Conventional and Renewable Energy Scenario of India: Present and Future

Mahendra Lalwani, Mool Singh

Department of Electrical Engineering, Malaviya National Institute of Technology, Jaipur, India
E-mail: mlalwani.ee@gmail.com

Abstract

This paper presents a review about conventional and renewable energy scenario of India. The ordinal terms of Consumption, Production and Supply are acquainted. In India most of the power generation is carried out by conventional energy sources, coal and mineral oil-based power plants which contribute heavily to greenhouse gases emission. Setting up of new power plants is inevitably dependent on import of highly volatile fossil fuels. Thus, it is essential to tackle the energy crisis through judicious utilization of abundant the renewable energy resources, such as biomass energy, solar energy, wind energy, geothermal energy and Ocean energy.

Last 25 years has been a period of exuberant hunt of activities related to research, development, production and demonstration at India. India has obtained application of a variety of renewable energy technologies for use in different sectors too. This paper presents current status, major achievements and future aspects of renewable energy in India. In this paper evaluation of current energy policies for conquering the obstructions and implementing renewables for the future is also been presented.

Keywords

Conventional Energy, Renewable energy, Solar, Wind, Biomass, Geothermal

1. Introduction

With high economic growth rates and over 17 percent of the world's population, India is a significant consumer of energy resources. India, at 1.17 billion people, is the second most populated country in the world. Despite the global financial crisis, India's energy demand continues to rise [19] (Fig.1). India consumes its maximum energy in Residential, commercial and agricultural purposes in comparison to China, Japan, Russia, EU-27 and US [1] (Fig. 2).

Energy 'self-sufficiency' was identified as the major driver for new and renewable energy in the country in the wake of the two oil shocks of the 1970s. The Ministry of New and Renewable Energy (MNRE) is the nodal Ministry of the Government of India for all matters relating to new and renewable energy. The broad aim of the Ministry is to develop and deploy new and renewable energy for supplementing the energy requirements of the country. The sudden increase in the price of oil, uncertainties associated with its supply and the adverse impact on the balance of payments position led to the establishment of the Commission for Additional Sources of Energy in the Department of Science & Technology in March 1981.

The Commission was charged with the responsibility of formulating policies and their implementation, programs for development of new and renewable energy apart from coordinating and intensifying R&D in the sector. In 1982, a new department, i.e., Department of Non-conventional Energy Sources (DNES), that incorporated CASE, was created in the Ministry of Energy. In 1992, DNES became the Ministry of Non-

conventional Energy Sources. In October 2006, the Ministry was re-christened as the Ministry of New and Renewable Energy [7].

In the following sections, a picture about conventional and renewable energy utilization/generation is given along with current status of renewable, future potentials of their uses, major achievements, and current government policies, delivery and outreach in Indian context in the country. At the end, some suggestions are proposed for effective dissemination of RE in the country.

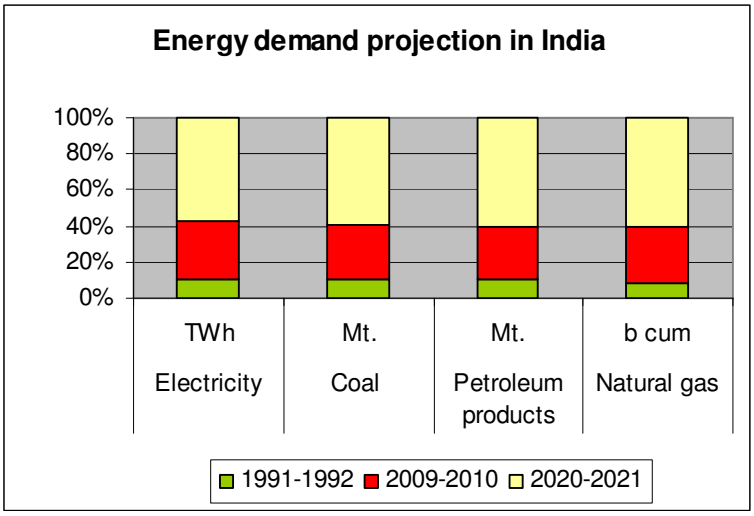

Figure 1: Energy demand projection in India

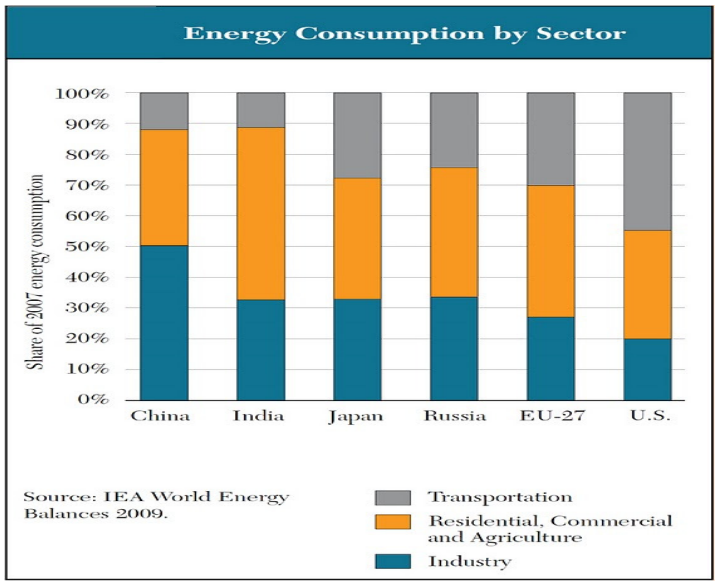

Figure 2: Energy consumption by sector, India compared to China, Japan, Russia, EU 27 and US

2. Conventional energy

The conventional energy supplies, generation/production and consumption in the country have been shown in Figs. 3–8.

2.1. Natural Gas

In 2009, India consumed roughly 1.8 Tcf of natural gas, almost 300 billion cubic feet (Bcf) more than in 2008, according to EIA (Energy Information Administration) estimations (Fig. 3) [13]. Natural gas demand is expected to grow considerably, largely driven by demand in the power sector. The power and fertilizer sectors account for nearly three-quarters of natural gas consumption in India.

