferation Treaty due to its weapons program, it was for 34 years largely excluded from trade in nuclear plant or materials, which hampered its development of civil nuclear energy [production] until 2009. Due to these trade bans and lack of indigenous uranium, India has uniquely been developing a nuclear fuel cycle to exploit its reserves of thorium. Although the trade ban stopped India importing uranium it helped it to develop indigenous technology and trained a large manpower in the nuclear field. With the signing of a nuclear cooperation agreement it is anticipated that foreign technology and fuel will boost India's nuclear power plans considerably, however, the initial euphoria has somewhat ebbed as India failed to sign the Nuclear liability bill.

The work of generating and maintaining nuclear power plant lies with "Nuclear Power Corporation India Limited" and it plans to build five nuclear power parks each with a capacity of eight nuclear reactors of 1000 MW. The nuclear power parks are planned at Kudankulam in Tamil Nadu, Jaitpur in Maharashtra, Mithi Virdi in Gujarat, Haripur in West Bengal and Kovvada in Andhra Pradesh.

Table 4. Growth of Automobiles in India.

Year	Car Production	% Change	Commercial	% Change	Total Vehicles Production	% Change
2010	2,814,584	29.39	722,199	54.86	3,536,783	33.89
2009	2,175,220	17.83	466,330	-4.10	2,641,550	13.25
2008	1,846,051	7.74	486,277	-9.99	2,332,328	3.35
2007	1,713,479	16.33	540,250	-1.20	2,253,999	10.39
2006	1,473,000	16.53	546,808	50.74	2,019,808	19.36
2005	1,264,000	7.27	362, 755	9.00	1,628,755	7.22
2004	1,178,354	29.78	332,803	31.25	1,511,157	23.13
2003	907,968	28.98	253,555	32.86	1,161,523	22.96
2002	703,948	7.55	190,848	19.24	894796	8.96
2001	654,557	26.37	160,054	-43.52	814611	1.62
2000	517,957	-2.85	283,403	-0.58	801360	-2.10
1999	533,149		285,044		818193	

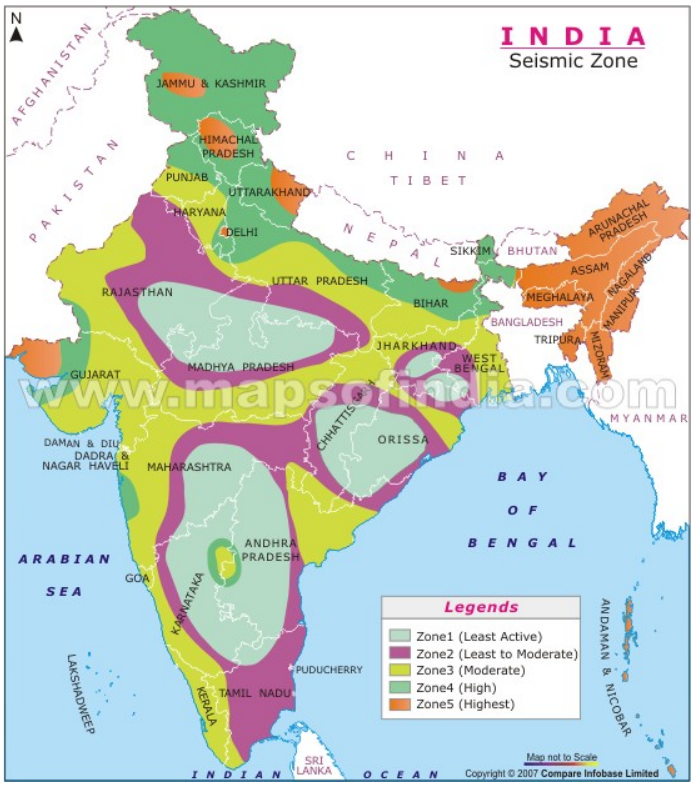

Figure 3. Map of India with Seismic Zones (Source: www.mapsofindia.com).

