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Environmental and Social issues related to Coal and Role of Renewable Energy Sources in India

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***Abstract:** The growth of any country is dependent on its ability to provide affordable and sustainable supply of energy. India is set to witness one of the highest growths in energy demand, largely based on buoyant economy and rising population. There is strong linkage between economic growth and energy demand as such there will be growing demand for energy in future. Coal is a pre-dominant source of energy in India and constitutes the largest share in India's energy production and consumption. Despite the recent focus on promoting other energy sources (in particular renewables), it is clear that the current coal-centric energy structure will continue for at least next two or three decades owing to technical and cost-related factors. The coal sector in India, in the past few years, has been subject to various controversies and issues like environmental and social, which raise question on the role of coal being primary energy source.*

The environmental impact of the coal industry includes issues such as land use, waste management, water and air pollution, caused by the coal mining, processing and the use of its products. In addition to atmospheric pollution, coal burning produces hundreds of millions of tons of solid waste products annually, including fly ash, bottom ash, and flue-gas desulfurization sludge, that contain mercury, uranium, thorium, arsenic, and other heavy metals.

A great ongoing social challenge for the coal industry is sustainable development and community acceptance of its role in society. The problem of Mining-Induced Displacement and Resettlement (MIDR) poses major risks to societal sustainability. MIDR is accompanied by the resettlement effect, defined as the loss of physical and non-physical assets, including homes, communities, productive land, income-earning assets and sources, subsistence, resources, cultural sites, social structures, networks and ties, cultural identity and mutual help mechanisms.

In spite of above environmental and social issues, coal will remain for a future mainstay at least for next 30 years, a foundation and a fundament of our economy. The challenge is to apply right coal winning technology for its production and use in the most efficient and environment friendly manner. Simultaneously, it is necessary to find out affordable, efficient and eco-friendly energy mix of energy sources for future.

In this attempt has been made to study the merits/demerits of available energy sources and to find the scope of renewable energy sources.

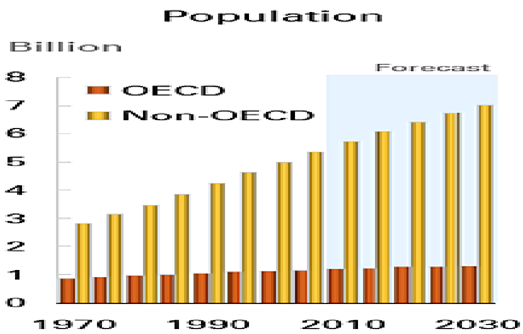
***Key words:** MMSCMD, Syngas, Energy scenario, Ocean thermal energy conversion, Fuel cells*

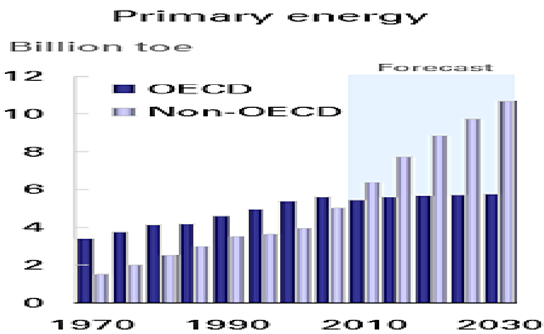
I. INTRODUCTION

By 2030, the World's population is expected to reach over 8 billion, from its current level of 6.4 billion and consequently global energy demand will grow by almost 60 percent by 2030 and rise to 16.5 billion tones of oil equivalent per year. Fossil fuels and in particular coal will have to meet this challenge in future. Nuclear energy though provides a significant proportion of energy in some countries, but in general it faces serious public opposition. Renewable energies are growing fast, but presently make up only a small part of global energy production. International Energy Agency (IEA) predicts that by 2030 only 14 percent of total energy demand will be met from renewable sources. In fact it is not wise to depend on a single source of energy. Coal can play a unique role in meeting the demand for a secure energy supply. Coal is globally abundant and economical as well of all fossil fuels, which can be used for both power generation and industrial applications. The production and utilization of coal is based on well-proven and widely used technologies. Coal reserves are significantly more abundant and much more widely and evenly dispersed than other fossil fuels. The world currently consumes over 5500 million tonnes of coal for use in power generation, steel production, and cement manufacture, as a chemical feedstock and as a liquid fuel.

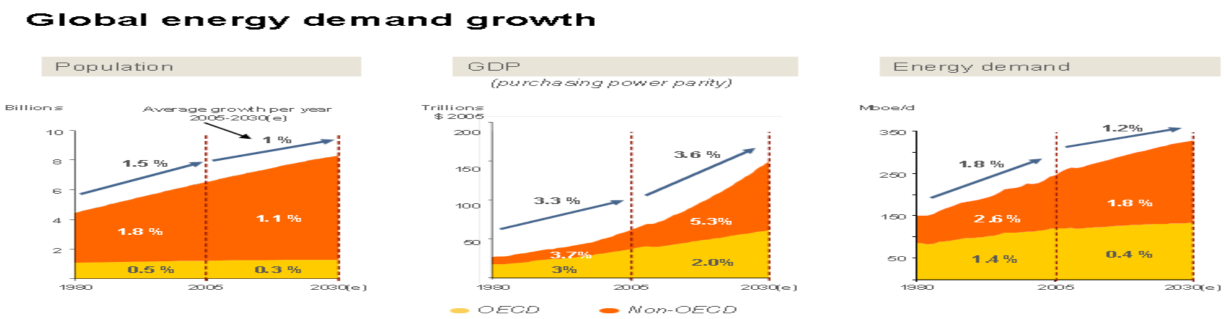
II. GLOBAL ENERGY SCENARIO

The Organization for Economic Co-operation and Development (OECD) is an international economic organization of 34 countries, founded in 1961 to stimulate economic progress and world trade. It is a forum of countries describing themselves as committed to democracy and the market economy, providing a platform to compare policy experiences, seeking answers to common problems, identify good practices and coordinate domestic and international policies of its members.