According to Oil and Gas Journal, India had approximately 38 trillion cubic feet (Tcf) of proven natural gas reserves as of January 2010[12]. The estimation is that India produced approximately 1.4 Tcf of natural gas in 2009, a 20 percent increase over 2008 production levels (Fig. 3). The bulk of India's natural gas production comes from the western offshore regions, especially the Mumbai High complex, though the Bay of Bengal and its Krishna-Godavari (KG) fields are proving quite productive. Despite the steady increase in India's natural gas production, demand has outstripped supply and the country has been a net importer of natural gas since 2004. India's net imports reached an estimated 445 Bcf in 2009.

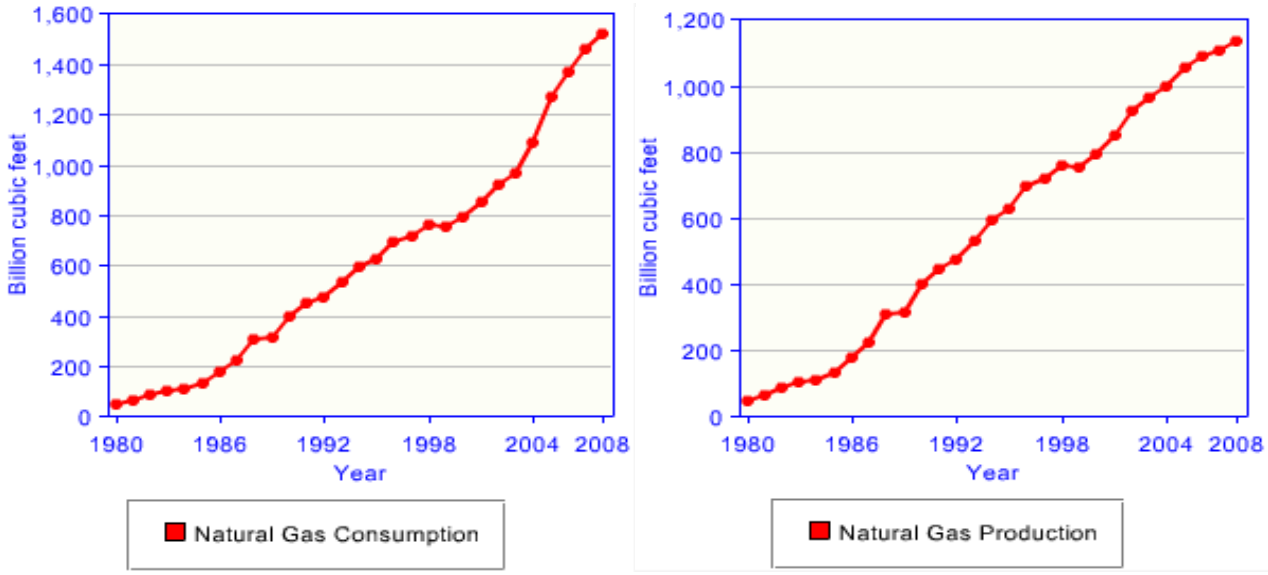

Figure 3: Natural Gas Consumption and production at India

2.2. Oil

India produced roughly 880 thousand barrels per day (bbl/d) of total oil in 2009 from over 3,600 operating oil wells. Approximately 680 thousand bbl/d was crude oil and the remainder was other liquids and refinery gain (Fig. 4) [13].

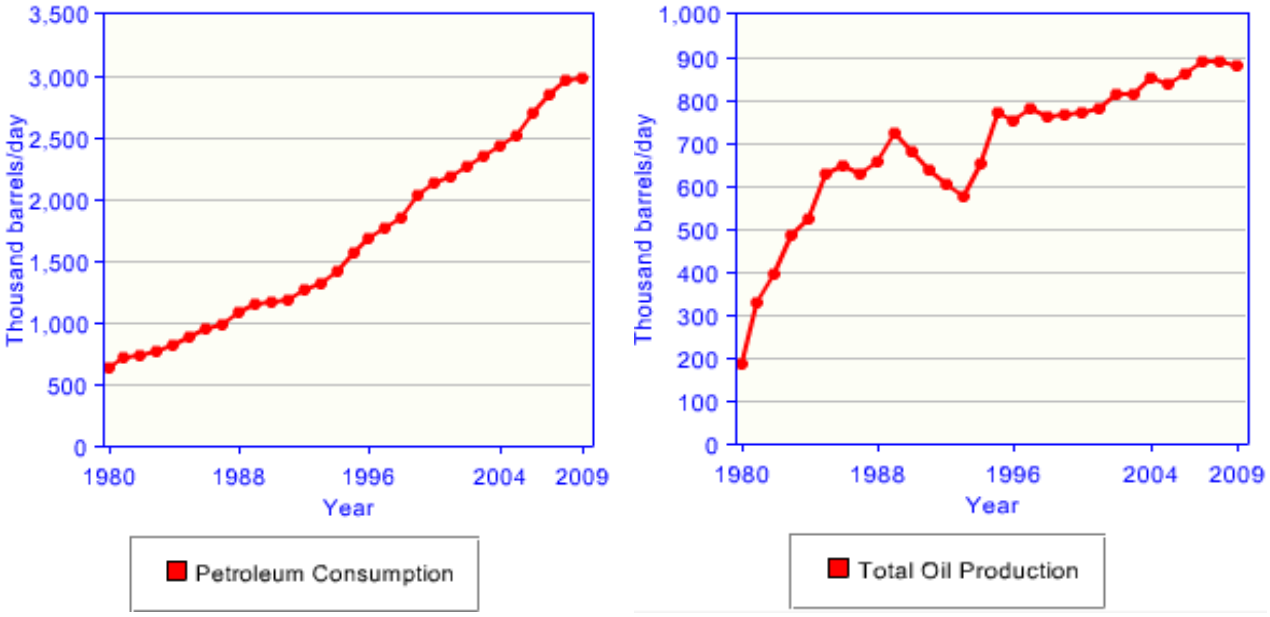

Figure 4: Petroleum Consumption and Production at India

In 2009, India consumed nearly 3 million bbl/d (Fig. 4), making it the fourth largest consumer of oil in the world. EIA expects approximately 100 thousand bbl/d annual consumption growth through 2011 [12]. In 2009, India was the sixth largest net importer of oil in the world, importing, nearly 2.1 million bbl/d, or about 70 percent, of its oil needs. The EIA (Energy Information Administration) expects India to become the fourth largest net importer of oil in the world by 2025, behind the United States, China, and Japan. According to Oil & Gas Journal (OGJ), India had approximately 5.6 billion barrels of proven oil reserves as of January 2010, the second-largest amount in the Asia-Pacific region after China. India's crude oil reserves tend to be light and sweet, with specific gravity varying from 38° API in the offshore Mumbai High field to 32° API at other onshore basins. Nearly 70 percent of India's crude oil imports come from the Middle East, primarily from Saudi Arabia, followed by Iran (Fig. 5) [13].