Despite all the advantages that nuclear power is supposed to offer it is a very costly affair [17]. In defense of nuclear power it is said that it is the initial capital cost that is very high and thereafter it is not a very costly business. It should not be necessary to impose a high tariff for supplying power from nuclear plants. But it will still not make nuclear power cheaper than hydro or thermal power that currently meets the bulk of electricity supply demand in the country. Further, there is considerable resistance from locals in view of the associated dangers with any nuclear plant and this has been further heightened with the recent damage to nuclear installations in Japan caused by an earthquake and subsequent tsunami [18]. Figure 3 gives the seismic zone map of India [19]. The figure indicates that India lies within the zone of seismic activity and a very small area is located in zone 1 which is seismically least active. This needs to be factored into the locating of nuclear power plants and the federal Minister of Environment and Forests has cautioned to carefully tread the path of nuclear energy by planning smaller nuclear plants instead of leapfrogging to 1600 MW plants.

India with its growing population and burgeoning energy needs has limited options, otherwise it will be forced to resort to more imports of coal and as of today nuclear energy is available at INR 3 to INR 4 for each KWh compared to solar energy at INR 20 per KWh. Another critique of nuclear energy in India is that it will be importing four different types of light water technology making it the most diverse in the world. Further, India with its secretive nuclear establishment has very little public debate on the safety and security related issues. This is compounded by the fact that the Atomic Energy Review Board functions under the administrative control of the government and is not fully independent. A 'gap analysis' by the National Disaster Management Authority (NDMA) submitted to the federal home ministry in 2009 listed 12 critical vulnerabilities that could seriously impede India's response to a disaster in any of its seven nuclear power plants. The lacunae identified include the lack of doctors trained to handle radiation related injuries, lack of emergency shelters and camping facilities near nuclear plants, non-identification of alternate sources of food and water, inadequate involvement of home guards, police and civil defense volunteers as first responders and inadequate emergency response centers. "The stock of monitoring equipment and personnel protection gear is very small and needs to be augmented to upgrade the capabilities to handle nuclear emergencies," the document noted. Last year the leakage of Cobalt-60 from a disused gamma irradiator at a scrap market in west Delhi killed one person and injured five others. The first responders, the police, were clueless. Doctors were unable to identify the symptoms of the radiation exposure. It was a microcosm of India's tardy response to a radiological incident. The only steps taken so far are the creation of ten National Disaster Response Force (NDRF) battalions numbering over 8,000 personnel. Trained by the BARC (Bhabha Atomic Research Center), they operate under the ministry of home affairs. These battalions located in Delhi, Pune, Ernakulam and Kolkata have been equipped with the basic equipment to respond to a nuclear emergency. That isn't enough to cope with a serious nuclear accident as occured in Japan in 2011.

4. Renewable Energy in India

India has been making continuous progress in conventional as well as renewable power generation. The trajectory of growth of installed capacity since 2002 (start of the 10th five year Plan), 2007 (start of 11th Plan), and as of 30 November .2010, is given in Table 5 below:

It is observed from the table that renewable grid capacity has increased more than 5 times in a span of 8 years and this compares favorably with the EU and far exceeds that of the US.

The growth so far is largely based on thermal [energy?] but all other sources have also made important contributions. However, problems are beginning to occur in each sector of conventional power. Mining and import of coal are both facing problems, especially for the huge quantities required. Logistics

and transport issues are also emerging. Moreover, at projected usage levels, questions are also raised about the period India's extractable coal reserves could last. Environmental and climate change threats are getting more severe and project clearances more difficult to obtain. In spite of many policy and infrastructural initiatives, it appears unlikely that quantities required to achieve projected conventional power capacity will be available.

Large hydro projects are also facing problems – largely related to environmental issues and some to project execution in difficult areas along with attendant issues of building long transmission lines. Natural gas difficulties and its competitive usages also do not create optimism. Nuclear power capacity building continues to face its own problems, especially with the huge targets proposed. In the above backdrop, therefore, it could reasonably be expected that there could be substantial and worrisome slippages in creating conventional power capacities over the next two decades and even in the long term. It is almost inevitable that this would lead to more consumption of diesel, furnace oil and kerosene. In a situation where India is currently importing more than 80% of the country's fuel needs, and with internal reserves unlikely to improve this percentage, serious problems of energy security would arise. Moreover, these may entail rising financial burdens of import and internal financial burdens of subsidies, which are already controversial. It is, therefore, imperative that substantive measures be taken to reduce their consumption for energy purposes and also reducing consumption drastically in personalized urban and long-distance freight transport. If energy shortages persist it is difficult to expect much improvement in energy access. India has an ambitious program of rural electrification (RGGVY). However, even though this may provide grid connectivity to many uncovered areas (still leaving substantial numbers unconnected), actual supply of electricity through the grid would remain both constrained and unpredictable. Providing energy access and energy security for the poor would, therefore, continue to be a major issue and problem. Solutions to this simply have to be found but which no longer appear possible from conventional sources. It is clear that India's need for secure, affordable, and environmentally sustainable energy has become one of the principal economic and development challenges for the country. It is also clear that while energy conservation and energy-efficiency have an important role to play in the national energy strategy, renewable energy will become a key part of the solutions and is likely to play an increasingly important role for augmentation of grid power, providing energy access, reducing consumption of fossil fuels and helping India pursue its low carbon developmental pathway.