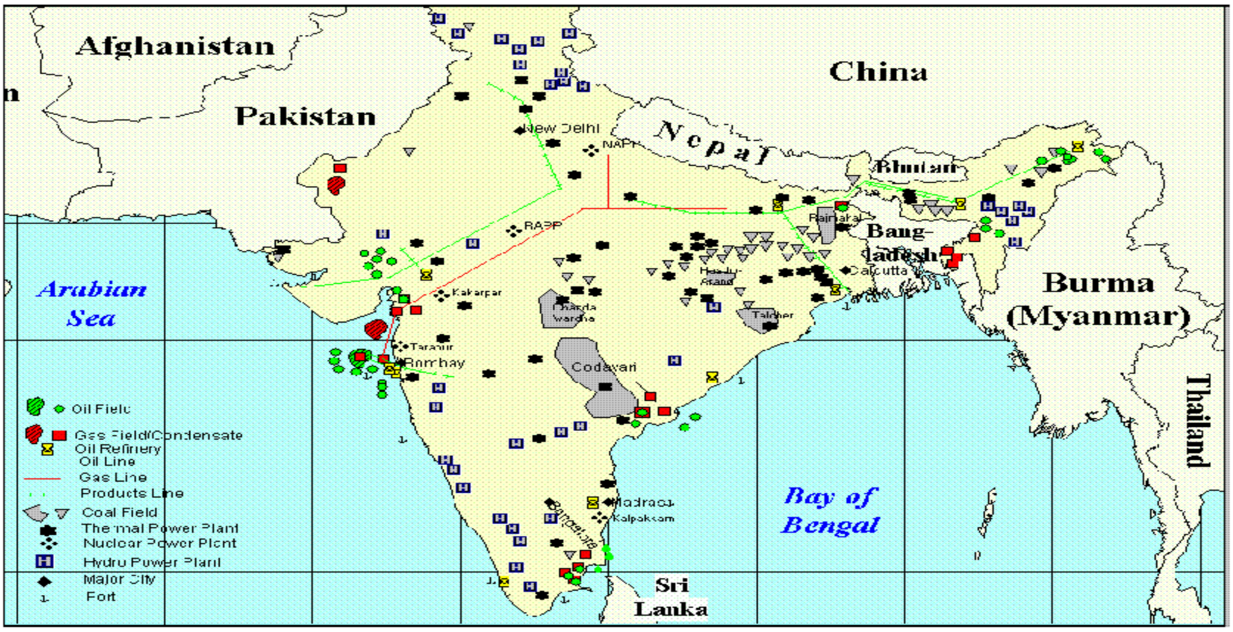
It is seen from the graphs that the population and energy demand of non- OECD countries have an increasing trends compared to OECD countries.



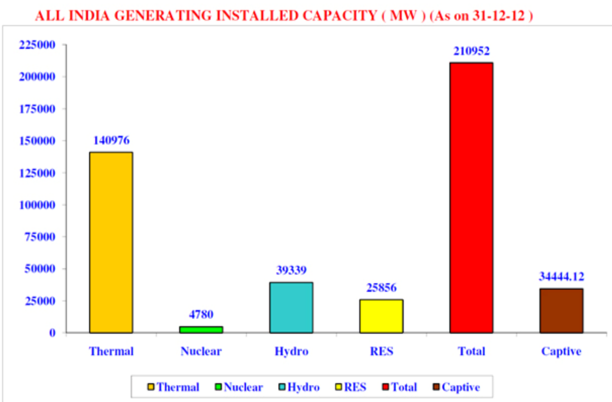
III. INDIA'S ENERGY SCENARIO

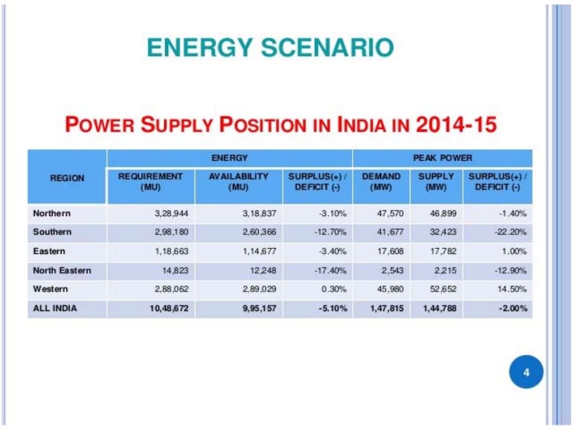
India is now the eleventh largest economy in the world, fourth in terms of purchasing power. It is poised to make tremendous economic strides over the next ten years, with significant development already in the planning stages. In recent years, India has emerged as one of the leading destinations for investors from developed countries. Most of the power generation in India is carried out by conventional energy sources, coal and mineral oil-based power plants which contribute heavily to greenhouse gases emission. Setting up new power plants requires inevitably import of highly volatile fossil fuels. This focuses the solution of the energy crisis on judicious utilization of abundant the renewable energy resources, such as biomass, solar, wind, geothermal and ocean energy. Following Energy map indicates locations of Coal fields, Oil/gas fields, Power plants, Oil/Gas line etc in India.