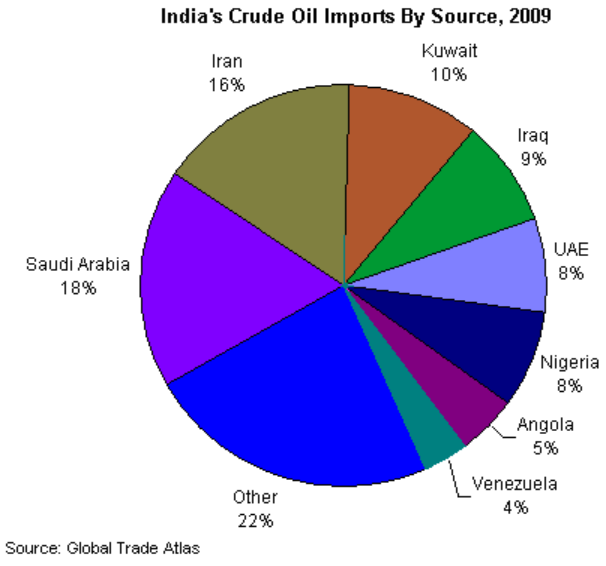

Figure 5: India's Crude Oil imports by Source, 2009

2.3. Coal

From the annual report of Ministry of Coal, Government of India, the Coal production in all over India during the period April, 2009 to January, 2010 has been 416.47 Million tones (Provisional) as compared to the production of 385.02 Million tones (MT) during the corresponding period of the previous year showing a growth of 8.17% [3].

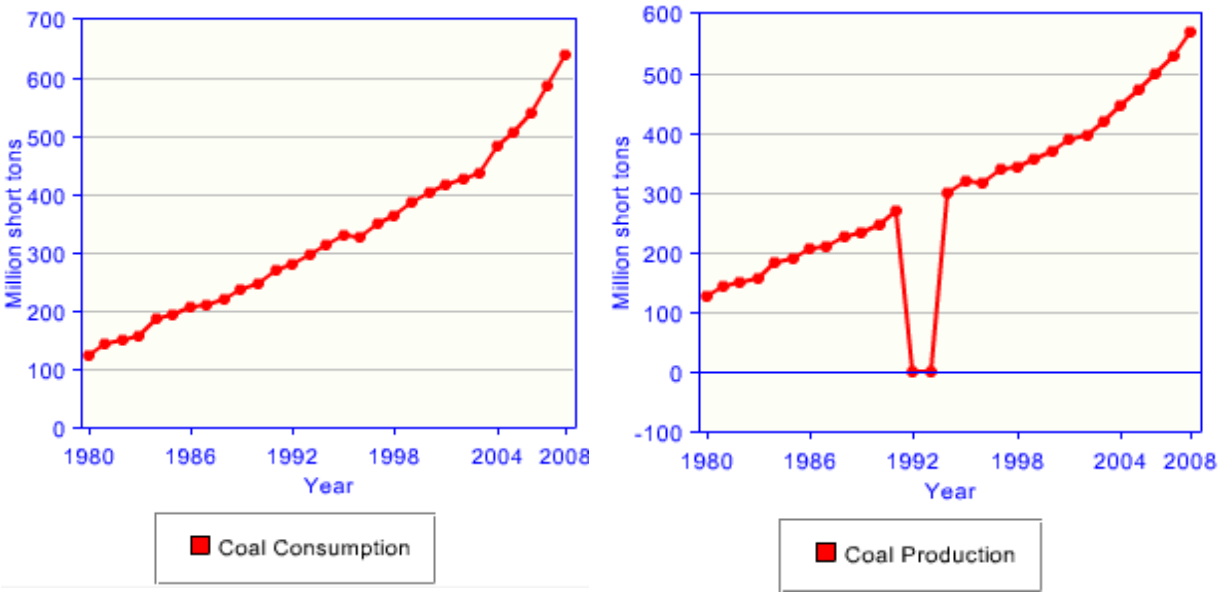

Figure 6: Coal Consumption and Production at India

The coal reserves of India up to the depth of 1200 meters have been estimated by the Geological survey of India at 267.21 billion tones as on April 1, 2009.The 28 year history of coal consumption and production is shown through Fig.6 respectively [13].Through sustained program of investment and great thrust on application of modern technologies, it has been possible to raise the production of coal from a level of about 70 million tones at the time of nationalization of coal mines in early 1970's to 365.09 million tones(All India –including Meghalaya) in 2009-10 (up to December 2009). India consumes 7% of coal of the world. As compared to these top 5 countries ROW (Rest of the World) consumes only 20% of the Coal (Fig.7). World's 68% coal is consumed in Electricity generation (Fig.7).

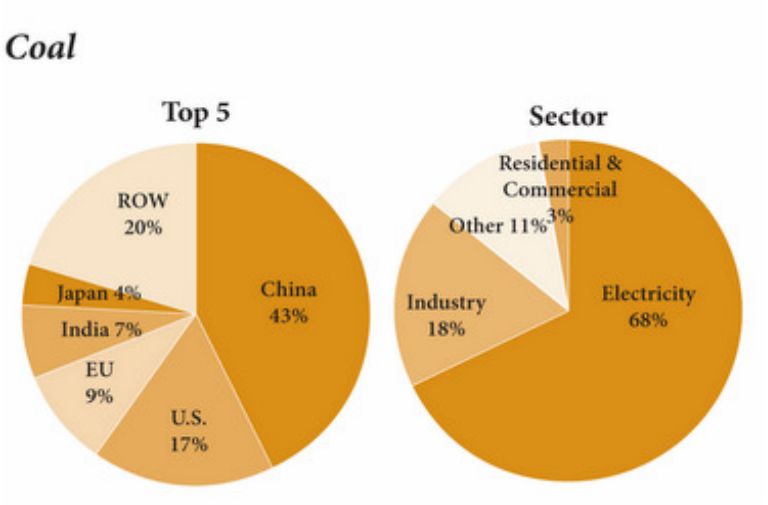

Figure 7: India in top 5 coal consumers, sector wise coal consumption

2.4. Electricity Generation and Consumption

In 2007, India had approximately 159 gigawatts (GW) of installed electric capacity and generated 761 billion kilowatt hours. Nearly all electric power in India is generated with coal, oil or gas. Conventional thermal sources produced over 80 percent of electricity in 2007. Hydroelectricity, a seasonally dependent power source in India, accounted for nearly 16 percent of power generated in 2007. Finally, nuclear energy produced roughly 2 percent of electricity during the same year, while geothermal and other renewable sources accounted for approximately 2 percent (Fig.8) [13].