5. Policy for Grid Renewable Power

The development of grid interactive renewable power essentially took off with the Electricity Act 2003 –which mandates the State Electricity Regulatory Commissions (SERCs) to (i) promote cogeneration and generation of electricity from renewable sources of energy by providing suitable measures for connectivity with the grid and sale of electricity to any person, and (ii) fix certain minimum percentages for purchase of renewable power in the area of each Distribution licensee. Section 61(h) mentions that these should be guiding factors while specifying the terms and conditions of determination of tariffs. The National Electricity Policy 2005 has further provided for progressive increases in these levels and purchases by distribution companies through competitive bidding processes. The Tariff Policy 2006 requires fixation by SERCs of a minimum percentage for purchase of energy from such sources taking into account availability of such resources in the region and its impact on retail tariffs and procurement by distribution companies at preferential tariffs determined by the SERCs. As of date, most of the SERCs have specified percentages for purchase of electricity from renewable sources of energy. Preferential tariffs for grid interactive renewable power are being given in most potential States like Rajasthan, Gujarat, Tamil Nadu etc.

Due to various measures taken by electricity regulatory commissions open access has been facilitated, thereby enabling buyers to choose their suppliers which not only fosters healthy competition but suppliers are forced to be innovative in quality and pricing to rope in customers. It has also led to more stable and secure grid operations which have led to decrease in outages due to grid failures. Depending on the availability of the renewable power in different states purchase obligations have been fixed in their respective distribution areas. Various states which have met their renewable purchase power obligations include Kerala (5%), Tamil Nadu (10%), Andhra Pradesh, Karnataka and Maharashtra (5%), Gujarat (2%) and Delhi (1%). However, the high cost of power from renewable sources discourages the states from buying than what is obligatory. However, there are other states which have not been able to meet the obligatory requirement due to a host of issues which include the precarious financial condition of distribution companies which are generally owned and operated by the state. The concept of Renewable Energy Certificates (REC) is being introduced so that those states which are deficient in renewable power can buy the REC's from renewable power generators located in different states.

6. Financial and Fiscal Incentives

The Government has been promoting private investment for the setting up of projects for power generation from renewable energy sources through an attractive mix of fiscal and financial incentives, in addition to the preferential tariffs being provided at the State level. These include capital/ interest subsidies, accelerated depreciation and nil/ concessional excise and customs duties. The level of capital subsidy being provided depends on the renewable resource and region, and varies from about 10% to 90% of project cost, the higher level being given for projects in the North -Eastern Region/ Special category States. In addition, Generation Based Incentives have also been introduced recently for Wind Power to attract private investment by Independent Power Producers not availing Accelerated Depreciation benefit and feed in tariffs for solar power.

Table 5. Trajectory of Growth of Installed Power Capacity in India.

Time period	Thermal (%) (MW)	Hydro (>25MW) (%) In MW	Nuclear (%) (MW)	Renewable Power (%) (MW)
1.4.2002	70.85% 74429	25% 26269	2.59% 2720	1.55% 1628
1.4.2007	64.06% 87015	25.51% 34654	2.87% 3900	7.55% 10258
31.9.2010	63.95% 106518	22.41% 37328	2.7% 4560	10.90% 18,155

(Source: Ministry of New and Renewable Energy, Government of India)

Table 6. Share of Different Renewable Sources in India.