ENERGY MAP OF INDIA



Total Installed Capacity of the country as on 31st December, 2012 was 245396 MW as depicted in the graph below. (Total installed capacity as on 30.06.2015, is 274818MW). Coal based generation contributes major part of the installed capacity and contributes to about 55% of the total energy generation. In addition to above, the installed capacity of captive power plants of 1MW and above is of the order of 34444 MW at the end of 2012.





ENERGY SCENARIO

POWER SUPPLY POSITION IN INDIA IN 2014-15

REGION	ENERGY			PEAK POWER		
	REQUIREMENT (MU)	AVAILABILITY (MU)	SURPLUS(+) / DEFICIT (-)	DEMAND (MW)	SUPPLY (MW)	SURPLUS(+) / DEFICIT (-)
Northern	3,28,944	3,18,837	-3.10%	47,570	46,899	-1.40%
Southern	2,98,180	2,60,366	-12.70%	41,677	32,423	-22.20%
Eastern	1,18,663	1,14,677	-3.40%	17,608	17,782	1.00%
North Eastern	14,823	12,248	-17.40%	2,543	2,215	-12.90%
Western	2,88,062	2,89,029	0.30%	45,980	52,652	14.50%
ALL INDIA	10,48,672	9,95,157	-5.10%	1,47,815	1,44,788	-2.00%

4

The country has been facing growing shortages over the past five years. During the fiscal year 2014-15, the electricity generated in utility sector is 1,030.785 billion KWh with a short fall of requirement by 38.138 billion KWh (-3.6%). As far as power supply position, it is observed that the Southern and North Eastern part of India are having deficit in power supply. Despite an ambitious rural electrification program, some 400 million Indians lose electricity access during blackouts. While 80% of Indian villages have at least an electricity line, just 52.5% of rural households have access to electricity. In urban areas, the access to electricity is 93.1%. The overall electrification rate in India is 64.5% while 35.5% of the population still live without access to electricity.

The electric power survey of India report claims:

» As on 31.03.2013, India's industrial demand accounted for 44.87% of electrical power requirement, domestic household use accounted for 21.79%, agriculture 17.95%, commercial 8.33%, public lighting and other miscellaneous applications accounted for the rest.(Ref: Growth of Electricity Sector in India 1947-2013 of Govt of India)

» The electrical energy demand for 2016–17 is expected to be at least 1,392 Tera Watt Hours, with a peak electric demand of 218 GW.

- The electrical energy demand for 2021–22 is expected to be at least 1,915 Tera Watt Hours, with a peak electric demand of 298 GW.

If current average transmission and distribution average losses remain same (32%), India needs to add about 135 GW of power generation capacity, before 2017, to satisfy the projected demand after losses. India's demand for electricity may cross 300 GW, earlier than most estimates. To explain the estimates, following four reasons are given:

- India's manufacturing sector is likely to grow faster than in the past
- Domestic demand will increase more rapidly as the quality of life for more Indians improve
- About 125,000 villages are likely to get connected to India's electricity grid
- Blackouts and load shedding artificially suppresses demand; this demand will be sought as revenue potential by power distribution companies

The electricity losses in India during transmission and distribution are about 24%, while losses because of consumer theft or billing deficiencies added another 10–15%. Power cuts are common throughout India and the consequent failure to satisfy the demand for electricity has adversely effected India's economic growth. The National Average per capita electricity consumption is 778.63KWh in India. State of Goa (2004.77 kWh) & Pondicherry (1864.5 kWh) account for maximum per capita consumption of electricity while states of Bihar (117.48 kWh), Manipur (207.15 kWh) & Assam (209.20 kWh) show the lowest per capita consumption.

Thermal power

Thermal power plants convert energy rich fuels such as coal, natural gas, petroleum products, agricultural waste, domestic trash/waste, etc. into electricity. Total thermal base installed capacity is 191264MW. Other sources of fuel include landfill gas & biogases. In some plants, renewal fuels such as biogas are co-fired with coal. Coal, Gas & Oil accounts for 60.8%, 8.4% & 0.4% electricity of India's total installed capacity. India's electricity sector consumes about 72% of the coal produced in the country. India expects that its projected rapid growth in electricity generation over the next couple of decades is expected to be largely met by thermal power plants.

Coal:

A large part of Indian coal reserve is similar to Gondwana coal. It is of low calorific value and high ash content. The carbon content is low in India's coal, and toxic trace element concentrations are negligible. The natural fuel value of Indian coal is poor. On average, the Indian power plants using India's coal supply consume about 0.7 kg of coal to generate a kWh, whereas United States thermal power plants consume about 0.45 kg of coal per kWh. This is because of the difference in the quality of the coal, as measured by the Gross Calorific Value (GCV). On average, Indian coal has a GCV of about 4500 Kcal/kg, whereas the quality elsewhere in the world is much better. The high ash content in India's coal affects the thermal power plant's potential emissions. Therefore, India's Ministry of Environment & Forests has mandated the use of beneficiated coals whose ash content has been reduced to 34% (or lower) in power plants in urban, ecologically sensitive and other critically polluted areas, and ecologically sensitive areas. Coal benefaction industry has rapidly grown in India, with current capacity topping 90 MT.

Total coal base installed capacity is 167208 MW (60.8%). Thermal power plants in India deploy a wide range of technologies. Some of the major technologies include:

- Steam cycle facilities (most commonly used for large utilities);
- Gas turbines (commonly used for moderate sized peaking facilities);

- Cogeneration and combined cycle facility (the combination of gas turbines or internal combustion engines with heat recovery systems); and
- Internal combustion engines (commonly used for small remote sites or stand-by power generation).