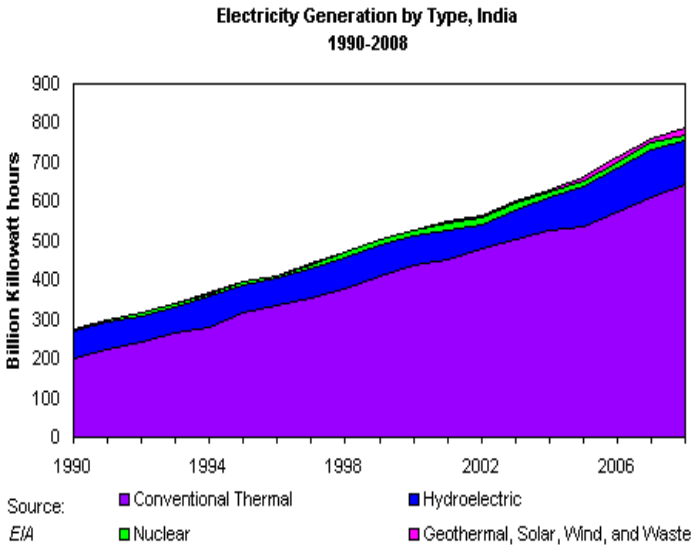

Figure 8: Electricity generation by type in India

3. Renewable Energy

According to the International Energy Agency (IEA), coal/peat account for nearly 40 percent of India's total energy consumption, followed by nearly 27 percent for combustible renewables and waste. Oil accounts for nearly 24 percent of total energy consumption, natural gas six percent, hydroelectric power almost 2 percent, nuclear nearly 1 percent, and other renewables less than 0.5 percent(Figure 9). Although nuclear power comprises a very small percentage of total energy consumption at this time, it is expected to increase in light of international civil nuclear energy cooperation deals [12]. According to the Indian government, nearly 30 percent of India's total energy needs are met through imports.

Current installed base of Renewable energy is 16,492.42 MW which is 10.12% of total installed base with the southern state of Tamil Nadu contributing nearly a third of it (5008.26 MW) largely through wind power. India is world's 6th largest energy consumer, accounting for 3.4% of global energy consumption. The economy of India, measured in USD exchange-rate terms, is the twelfth largest in the world, with a GDP (Gross Domestic Product) of around $1 trillion (2008). GDP growth rate of 9.0% for the fiscal year 2007–2008 which makes it the second fastest big emerging economy, after China, in the world. There is a very high demand for energy, which is currently satisfied mainly by coal, foreign oil and petroleum, which are apart from being a non-renewable.

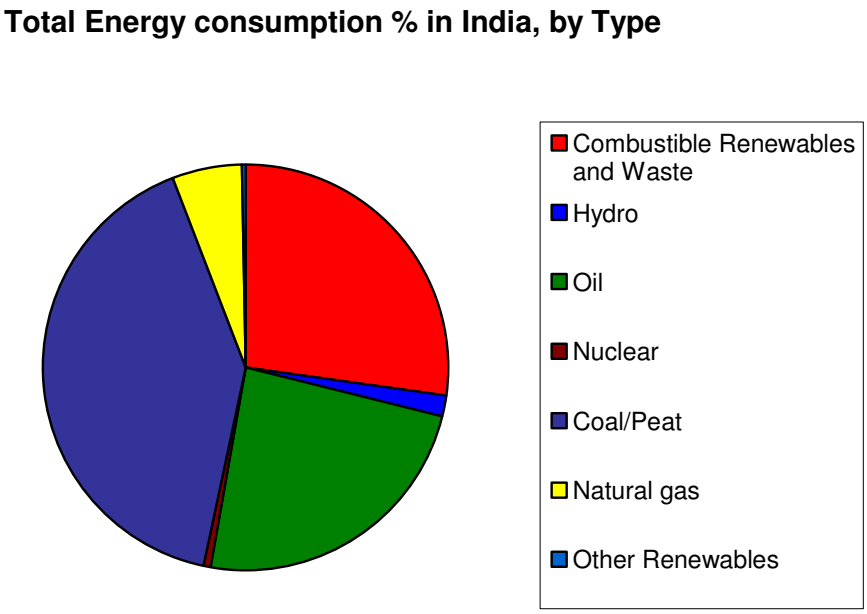

Figure 9: Type wise energy consumption in India

Table 1: Total Energy Consumption in India

Total Energy consumption % in India, by Type	
Combustible Renewables and Waste	27.2
Hydro	1.8
Oil	23.7
Nuclear	0.8
Coal/Peat	40.8
Natural gas	5.6
Other Renewables	0.2

3.1. Solar Energy

Radiant light and heat from the sun, has been harnessed by humans since ancient times using a range of ever-evolving technologies. Solar radiation, along with secondary solar-powered resources such as wind and wave power, hydroelectricity and biomass, account for most of the available renewable energy on earth. Only a minuscule fraction of the available solar energy is used [25].India is both densely populated and has high solar insolation, providing an ideal combination for solar power in India.

In solar energy sector, some large projects have been proposed, and a 35,000 km² area of the Thar Desert has been set aside for solar power projects, sufficient to generate 700 to 2,100 gigawatts. India is endowed with rich solar energy resource. The average intensity of solar radiation received on India is 200 MW/km square (megawatt per kilometer square). With a geographical area of 3.287 million km square, this amounts to 657.4 million MW. However, 87.5% of the land is used for agriculture, forests, fallow lands, etc., 6.7% for housing, industry, etc., and 5.8% is either barren, snow bound, or generally inhabitable. Thus, only 12.5% of the land area amounting to 0.413 million km square can, in theory, be used for solar energy installations.