Resource	Potential (MW)	Upto 9th Plan	Upto 10th Plan	11th Plan Target	Upto 30.09.10	Cumulative Achievement	12th Plan Projection (2017)	13th Plan Projection (2022)
Wind Power	48,500	1667	5,427	9,000	4,714	12,809	27300	38,500
Small Hydro Power	15,000	1,438	538	1,400	759	2,823	5000	6,600
Bio Power*	23,700	390	795	1,780	1,079	2,505	5100	7,300
Solar Power	20-30 MW/sq km	2	1	50	8	18	4000	20,000
Total		3,497	6,761	12,230	6,560	18,155	41,400	72,400

(Source: Ministry of New and Renewable Energy, Government of India)

* Includes biomass, bagasse cogeneration, urban and industrial waste to energy

7. Impact of Policy and Vision 2022

During the last many years the share of renewable energy has steadily increased due to the initiative taken by Government of India and as indicated in Table 5. The share of various types of renewable energy is indicated in Table 6. All figures are in MW.

It is estimated that total share of renewable energy will be 15.9% by 2022. In the larger perspective of grid power an innovative scheme is being tried in India called as tail-end grid. So far the emphasis has been on large plants whether they are wind, solar, hydro or biomass. Locations for wind and hydro are fixed. However, for biomass the difficulties of ensuring collection and transportation of fuel are leading towards smaller plants. For solar PV, a total of 100 MW capacity is being set up with smaller plants of 100 KW to 2 MW, which are connected to grid through 11 kV feeders. It is expected that small plants would reduce the transmission losses by 5-7% with respect to large capacity plants of 50 - 100 MW size and improve both voltage and frequency at the tail end. The same approach is being planned for biomass based power plants of up to 2 MW capacity as the logistics of fuel management would become much more manageable and more environmentally friendly. It is envisaged that hundreds of such plants will be built in the next few years thus improving the transmission infrastructure.

8. Biomass Power and Bagasse Cogeneration Program

This program aims at the utilization of biomass, such as agro-waste in the form of straws, stalks, stems and fibres; agro-industrial processing residues such as shells, husks, deoiled cakes, wood from dedicated energy plantations and bagasse from sugar mills, for power generation using combustion technology. The current potential for power generation from surplus agro and agro-industrial residues is estimated at 17000 MW. With efficient power cogeneration plants in new sugar mills and modernization of existing ones, the potential of surplus power generation through bagasse cogeneration in sugar mills is estimated at 5000 MW. Thus the total estimated biomass power potential is about 22,000 MW.

9. Wind Power

The wind power program is the fastest growing renewable energy program [in India] and is almost entirely coming through private sector investments. India has a potential of around 48,500 MW. With a capacity addition of 12,800 MW, it contributes to around 75% of the grid-connected renewable energy power installed capacity. The major wind power capacity is in the states of Tamil Nadu, Gujarat, Maharashtra, Karnataka and Rajasthan. Wind electric generators of unit sizes between 225 kW and 2.10 MW have been deployed across the country. Wind Electric Generators of unit capacity up to 2.10 MW are being manufactured India. An ambitious target of 9,000 MW was set for 11th Plan, of which 5,715 MW had already been achieved by September, 2010. This has been possible because of the multi-dimensional approach of central and state governments. The main driving force for development of wind sector has been the provision of accelerated depreciation of 80%, an incentive also available to many other sectors. This provision has enabled large profit making companies, small investors and captive users to participate in the sector. However, independent power producers (IPPs) and foreign direct investment (FDI) were not able to benefit from the accelerated depreciation provision. In order to increase the investor base, the government has launched a scheme for Generation Based Incentives through which additional incentives of 50 paise per unit [generated will be provided to the developers that do not receive accelerated depreciation benefits. The effort is to do 2000 MW or more annually.

10. Small Hydro Power

The estimated potential for power generation in India from small hydro plants is about 15,000 MW from 5718 identified sites. So far over 760 small hydropower projects aggregating to 2,803 MW have been set up in various parts of the country and 285 projects of about 940 MW are in various stages of implementation. At present, a capacity addition of about 300 MW per year is being achieved, of which about 70% is coming through the private sector. In order to accelerate the pace of small hydro development, both public and private sector participation for commercial projects and decentralized micro hydro for remote village electrification are being encouraged. Attention is being focused on States with the maximum hydro potential and improving environment policies to attract private sector investments.