India has an extensive review process, one that includes environment impact assessment, prior to a thermal power plant being approved for construction and commissioning. The Ministry of Environment and Forests has published a technical guidance manual to help project proposers and to prevent environmental pollution in India from thermal power plants.

Natural gas:

The installed capacity of natural gas-based power plants is 23062 MW as on 30.06.2015 (i.e. 8.4%). These base load power plants are operating at overall PLF of 25% only due to severe shortage of Natural gas in the country. The breakeven price for switching from imported coal to LNG in electricity generation is very high. Indian government has taken steps to enhance the generation from the stranded gas based power plants for meeting peak load demand by waiving applicable import duties and taxes due to drastic fall in the LNG and crude oil international prices. It is envisaged that the share of natural gas in the primary energy mix would reach 20% till 2030 if not more. In future, the natural gas demand is all set to grow significantly at a CAGR of 6.8% to 746 MMSCMD in 2029-30.

Gasification of coal or lignite or biomass, produces syngas or coal gas or wood gas which is a mixture of hydrogen, carbon monoxide and carbon dioxide gases. Coal gas can be converted in to synthetic natural gas by using Fischer–Tropsch process at low pressure and high temperature. Coal gas can also be produced by underground coal gasification where the coal deposits are located deep in the ground or uneconomical to mine the coal. Synthetic Natural Gas (SNG) production technologies have tremendous scope to meet the SNG requirements of gas-based power stations fully using the locally available coal (or imported coal in short run). Dankuni coal complex is producing **syngas** which is piped to the industrial users in Calcutta. Many coal based fertiliser plants which are shut down can also be retrofitted economically to produce synthetic natural gas for bridging natural gas shortages. The SNG produced from coal/biomass is reliable & dependable fuel supply to the gas based power stations and other natural gas consumers.

As per the Ministry of petroleum, Government of India, India has 1,437 billion cubic metres (50.7×1012 cu ft) of confirmed natural gas reserves as of April 2010. The electrical power and fertiliser sectors account for nearly three-quarters of natural gas consumption in India. Natural gas is expected to be an increasingly important component of energy consumption as the country pursues energy resource diversification and overall energy security.

Until 2008, the majority of India's natural gas production came from the Mumbai High complex in the northwest part of the country. Recent discoveries in the Bay of Bengal have shifted the centre of gravity of Indian natural gas production.

The country already produces some coal bed methane and has major potential to expand this source of cleaner fuel. According to a 2011 Oil and Gas Journal report, India is estimated to have between 600 to 2000 Tcf of shale gas resources which is one of the world's largest.

Nuclear power:

Nuclear power is 4th largest source of electricity in India after thermal, hydroelectric and renewable sources. In 1971, India set up its first pressurized heavy water reactors with Canadian collaboration in Rajasthan. In 1987, India created Nuclear Power Corporation of India Limited to commercialize nuclear power. As on 30.06.2015, India has 5780 MW of installed electricity generation capacity using nuclear fuels in seven nuclear plants. India's Nuclear plants generated 32455 million units or 3.75% of total electricity produced in India. Kudankulam Nuclear Power Plant has initial installed capacity of 2 GW; this plant will be expanded to 6.8 GW capacity. Nuclear Power Corporation of India Limited has set its objective to establish 63 GW generation capacity by 2032, as a safe, environmentally benign and economically viable source of electrical energy to meet the increasing electricity needs of India.

India's nuclear power generation effort satisfies many safeguards and oversights, such as getting ISO-14001 accreditation for environment management system and peer review by World Association of Nuclear Operators including a pre-start up peer review

The country plans to implement fast breeder reactors, using plutonium based fuel. Plutonium is obtained by reprocessing spent fuel of first stage reactors. India successfully launched its first prototype fast breeder reactor of 500 MW capacity in Tamil Nadu, and now operates two such reactors.

India has nuclear power plants operating in the following states: Maharashtra, Gujarat, Rajasthan, Uttar Pradesh, Tamil Nadu and Karnataka. These reactors have an installed electricity generation capacity between 100 to 540 MW each. In 2011, The Wall Street Journal reported the discovery of uranium in a new mine in India, the country's largest ever. The estimated reserves of 64,000 tonnes, could be as large as 150,000 tonnes (making the mine one of the world's largest). The new mine is expected to provide India with a fuel that it now imports. Nuclear fuel supply constraints had limited India's ability to grow its nuclear power generation capacity.

India's share of nuclear power plant generation capacity is just 1.2% of worldwide nuclear power production capacity, making it the 15th largest nuclear power producer. Nuclear power provided 2.1% of the country's total electricity generation and aims to supply 9% of its electricity needs with nuclear power by having "an ambitious plan to reach a nuclear power capacity of 63,000 MW in 2032. India's largest nuclear power plant project under implementation is at Jaitapur, Maharashtra in partnership with Areva, France.

India's government is also developing up to 62 nos, mostly thorium reactors, which it expects to be operational by 2025. It is the "only country in the world with a detailed, funded, government-approved plan" to focus on thorium-based nuclear power.