Even if 10% of this area can be used, the available solar energy would be 8 million MW, which is equivalent to 5,909 mtoe (million tons of oil equivalents) per year.

In July 2009, India unveiled a $19 billion plan, to produce 20 GW of solar power by 2020.Under the plan, solar-powered equipment and applications would be mandatory in all government buildings including hospitals and hotels. On November 18, 2009, it was reported that India was ready to launch its National Solar Mission under the National Action Plan on Climate Change, with plans to generate 1,000 MW of power by 2013.

India has a vast potential for renewable energy sources, especially in areas such as solar power, biomass and wind power. The current installed capacity of renewable energy is around 92204 MW, constituting about 7.3 percent of India's total installed generation capacity. Technological breakthroughs for cost-effective photovoltaic technology could generate a quantum leap in the renewable energy sector since India is well endowed with solar insolation (average of 6 kwh/ sq.mt./day).India plans to announce increased subsidies for solar-power generation, as the country looks to scale up production of renewable energy and show it is committed to mitigating climate change.

India just had 2.12 megawatts of grid-connected solar generation capacity. As part of the National Solar Mission, the ministry aims to bolster the annual photovoltaic production to at least 1,000 megawatts a year by 2017. With an installed capacity of 123 GW, the country currently faces energy shortage of 8 percent and a peak demand shortage of 11.6 percent. In order to sustain a growth rate of 8 percent, it is estimated36 that the power generation capacity in India would have to increase to 306 GW in the next ten years which is 2.5 times current levels. However, as of October 2009, India is currently ranked number one along with the United States in terms of installed Solar Power generation capacity.

The Karnataka Power Corporation Limited (KPCL) has installed India's largest solar photovoltaic power plant at Yalesandra village in Kolar district of Karnataka. Built at the cost of about $13 million, the plant makes use of modular crystalline technology to generate solar energy (Fig.10)

Table 2: Total Energy Consumption in India

Number of solar street lighting systems	55,795
Number of home lighting systems	342,607
Solar lanterns	560,295
Solar photovoltaic power plants	1566 kW
Solar water heating systems	140 km^2 of collector area
Box-type solar cookers	575,000
Solar photovoltaic pumps	6,818

Figure 10: India's largest solar photovoltaic power plant

3.2. Wind Energy

The development of wind power in India began in the 1990s, and has significantly increased in the last few years. Although a relative newcomer to the wind industry compared with Denmark or the US, India has the fifth largest installed wind power capacity in the world. The worldwide installed capacity of wind power reached 157,899 MW by the end of 2009 [20]. USA (35,159 MW), Germany (25,777 MW), Spain (19,149 MW) and China (25,104 MW) are ahead of India in fifth position (Fig. 11). The short gestation periods for installing wind turbines, and the increasing reliability and performance of wind energy machines has made wind power a favored choice for capacity addition in India.

Samana wind farm is the largest wind project undertaken to date by RULON. CLP India, the Group's subsidiary in India, is partnering with wind turbine manufacturer Enercon (India) Limited to develop this greenfield project in India's north-western state of Gujarat. Samana wind farm has a generating capacity of 100.8 MW, and is expected to be completed in two phases – the first 50.4 MW by June 2008 and the other 50.4 MW by January 2009. The project further leads RULON into the wind power market of India (Fig.12)

Suzlon, India's largest wind power company, has risen to ranking 5th worldwide, with 7.7%of the global market share in just over a decade. Suzlon holds some 52 percent of market share in India. Suzlon's success has made India the developing country leader in advanced wind turbine technology (Fig.13).

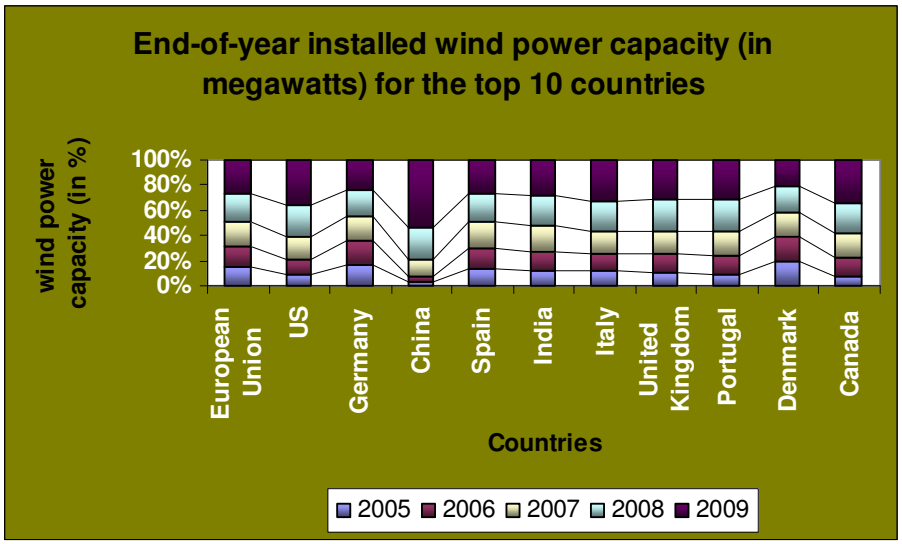

Figure 11: India in top 10 countries: Installed wind power capacity

Figure 12: Samana wind farm, the largest wind project at Gujarat

Figure 13: Wind-powered turbines set up by Suzlon Energy near Dhule, India, are part of the technology increasingly reaching the country's rural regions

3.3. Hydropower

India is endowed with economically exploitable and viable hydro potential assessed to be about 84,000 MW at 60% load factor (1,48,701 MW installed capacity). In addition, 6780 MW in terms of installed capacity from Small, Mini, and Micro Hydel schemes have been assessed. Also, 56 sites for pumped storage schemes with an aggregate installed capacity of 94,000 MW have been identified [16]. However, only 19.9% of the potential has been harnessed so far. Hydroelectricity is the term referring to electricity generated by hydropower; the production of electrical power through the use of the gravitational force of falling or flowing water. It is the most widely used form of renewable energy. India is blessed with immense amount of hydro-electric potential and ranks 5th in terms of exploitable hydro-potential on global scenario (Fig. 14) [20]. India was one of the pioneering countries in establishing hydro-electric power plants. The power plant at Darjeeling and Shimsha (Shivanasamudra) was established in 1898 and 1902 respectively and is one of the first in Asia. The installed capacity as of 2008 was approximately 36,877. The public sector has a predominant share of 97% in this sector.In addition, 56 number of pumped storage projects have also been identified with probable installed capacity of 94,000 MW. In addition to this, hydro-potential from small, mini & micro schemes has been estimated as 6 782 MW from 1 512 sites.