11. Solar power

Among the various renewable energy resources, India possesses a very large solar energy potential; most parts of the country are blessed with good amounts of sunshine. There are about 300 clear sunny days in a year in most parts of country. The average solar radiation incident over India varies from 4 kWh/day - 7 kWh/day. The solar radiation received over the Indian land area is estimated to be about 5,000 trillion kWh/year. In June, 2008, a National Action Plan on Climate Change was announced, which included eight major national missions with the one on solar energy being the centre piece. This mission envisages a major step up in the utilization of solar energy for power generation and other purposes. The Jawaharlal Nehru National Solar Mission (JNNSM) was launched by the Prime Minister of India in January 2010, with a target of 20,000 MW grid solar power (based on solar thermal power generating systems and solar photovoltaic (SPV) technologies), 2000 MW of Off-grid capacity including 20 million solar lighting systems and 20 million sq.m. solar thermal collector area by 2022. The Mission will be implemented in three phases. The first phase will be of three years (up to March, 2013), the second up to March 2017 and the third phase will continue until March, 2022. The target

for phase-I is to set up 1,100 MW grid connected solar plants including 100 MW of roof top and small solar plants and 200 MW capacity equivalent off-grid solar applications and 7 million sq. m solar thermal collector area.

A new architecture has been designed for the 1000 MW projects. These will be implemented through NTPC Vidyut Vyapar Nigam (NVVN). NVVN will sell the solar power to the State utilities after bundling solar power with the equivalent capacity of thermal power. CERC has announced tariffs for the purchase of solar power by NVVN. The tariff for 2011 for PV is Rs.17.91 per unit and Rs. 15.31 per unit for solar thermal power. The main objectives of the mission are to help reach grid parity by 2022 and help set up indigenous manufacturing capacity.

12. Off-Grid Renewable Power Programs

Indian renewable energy priorities are different from those of developed countries. Firstly, and most importantly, it provides energy access to large rural populations including those in inaccessible areas and meets the unobtained demand in many other areas. Perhaps the remotest areas can get electricity only through renewable sources. Secondly there is another important, unrecognized consequence attributed to of off-grid applications. In one way or the other, they replace fossil fuels and can make a significant contribution to reduction in their consumption which is so important from the point of view of energy security. For instance, rural lighting replaces kerosene, a biogas plant or solar cooking system replace cooking gas, solar PV replaces diesel or furnace oil in various areas. Renewable energy can also meet the requirement of process heat in small enterprises and in a way replace small diesel generator sets which consume diesel oil. It has a great strength in its ability to supply power in a decentralized and distributed mode which has the advantage of consumption at the production point and so reduces land and environmental concerns. Table 7 gives the achievements made in the off grid power program.

Table 7. Achievement in Off Grid Power System.

S.No.	Resource/System	Achievement up to 30.09.2010
1	Biomass Power	263.1 MW
2	Biomass Gasifier	128.2 MWeq
3	Waste to Energy	60.8 MWeq
4	Solar PV Power Plants	2.9MWp
5	Hybrid Systems	1.1 MWp
6	Family type Biogas Plants	4.27 million
7	SPV Home Lighting system	6,19,428 nos.
8	Solar lantern	8,13,380 nos.
9	SPV Street Lighting System	1,21,227 nos.
10	SPV Pumps	7,495 nos.
11	Solar Water Heating - Collector Area	3.77 million sq m

(Source: Ministry of New and Renewable Energy, Government of India)

Although the figures appear impressive there is an imperative need for up scaling this program in an inclusive mode. More stress needs to be given for tapping the potential of off grid energy in rural areas of India which are not connected by grid as it is economically unviable to extend the grid in each corner where there may not be positive economic returns. The Jawaharlal Nehru National Solar Mission envisages upscaling "Solar water Heating – Collector Area" to 20 million sq m, deploying solar lighting systems in rural areas to 20 million and enhancing off grid solar application to 2000 MW by 2022. In order to sustain satisfactory performance and generation of output in the envisaged energy forms a flexible funding approach need to be adopted with array of instruments including support in the form of capital subsidy, interest subsidy, viability gap funding etc. The greatest potential for off grid [energy production] appears to be in solar technology. Besides specific solar programs another area that needs focus is solar cooking. The world's largest solar system for cooking in a community kitchen has been installed in Shirdi where food for 20,000 people is cooked daily and it saves 60,000 kg of LPG every year. All institutions including large institutions with hostels, hospitals/medical colleges, military/para-military establishments, industrial organizations, or wherever a large number of meals are cooked, can be potential targets.