IV. Issues With India's Power Sector

The country currently is getting electricity from coal (60%), hydroelectricity (16%), other renewable sources (12%), natural gas (9%) and gets 2% of its electricity from nuclear power. India's electricity sector faces many issues. Some are:

- Inadequate last mile connectivity: Due to lack of last-mile link-up with all electricity consumers and reliable power supply (to exceed 99%), many consumers depend on DG sets using costly diesel oil for meeting unavoidable power requirement
- Having Lack of sense for energy-efficient lookout - Thus, while experts express the huge potential for energy conservations in this sector, the belief still predominates among stakeholders that energy-efficient buildings are more expensive than conventional buildings, which adversely affects the “greening” of the building sector.
- Key implementation challenges for India's electricity sector- It includes new project management and execution, ensuring availability of fuel quantities and qualities, lack of initiative to develop large coal and natural gas resources available in India, land acquisition, environmental clearances at state and central government level, and training of skilled manpower to prevent talent shortages for operating latest technology plants.
- Shortages of fuel: Due to primitive mining techniques, poor transport infrastructure, theft of fuel. Despite abundant reserves of coal, India is facing a severe shortage of coal. Most of India's coal lies under protected forests or designated tribal lands. Any mining activity or land acquisition for infrastructure in these coal-rich areas of India, has been rife with political demonstrations, social activism and public interest litigations.
- Poor pipeline connectivity and infrastructure to harness India's abundant coal bed methane and shale gas potential.

» The giant new offshore natural gas field has delivered less fuel than projected. India faces a shortage of natural gas.

» Hydroelectric power projects in India's mountainous north and north east regions have been slowed down by ecological, environmental and rehabilitation controversies, coupled with public interest litigations.

» Theft of power

» Losses in the connector systems leading to premature failure of capital equipments.

» India's nuclear power generation potential has been stymied by political.

» Average transmission, distribution and consumer-level losses exceeding 30% which includes auxiliary power consumption of thermal power stations, fictitious electricity generation by wind generators & independent power producers (IPPs), etc.

» Intermittent and unreliable electricity supply.

» Lack of clean and reliable energy sources such as electricity is, causing about 800 million people in India to continue using traditional biomass energy sources, causing indoor air pollution resulting in 3 to 4 lakhs deaths per year and other chronic health issues.

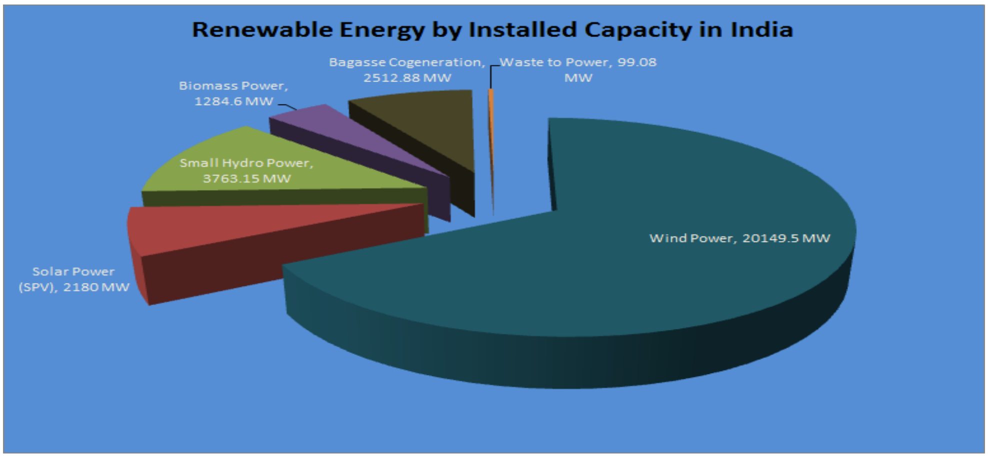
» India's coal-fired, oil-fired and natural gas-fired thermal power plants are inefficient and offer significant potential for greenhouse gas (CO2) emission.

Despite its natural resource potential, and an opportunity to create energy industry jobs, India has yet to hold a licensing round for its shale gas blocks. The traditional natural gas reserves too have been very slow to develop in India.

V. Renewable Energy Sources in India

Renewable energy is derived from natural processes that are replenished constantly. In its various forms, it derives directly from the sun, or from heat generated deep within the earth. Included in the definition is electricity and heat generated from solar, wind, ocean, hydropower, biomass, geothermal resources, bio fuels and hydrogen derived from renewable resources. India’s total renewable power sources installed is 36,470 MW (13%) with breakup as under:

Small hydro	4,101.55 MW	Wind power	23,762.81 MW
Biomass power/ Cogeneration	1,410.20 MW	Bagasse cogeneration	3,008.35 MW
Waste-to-power	127.00 MW	Solar power	4,060.65 MW



The potential of renewable power sources is huge only thing we have to extract the same with our full willingness and accept them with their limitations. In following paras, the same is elaborated in detail.

6.1 Hydropower

Energy from small hydro is the oldest. It is most reliable of all renewable energy sources. The development of small scale hydropower in India started almost in the pace with the world's first hydroelectric installation in 1882 at Appleton USA. The 130 KW installations in Sidrapong (Darjeeling) in the year 1897 was the first installation in India and other installations were Shivasamundram at Mysore (2000 kW), and Bhoorisingh in Chamba (40 kW) in 1902, Galogi at Mussoorie (3000 kW) in 1907, Jubbal (50 kW) in 1911 and Chhaba (1750 kW) at Shimla in 1913. These plants were used primarily for lighting in important towns and are still working.

India is endowed with economically exploitable and viable hydro potential assessed to be about 84,000 MW at 60% load factor. In addition, 6740 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. 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.

The present installed hydro power station capacity as on 30.06.2015 is 41997 MW which is 15.3% of total electricity generation in India. The public sector has a predominant share of 97% in this sector. National Hydroelectric Power Corporation (NHPC), Northeast Electric Power Company (NEEPCO), Satluj Jal Vidyut Nigam (SJVNL), Tehri Hydro Development Corporation, NTPC-Hydro, are a few public sector companies engaged in development of hydroelectric power in India.