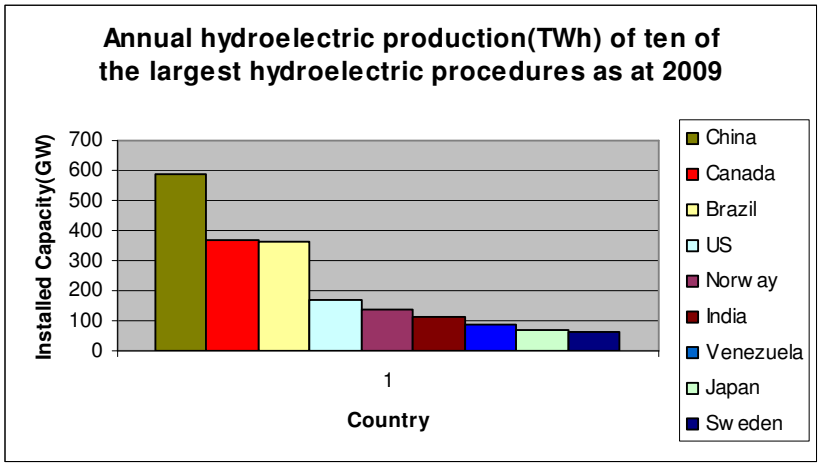

Figure 14: Annual hydroelectric productions (TWh) of ten of the largest procedures as at 2009

Figure 15: Parbati Stage - II Power Station (800MW), Operated by NHPC.

Figure 16: Chamera Stage - I Power Station (540MW), Operated by NHPC.

The Parbati Hydroelectric Project (Stage-II) (Fig.15) is a run-of-the-river scheme proposed to harness hydro potential of the lower reaches of the river Parbati, The proposed scheme is 'inter basin transfer' type [23]. Chamera Power Station Stage-I (540 MW) is a run-of-the-river scheme built on river Ravi, which is a major river of the Indus Basin, originating in the Himalayas from the Baira Bhanghal branch of the Dhaula Dhar Range. The project was commissioned in April 1994 (Fig. 16) [6].

3.4. Biomass

Biomass has been a key player in energy generation even in the past. Biomass, defined as all land and water-based vegetation as well as organic wastes, fulfilled almost all of human kind's energy need prior to the industrial revolution. In present day scenario, once again its utilization for generation of energy has gained momentum because of limited availability of the conventional energy resources as well as environmental concern due to GHG emissions.

In the past decade there has been renewed interest in the biomass as a renewable energy source worldwide. The major reasons for this are as follows. First of all technological developments relating to the conversion, crop production, etc. promise the application of biomass at lower cost and with higher conversion efficiency than was possible previously. In Western Europe and in the US, the second main stimulus is food surpluses producing agricultural sector. This situation has led to a policy in which land is set aside in order to reduce surpluses. In these regions, a number of factors associated with surplus land, such as the de-population of rural areas and payment of significant subsidies to keep land fallow, have provided sufficient driving force to the introduction of alternative, non-food crops desirable. Thirdly, the potential threat posed by climate change, due to high emission levels of greenhouse gases, the most important being CO_2, has become a major stimulus for renewable energy sources in general. When produced by sustainable means, biomass emits roughly the same amount of carbon during conversion as is taken up during plant growth. The use of biomass therefore does not contribute to a build up of CO_2 in the atmosphere. India is very rich in biomass and has a potential of 16,881MW (agro-residues and plantations), 5000MW (bagasse cogeneration) and 2700MW (energy recovery from waste). Biomass power generation in India is an industry that attracts investments of over INR 600 crores every year, generating more than 5000 million units of electricity and yearly employment of more than 10 million man-days in the rural areas [2].

3.5. Geothermal energy

Geothermal energy is the earth's natural heat available inside the earth. This thermal energy contained in the rock and fluid that filled up fractures and pores in the earth's crust can profitably be used for various purposes. This energy is accessed by drilling water or steam wells in a process similar to drilling for oil. Geothermal energy is an enormous, underused heat and power resource that is clean (emits little or no greenhouse gases), reliable (average system availability of 95%), and homegrown (making us less dependent on foreign oil) [20].

India has reasonably good potential for geothermal; the potential geothermal provinces can produce 10,600 MW of power. Rocks covered on the surface of India ranging in age from more than 4500 million years to the present day and distributed in different geographical units. The rocks comprise of Archean, Proterozoic, the marine and continental Palaeozoic, Mesozoic, Teritary, Quaternary etc., More than 300 hot spring locations have been identified by Geological survey of India (Thussu, 2000).But yet geothermal power projects has not been exploited at all, owing to a variety of reasons, the chief being the availability of plentiful coal at cheap costs.

However, with increasing environmental problems with coal based projects, India will need to start depending on clean and eco-friendly energy sources in future; one of which could be geothermal. India occupies 15th position in geothermal power use by country (Fig. 17) [22]

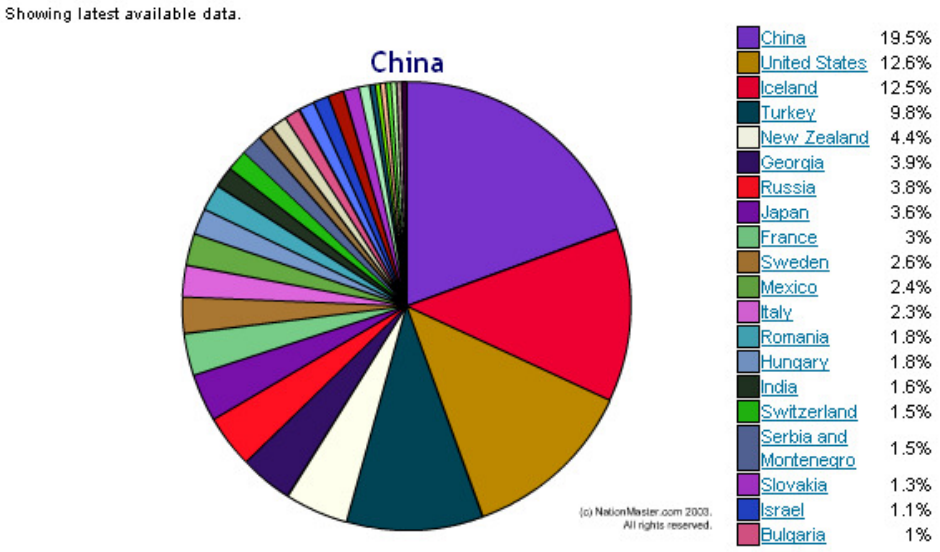

Figure 17: Geothermal power use by country, India is on 15th rank

4. Current Energy Policies

The ultimate objective of the renewable energy policy framework is to significantly increase the share of renewable energy source in India's energy mix from [11,14,15]. These energy policies are set by government.