Another potential use of solar energy is in the field of refrigeration and air conditioning. The maximum demand for cooling is during the day when the solar energy is abundantly available.

An extension of off-grid relates to rural electrification. Over 40% of the country's population currently does not have access to [grid] energy. This has become a major problem and inspite of large investments under the RGGVY for rural transmission, it has been found increasingly difficult to provide this access, especially in certain identified areas. Biomass based solutions are possible as India generates about 600 million tonnes of biomass based on agriculture. These are relatively more commercially viable and can be implemented in market mode with some Government support. Similarly here is a huge potential for tapping family type Biogas Plants and the present number can be easily raised from 4.27 million to 8 million while there is the potential to raise biomass power to 22000 MW for grid as well as off grid power as discussed earlier. In Bihar state about 150 villages have already been powered by mini grids using rise husk based gasification systems. Pilot biomass projects are under preparation for using pine needles in Himalayan pine forests while Lantana weed in the forests areas of Central India and dedicated bamboo plantations are being examined as sources of biomass for energy production.

13. Financing of Renewable Energy

Renewable power generation capacity in India has been set up largely through private sector investments and has been possible due mainly to a conducive, strong and clear policy framework and investor friendly environment. New investment is the most potent indicator of growth of the sector. It is estimated that, in 2009 the total financial investment in clean energy in India was at US $ 3.2 billion out of which more than US $ 1 billion is in the form of FDI. Ernst and Young ranked India the fourth most attractive country for renewable energy investment in the world, only behind the United States, China, and Germany. Although the government provides support in the form of easy finance, institutional mechanisms still need to be strengthened. Further, renewable energy is central to climate change mitigation efforts. Broad estimates indicate that mitigation from the existing renewable energy portfolio is equivalent to around 4-5% of total energy related emissions in the country. Further, the vast market potential and well developed industrial, financing and business infrastructure, has made India a favorable destination for Clean Development Mechanism (CDM) projects, with renewable energy projects having the major share. National renewable energy plans offer ample opportunity for CDM projects and technological innovations. An analysis of CDM pipeline highlights the fact that there is not enough participation from private households, small enterprises, and rural areas and funds from CDM needs to be tapped more vigorously. The Government of India has also created a "Clean Energy Fund" by imposing a surcharge of INR 50 (US $1.11) on the sale of every tonne of coal to finance clean energy projects.

14. Employment Opportunities

As stated in a report by The Climate group and HSBC, renewable energy has vast potential in terms of creating new job

opportunities in India where there is high rate of unemployment and disguised employment. The report estimates that implementation of the National Action Plan on Climate Change could create an additional 10.5 million direct green jobs and India's share of US $ 2.2 trillion can be US $ 135 billion. Further, global expansion of wind power could create 288,500 Indian jobs if Indian firms were able to penetrate 10% of the global market.

15. Conclusion

Energy is vital for development and this means that if India is to move to a higher growth trajectory than is now feasible, it must ensure the reliable availability of energy. The present energy scenario in India is not satisfactory. The power supply position prevailing in the country is characterized by persistent shortages and unreliability and also high prices for industrial consumers. There is also concern about the position regarding petroleum products. India depends to the extent of 70-80 percent on imported oil, and this naturally raises issues about energy security. These concerns have been exacerbated by recent movements in international oil prices. Electricity is produced domestically but its supply depends upon the availability of coal, exploitation of hydro power sources and the scope for expanding nuclear power, and there are constraints affecting each source. A vibrant functioning society needs energy as its lifeline and the quantum of its use indicates the quality of life being experienced by its members. There is a great disparity in the energy use amongst different regions of the world and even for countries like India where the rural areas are bereft of the benefits of energy and where obtaining food and shelter is a daily challenge [20]. India needs to bridge this divide as soon as possible and this is of paramount importance for any growth which should include all sections of society.