Pumped storage schemes are perfect centralized peaking power stations for the load management in the electricity grid. Pumped storage schemes would be in high demand for meeting peak load demand and storing the surplus electricity as India graduates from electricity deficit to electricity surplus. They also produce secondary /seasonal power at no additional cost when rivers are flooding with excess water. India has already established nearly 6800 MW pumped storage capacity which is part of its installed hydro power plants.

The term 'small hydro' has a wide range in usage. It covers schemes having installed capacities from a few kW to 25 MW. In India small hydro schemes are further classified as; Micro hydro up to 100 kW plant capacity, Mini hydro from 101 kW to 2000 kW and Small hydro up to 25000 kW plant capacities.

6.2 Biomass and Biogas Energy

Biomass is produced in nature through photosynthesis achieved by solar energy conversion. Biomass means organic matter. In simplest form, the process of photosynthesis is in the presence of solar radiation. In this system biomass, bagasse, forestry and agro residue & agricultural wastes are used as fuel to produce electricity. An estimated production of 350 million tons of agricultural waste every year, biomass is capable of supplementing coal to the tune of about 200 million tones producing of power. The large quantities of cattle dung can be used in bio energy technologies viz., biogas, gasifier, biomass combustion, cogeneration etc., to produce energy thermal or electrical energy. Biomass energy co-generation program is being implemented with the main objective of promoting technologies for optimum use of biomass resources of India. Nearly 750 million tons of non edible (by cattle) biomass is available annually in India which can be put to use for higher value addition.

Torrefied biomass

Biomass can be used after Torrefaction in the pulverised coal mills for replacing imported coal. North West and southern regions can replace imported coal use with torrefied biomass where surplus agriculture/crop residual biomass is available.

Biomass gasifier

India has been promoting biomass gasifier technologies in its rural areas, to utilise surplus biomass resources such as rice husk, crop stalks, small wood chips, and other agro-residues. The goal was to produce electricity for villages with power plants of up to 2 MW capacities. During 2011, India installed 25 rice husk based gasifier systems for distributed power generation in

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70 remote villages of Bihar. The largest biomass-based power plant in India is at Sirohi, Rajasthan, having the capacity of 20 MW, i.e., Sambhav Energy Limited. In addition, gasifier systems are being installed at 60 rice mills in India. During the year, biomass gasifier projects of 1.20 MW in Gujarat and 0.5 MW in Tamil Nadu were successfully installed. This pilot programme aims to install small-scale biogas plants for meeting the cooking energy needs in rural areas of India. During 2011, some 45000 small-scale biogas plants were installed. Cumulatively, India has installed 4.44 million small-scale biogas plants.

In 2011, India started a new initiative with the aim to demonstrate medium size mixed feed biogas-fertiliser pilot plants. This technology aims for generation, purification/enrichment, bottling and piped distribution of biogas. India approved 21 of these projects with aggregate capacity of 37016 cubic metre per day, of which 2 projects have been successfully commissioned by December 2011. India has additionally commissioned 158 projects under its Biogas based Distributed/Grid Power Generation program, with a total installed capacity of about 2 MW.

India is rich in biomass and has a potential of 16,881 MW (agro-residues and plantations), 5000 MW (bagasse cogeneration) and 2700 MW (energy recovery from waste). Biomass power generation in India is an industry that attracts investments of over Rs 6 billion every year, generating more than 5000 million units of electricity and yearly employment of more than 10 million man-days in the rural areas.

As of 2010, India burnt over 200 million tonnes of coal replacement worth of traditional biomass fuel every year to meet its energy need for cooking and other domestic use. This traditional biomass fuel – fuel wood, crop waste and animal dung – is a potential raw material for the application of biomass technologies for the recovery of cleaner fuel, fertilisers and electricity with significantly lower pollution. Biomass available in India can and has been playing an important role as fuel for sugar mills, textiles, paper mills, and Small and Medium Enterprises (SME)

The biomass power generation potential in India is estimated at 30000 MW. Biomass can be used in three ways – gasification, methane gas production and combustion. The technologies being promoted include combustion either for power in captive or grid connected modes, or for heat applications

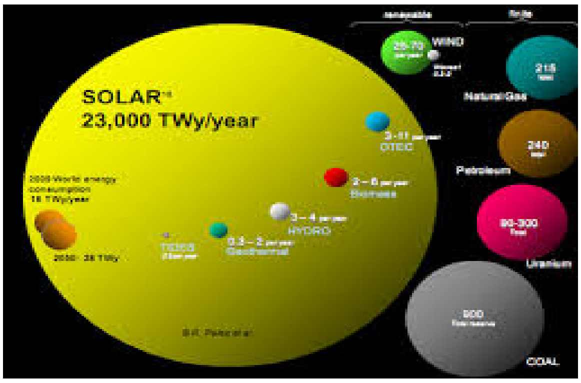
6.3 Wind Energy

Energy of wind can be economically used to generate electrical energy. Wind can also be used to provide mechanical power such as for water pumping. In India generally wind speeds obtainable are in the lower ranges. Therefore, attempts are on the development of low cost, low speed mills for irrigation of small and marginal farms for providing drinking water in rural area. The developments are being mainly concentrated on water pumping wind mill suitable for operation in a wind speed range of 8 to 36 kmph. In India high wind speeds are obtainable in coastal areas of Saurashtra, western Rajasthan and some parts of central India.