4.1. National Electricity Policy, 2005

The National Electricity Policy aims at achieving the following objectives; access to electricity, availability of power demand (to be fully met by 2012), energy and peaking shortages to be overcome and spinning reserve to be available, supply of reliable and quality power of specified standards in an efficient manner and at reasonable rates, per capita availability of electricity to be increased to over 1000 units by 2012, financial turn around and commercial viability of electricity sector and protection of consumers' interests.

4.2. The Electricity Act 2003

The Electricity Act contains the following provisions pertaining to non-conventional energy sources. Under Sections 3(1) and 3(2), it has been stated that the Central Government shall, from time to time, prepare and publish the National Electricity Policy and Tariff Policy, in consultation with the state governments and authority for development of the power system based on optimal utilization of resources such as coal, natural gas, nuclear substances or material, hydro and renewable sources of energy. Section 4 states that the Central Government shall, after consultation with the state governments, prepare and notify a national policy, permitting stand-alone systems for rural areas. Section 61, 61(h) and 61(i) state that the appropriate commission shall, subject to the provision of this Act, specify the terms and conditions for the determination of tariff, and in doing so, shall be guided by the following, namely, the promotion of cogeneration and generation of electricity from renewable sources of energy; and the National Electricity Policy and Tariff Policy.

Section 86(1) and 86(1)(e) state that the state commissions shall discharge the following functions, namely, 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 also specify, for purchase of electricity from such sources, a percentage of the total consumption of electricity in the area of a distribution license.

4.3. Tariff Policy, 2006

The Tariff Policy announced in January 2006 has the following provisions:

1. Pursuant to provisions of section 86 (1) (e) of the Act, the Appropriate Commission shall fix 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.

2. It will take some time before non-conventional technologies can compete with conventional sources in terms of cost of electricity. Therefore, procurement by distribution companies shall be done at preferential tariffs determined by the Appropriate Commission.

3. Such procurement by Distribution Licensees for future requirements shall be done, as far as possible, through competitive bidding process under Section 63 of the Act within suppliers offering energy from same type of nonconventional sources.

4. The Central Commission should lay down guidelines within three months for pricing non-firm power, especially from nonconventional sources, to be followed in cases where such procurement is not through competitive bidding.

4.4. National Rural Electrification Policies, 2006

1. Goals include provision of access to electricity to all households by the year 2009, quality and reliable power supply at reasonable rates, and minimum lifeline consumption of 1 unit/household/day as a merit good by year 2012.
2. For villages/habitations where grid connectivity would not be feasible or not cost effective, off-grid solutions based on standalone systems may be taken up for supply of electricity.
3. State government should, within 6 months, prepare and notify a rural electrification plan, which should map and detail the electrification delivery mechanism.
4. The Gram Panchayat shall certify and confirm the electrified status of the village as on 31st March each year.

4.5. Integrated Energy Policy Report (Planning Commission) 2006

Suggest a path to meet energy needs of the country in an integrated manner up to 2031–2032. It recommended special focus on renewable energy development.

5. Major Achievements

The Ministry of New & Renewable Energy (MNRE) has been facilitating the implementation of broad spectrum programs including harnessing renewable power, renewable energy to rural Areas for lighting, cooking, and motive power, use of renewable energy in urban, industrial and commercial applications and development of alternate fuels and applications [4]. The Major achievements are summarized as below:

Source: Ministry of New and Renewable Energy			
Annual Achievement 2010-11 and Cumulative achievement as on 30.6.2010			
No.	**Source/System**	**Achievements during 2010-11(up to 30.6.2010)**	**Cumulative achievements(up to 30.6.2010)**
I.	**Power from Renewables**		
A	**Grid-interactive renewable power**		
1	Biomass Power(Agro residues)	45.5 MW	901.1 MW
2	Wind Power	202.73 MW	12009.48 MW
3	Small Hydro Power (up to 25 MW)	31.64 MW	2767.05 MW
4	Cogeneration-bagasse	67.5 MW	1411.53 MW
5	Waste to Energy	7.5 MW	72.46 MW
6	Solar Power	2.0 MW	12.28 MW
	Total (in MW)	**356.87 MW**	**17173.9 MW**
B	**Off-Grid/ Distributed Renewable Power(including Captive/ CHP plants)**		
7	Biomass Power/Cogen.(non-bagasse)	6.0 MW	238.17 MW
8	Biomass Gasifier	4.0 MWeq.	125.44 MWeq
9	Waste- to- Energy	6.0 MWeq.	52.72 MWeq
10	Solar PV Power Plants	0.0 MWp	2.92 MWp
11	Aero- Generators/ Hybrid System	0.0 MW	1.07 MW
	Total (in MW)	**16.00MWeq**	**420.32 MWeq**
II.	**Remote Village Electrification**	208 Villages & Hamlets	6867 Villages & Hamlets
III.	**Decentralized Energy System**		
12	Family Type Biogas Plants	0.07 lakh	42.60 lakh
13	SPV Home Lighting System	nos.	6,03,307 nos.
14	Solar Lantern	nos.	7,97,344 nos.
15	SPV Street Lighting System	nos.	1,19,634 nos.
16	SPV Pumps	nos.	7,334 nos.
17	Solar Water Heating-Collector Area		3.53 Mln. sq. m.
MWeq.=Megawatt equivalent; MW=Megawatt; MWp=Megawatt peak; sq. m.=square meter			