Energy is central to achieving the interrelated economic, social, and environmental aims of sustainable human development. But if India is to realize this important goal, the kinds of energy India produces and the ways it uses them will have to change. Otherwise, environmental damage will accelerate, inequity will increase, and economic growth will be jeopardized. All energy sources are having advantages as well as certain disadvantages but resources are not an end in themselves, and their attractiveness must be seen in the context of societies' energy service needs, of the technologies that convert resources into energy services, and of the economics associated with their use. These analyses have shown that India will have to plan for the fulfillment of its energy needs based on a judicious mix of the natural resources endowed to it, keeping sustainable development in focus and having a minimum carbon foot print. Developed countries of the world also need to understand that climate change is a phenomenon which has no boundaries and the world is facing this threat because of skewed policies followed by them and they are also duty bound to help India attain the goal of achieving energy security for its population by the transfer of clean [energy] technology and by making available appropriate funding mechanisms.

India, with its vast population and limited natural resources for meeting its energy requirements, needs to maintain its momentum of growth and this can be made possible only with a clear strategy for use of best possible energy options available. India needs to have a long term strategy for meeting its energy needs by 2050 and a short term goal of 2020 which can be small steps towards attaining energy security by 2050. The broad vision behind energy policy must be to meet energy demands reliably with energy which is clean and affordable and this must be done in an environmentally sustainable manner using different fuels and forms of energy, conventional and non-conventional, as well as new and emerging sources to ensure supplies at all times.

India needs to have a consistent energy policy which at times is made difficult as currently there are five ministries (Coal, Petroleum and Natural Gas, Atomic Energy, Power and New and Renewable energy) and each one is concerned with its own turf leading to a lack of synergy and sub-optimal results. It needs to create policies which provide for enabling environment for all the stake holders so that desirable outcomes are achieved. It is not necessary to compare the economics of alternatives as pricing at a given point in time may depend on different prices of fuel and technological developments.

It is imperative for India to have a consistent energy policy, together with relentless pursuit of energy efficiency and conservation, maximizing coal production and improving the rail and port infrastructure as well as development of alternative infrastructure for coal transportation such as coastal rivers because coal, being the cheapest form of energy, will be the flag bearer of India's energy needs. There is also an urgent need to fully exploit the hydro and nuclear potential of the country but here it is important that inhabitants of a particular area are taken into confidence so they do not feel alienated from the project. India needs to vigorously raise the level of international diplomacy to gain a foot hold in the exploration of oil, coal and other hydrocarbon resources at a global level. India needs to step up its effort in the direction of coal gasification, carbon sequestration and undertaking projects for bio fuels. As per my analysis it is not possible for India to achieve energy security by concentrating on non renewable sources like coal and oil as the world does not have enough of such resources to meet demands which are continually increasing. India needs to look increasingly towards renewable energy for attaining energy security by 2050 and India's target of getting around 15.9% of total energy need from renewable sources by 2022 is too modest. India being endowed with year round solar radiation must exploit this source to the fullest extent as it is abundant and will remain as long as Earth is in existence irrespective of the cost involved today. As rightly said by a renowned nuclear scientist in India, expensive energy is still better than having no energy. Further, India needs to fully exploit the potential of other renewable energy sources like bio fuels, wind, hydro and even nuclear energy, as projections of energy requirements indicate an approximately three times increase from around 620 Mtoe in 2008 to 2043 Mtoe by 2031-32. It means that India needs to increase the share of renewable energy substantially as non renewable sources of energy are just not available and India will risk losing growth momentum leading to wide spread inequalities which can have serious social and political ramifications. The world community also needs to understand the challenges being faced by India and help by putting in place innovative financial instruments for financing the energy needs of India and lifting of technical barriers. Finally, India needs to wake up and respond by improving efficiency, boosting infrastructure development and promoting private equity participation as the government cannot raise capital on its own for this purpose.

India needs to realize the vast potential of renewable energy and need to step up effort for attaining the goal of "20 11 20 20" by 2020 i.e. 20% reduction in GHG, 11% reduction in consumption of energy by bringing about attitudinal changes, 20% share of renewable energy and 20% conservation of energy from the year 2011 till 2020. These targets are attainable and not only provide cleaner energy but also open a new field for providing employment opportunities to millions of people who are unemployed or disguised employment. This momentum then needs to be maintained so that India attains a target of having 70% renewable energy use by 2050.

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