India has the fifth largest installed wind power capacity in the world. In 2010, wind power accounted for 6% of India's total installed power capacity, and 1.6% of the country's power output. The development of wind power in India began in the 1990s by Tamil Nadu Electric Board near Tuticorin, and has significantly increased in the last few years. As December 2011, the installed capacity of wind power in India was 15.9 GW, spread across many states of India. The largest wind power generating state was Tamil Nadu accounting for 30% of installed capacity, followed in decreasing order by Maharashtra, Gujarat, Karnataka, and Rajasthan and further 6 GW of additional wind power capacity will be installed. In Tamil Nadu, wind power is mostly harvested in the southern districts such as Kanyakumari, Tirunelveli and Tuticorin. The state of Gujarat is estimated to have the maximum gross wind power potential in India, with a potential of 10.6 GW.

6.4 Solar Energy

Solar energy has the greatest potential of all the sources of renewable energy. If only a small amount of this form of energy could be used, it will be one of the most important supplies of energy specially when other sources in the country have depleted energy comes to the earth from the sun. This energy keeps the temperature of the earth above than in colder space, causes current in the atmosphere and in ocean. It causes the water cycle and generates photosynthesis in plants. The sun gives us 1000 times more power than we need. If we can use 5% of this energy, it will be 50 times what the world will require electrical energy that can be produced from the solar energy by photovoltaic solar cells. SPV cell converts the solar energy directly to electrical energy. The most significant applications of SPV cells in India are the energization of pump sets for irrigation, drinking water supply and rural electrification etc. Sunshine available in India is for nearly 300days in a year. Comparison of solar with other sources on global basis indicated below



India is endowed with a vast solar energy potential. India receives one of the highest global solar radiation - an energy of about 5,000 trillion kWh per year is incident over India's land mass with most parts receiving 4-7 kWh per m2 per day. Under Solar Mission, a central government initiative, India plans to generate 20 GW grid-based solar power, 2 GW of off-grid solar power and cover 20 million square meters with solar energy collectors by 2020. India plans utility scale solar power generation plants through solar parks with dedicated infrastructure by state governments, among others, the governments of Gujarat and Rajasthan.

Installation of solar power plants require nearly 2.4 hectares (6 acres) land per MW capacity which is similar to coal-fired power plants when life cycle coal mining, consumptive water storage & ash disposal areas are also accounted and hydro power plants when submergence area of water reservoir is also accounted. 1.33 million MW capacity solar plants can be installed in India on its 1% land (32,000 square km). There are vast tracts of land suitable for solar power in all parts of India exceeding 8% of its total area which are unproductive barren and devoid of vegetation. Part of waste lands (32,000 square km) when installed with solar power plants can produce 2000 billion Kwh of electricity (two times the total generation in the year 2013-14) with land productivity/yield of 1.5 million Rs per acre (6 Rs/kwh price) which is at par with many industrial areas and many times more than the best productive irrigated agriculture lands. Moreover, these solar power units are not dependent on supply of any raw material and are self productive. There is unlimited scope for solar electricity to replace all fossil fuel energy requirements (natural gas, coal, lignite, nuclear fuels and crude oil) if all the marginally productive lands are occupied by solar power plants in future.

The major disadvantage of solar power (PV type) is that it cannot produce electricity during the night time and cloudy day time also. In India, this disadvantage can be overcome by installing pumped-storage hydroelectricity stations. This can be achieved by utilizing all the usable river waters by interlinking Indian rivers. These river water pumping stations would also be envisaged with pumped-storage hydroelectricity features to generate electricity during the night time. These pumped-storage stations would work at 200% water pumping requirement during the day time and generate electricity at 50% of total capacity during the night time. Also, all existing and future hydro power stations can be expanded with additional pumped-storage hydroelectricity units to cater night time electricity consumption. Most of the ground water pumping power can also be met directly by solar power.

6.5 Ocean Energy Technology:

Although currently under-utilized, Ocean energy is mostly exploited by just a few technologies: Wave, Tidal, Current Energy and Ocean Thermal Energy.

a) Tidal Energy

Oceans cover 70% of the earth's surface and represent an enormous amount of energy in the form of wave, tidal, marine current and thermal gradient. The tidal cycle occurs every 12 hours due to the gravitational force of the moon. The difference in water height from low tide and high tide is potential energy. Similar to traditional hydropower generated from dams, tidal water can be captured in a barrage across an estuary during high tide and forced through a hydro-turbine during low tide. To capture sufficient power from the tidal energy potential, the height of high tide must be at least five meters greater than low tide. There are only approximately 20 locations on earth with tides this high and India is one of them. The Gulf of Cambay and the Gulf of Kutch in Gujarat on the west coast have the maximum tidal range of 11m and 8m with average tidal range of 6.77m and 5.23m respectively.

The energy potential of our seas and oceans well exceeds our present energy needs. India is surrounded by sea on three sides; its potential to harness tidal energy is significant. India has a long coastline with the estuaries and gulfs where tides are strong enough to move turbines for electrical power generation. A variety of different technologies are currently under development throughout the world to harness this energy in all its forms including Waves (40,000 MW) and Tides (9000 MW). Deployment is currently limited but the sector has the potential to grow, fuelling economic growth, reduction of carbon footprint and creating jobs not only along the coasts but also inland along its supply chains. Tidal energy technologies harvest energy from the seas. The potential of tidal wave energy becomes higher in certain regions by local effects such as shelving, funneling, reflection and resonance. The tides in the sea are the result of the universal gravitational effect of heavenly bodies like sun and moon on the earth. Due to fluidity of water mass, the effect of this force becomes apparent in the motion of water. It shows a periodic rise and fall in levels. It is in synthesis with the daily cycle of rising and setting of sun and moon. This periodic rise and fall of the water level of sea is called tide. These tides can be used to produce electrical energy. It is called, "Tidal Energy". When the water is above the mean sea level, it is called, "Flood Tide". When the level is below the mean sea level, it is called, "Ebb Tide". To harness the tides, a dam is built across the mouth of the bay. It will have large gates in it. It has low head hydraulic reversible turbines. A tidal basin is formed. It gets separated from the sea by dam. The difference in water level is obtained between the basin and sea. By using reversible water turbines, turbines can be run continuously, both during high tide and low tide. The turbine is coupled to generator. Potential energy of the water stored in the basin as well as energy during high tides used to drive turbine. It is coupled to generator to generate electrical energy. The report claims, barrage technology could harvest about 8 GW from tidal energy in India, mostly in Gujarat. The barrage approach has several disadvantages, one being the effect of any badly engineered barrage on the migratory fishes, marine ecosystem and aquatic life. Integrated barrage technology plants can be expensive to build.