6. Suggestions

Following suggestions are given for policy makers for development, dissemination and better and efficient use of renewable energy technologies in the country:

1) Establishment of biomass /solar / wind power generation systems and energy saving in every government office to encourage and inspire people.
2) Strenuous exaltation of renewable energy by government agencies, public sector, corporate, academic institutions etc.
3) Foundation of national-level body to increase awareness of renewable energy at comprehensive level.
4) Research and development of renewable energy technologies get provided the financial support and sponsorship.
5) Setting up aspiring goals and targets for power generation non-conventional sources.
6) Making it compulsory to install solar water heating systems for all urban residential and commercial establishments.
7) Imperative renewable energy systems provision for new residential, commercial and industrial buildings.
8) Restricting use of large battery energy storage systems and promoting use of biofuels in vehicles.
9) Abrogating duties / taxes on import of small-scale renewable energy generating equipment and providing manageable loans for setting up renewable energy enterprises.
10) Handsome incentives and subsidies for installation and successful operation of renewable energy equipment and additional incentives for buyers and manufacturers of renewable energy equipments in rural areas.
11) Cultivation of energy crops on marginal and degraded land.

7. Conclusions

There is an urgent need for transition from petroleum-based energy systems to one based on renewable resources to decrease reliance on depleting reserves of fossil fuels and to mitigate climate change. In addition, renewable energy has the potential to create many employment opportunities at all levels, especially in rural areas. So Isolated systems, whose cost depends on load factor are needed to be linked with rural industry. Innovative financing is also a requirement.

Mainstreaming of renewables is very essential. Energy security, economic growth and environment protection are the national energy policy drivers of any country of the world. The need to boost the efforts for further development and promotion of renewable energy sources has been felt world over in light of high prices of crude oil.

A disparaging part of the solution lies in promoting renewable energy technologies as a way to address concerns about energy security, economic growth in the face of rising energy prices, competitiveness, health costs and environmental degradation. The cost-effectiveness of Wind and Small Hydro power energy should also be taken into account.

An emphasis should be given on presenting the real picture of massive renewable energy potential; it would be possible to attract foreign investments to herald a Green Energy Revolution in India.

Specific action include promoting deployment, innovation and basic research in renewable energy technologies, resolving the barriers to development and commercial deployment of biomass, hydropower, solar and wind technologies, promoting straight (direct) biomass combustion and biomass gasification technologies, promoting the development and manufacture of small wind electric generators, and enhancing the regulatory/tariff regime in order to main stream renewable energy sources in the national power

system(Source: NAPCC). Accordingly, increased focus is being laid on the deployment of renewable power that is likely to account for around 5% in the electricity-mix by 2032.

India's quest for energy security and sustainable development rests a great deal on the ability to tap energy from alternate sources or the renewable sources.

8. References

[1]. Energy Consumption by Sector in 2007: China, India, Japan, Russia, EU-27, and the United States available at: http://www.earthtrendsdelivered.org/energy_consumption_by_sector_in_2007_china_usa_india_japan_russia_eu-27

[2]. Singh J, GU S. Biomass conversion to energy in India—A critique. Renewable and Sustainable Energy Reviews 2010;14:1367–1378

[3]. Coal Statistics from Annual Report 2009-10 available at: http://coal.nic.in/annrep0910.pdf

[4]. Major achievement in Energy and Renewable Energy available at: http://www.mnre.gov.in/achievements.htm

[5]. Liming H. Financing rural renewable energy: A comparison between China and India. Renewable and Sustainable Energy Reviews 2009;13:1096–1103

[6]. Details of Chamera-I available at: http://www.nhpcindia.com/Projects/english/Scripts/Prj_Introduction.aspx?vid=63

[7]. Details of history of departments for Renewable Energy: http://www.mnre.gov.in/

[8]. Golait N., Moharil R.M., Kulkarni P.S. Wind electric power in the world and perspectives of its development in India. Renewable and Sustainable Energy Reviews 2009 ; 13:233–247

[9]. Ghosh D, Shukla PR, Garg A, Ramana VP. Renewable energy technologies for the Indian power sector: mitigation potential and operational strategies. Renewable and Sustainable Energy Reviews 2002; 6:481–512.

[10]. Energy Policy of India available at: http://en.wikipedia.org/wiki/Energy_policy_of_India

[11]. Maithani PC. Renewable energy policy framework of India. India: Narosa Publication Delhi; 2008. p. 41–54.

[12]. India Energy statistics available at: http://www.eia.doe.gov/cabs/India/Full.html

[13]. India Energy profile available at: http://tonto.eia.doe.gov/country/country_energy_data.cfm?fips=IN

[14]. Information and Public Awareness. Booklet on Renewable energy of Ministry of Non-Conventional Energy Sources, Government of India. http://www.mnre.gov.in/booklets/Book12-e.pdf

[15]. Indian Renewable Energy Development Agency Ltd. Booklet on Renewable energy of Ministry of Non-Conventional Energy Sources, Government of India. http://www.mnre.gov.in/booklets/Book11-e.pdf

[16]. Hydro Power scenario available at: http://www.nhpcindia.com/English/Scripts/Hydro_Potential.aspx

[17]. Varuna S.K.,Singal. Review of augmentation of energy needs using renewable energy sources in India. Renewable and Sustainable Energy Reviews 2007; 11:1607– 15.

[18]. GOI. Tenth Five year plan 2002–2007, planning commission, New Delhi. Available at: http://planningcommission.nic.in/aboutus/committee/wrkgrp11/wg11_ renewable.pdf

[19]. Planning Commission, Govt. of India—September 1995 & September 1996 Projections to 2020–2021.

[20]. Basic definitions available at: http://en.wikipedia.org/wiki/Energy

[21]. Future Perspectives for Renewable Energy in India available at: http://www.alternative-energy-news.info/future-renewable-energy-india/

[22]. Energy Statistics of Geothermal power use (most recent) by Country : http://www.nationmaster.com/red/pie/ene_geo_pow_use-energy-geothermal-power-use

[23]. Details of Parbati-II available at: http://nhpcindia.com/Projects/English/Scripts/Prj_Introduction.aspx?vid=67

[24]. Future Perspectives for Renewable Energy in India available at: http://www.alternative-energy-news.info/future-renewable-energy-india/
[25]. Details of Solar power in India available at: http://en.wikipedia.org/wiki/Solar_power_in_India