Another tidal wave technology harvests energy from surface waves or from pressure fluctuations below the sea surface. A report from the Ocean Engineering Centre, Indian Institute of Technology, Madras estimates the annual wave energy potential along the Indian coast is between 5 MW to 15 MW per metre, suggesting a theoretical maximum potential for electricity harvesting from India's 7500 kilometre coast line may be about 40 GW. India built its first seas surface energy harvesting technology demonstration plant in Vizhinjam, near Thiruruvananthpuram.

b) Current Energy

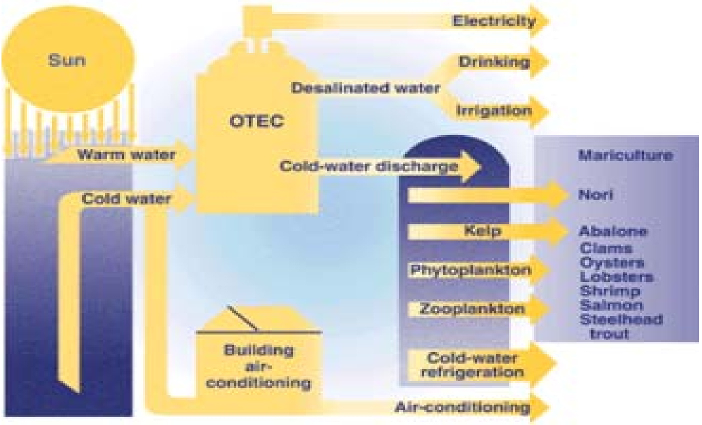
Marine current is ocean water moving in one direction. This ocean current is known as the Gulf Stream. Tides also create currents that flow in two directions. Kinetic energy can be captured from the Gulf Stream and other tidal currents with submerged turbines that are very similar in appearance to miniature wind turbines. As with wind turbines, the constant movement of the marine current moves the rotor blades to generate electric power.

c) Wave Energy

Wave energy is generated by the movement of a device either floating on the surface of the ocean or moored to the ocean floor. Many different techniques for converting wave energy to electric power have been studied. Wave conversion devices that float on the surface have joints hinged together that bend with the waves. This kinetic energy pumps fluid through turbines and creates electric power. Stationary wave energy conversion devices use pressure fluctuations produced in long tubes from the waves swelling up and down. This bobbing motion drives a turbine when critical pressure is reached. Other stationary platforms capture water from waves on their platforms. This water is allowed to runoff through narrow pipes that flow through a typical hydraulic turbine. Wave energy is proving to be the most commercially advanced of the ocean energy technologies with a number of companies competing for the lead.

d) Ocean Thermal Energy Conversion (OTEC)

Ocean thermal energy conversion (OTEC) uses the temperature difference (Above 20Deg C) between cooler deep (lower than 1000 meter) and warmer shallow or surface sea waters to run a heat engine and produce useful work, usually in the form of electricity. This is also an indirect method of utilizing solar energy. A large amount of solar energy is collected and stored in tropical oceans. The surface of the water acts as the collector for solar heat, while the upper layer of the sea constitutes infinite heat storage reservoir. Thus the heat contained in the oceans, could be converted into electrical energy by utilizing the fact that the temperature difference between the warm surface waters of the tropical oceans and the colder waters in the depth is about 20 - 250 K. Utilization of this energy, with its associated temperature difference and its conversion into work, forms the basis of Ocean Thermal Energy Conversion (OTEC) systems. The surface water, which is at higher temperature, could be used to heat some low boiling organic fluid and the vapors of which would run a heat engine. The exit vapor would be conducted by pumping cold water from the deeper regions. The amount of energy available for ocean is replenished continuously. All the systems of OTEC method work on a closed Rankine cycle. It uses low boiling organic fluids like ammonia, Propane, R - 12, R - 22 etc.



In 2003, with Saga University of Japan, NIOT attempted to build and deploy a 1 MW demonstration plant. However, mechanical problems prevented success. Research focuses on two types of OTEC technologies to extract thermal energy and convert it to electric power: closed cycle and open cycle. In the closed cycle method, a working fluid, such as ammonia, is pumped through a heat exchanger and vaporized. This vaporized steam runs a turbine. The cold water found at the depths of the ocean condenses the vapor back to a fluid where it returns to the heat exchanger. In the open cycle system, the warm surface water is pressurized in a vacuum chamber and converted to steam to run the turbine. The steam is then condensed using cold ocean water from lower depths.

India is geographically well placed as far as the OTEC potential is concerned. Around 2000km of coast length along the South Indian coast, a temperature difference above 20 Deg C throughout the year is available. That is about 1.5 x 106 sq kms of tropical water in the Exclusive Economic Zone around India with a power density of 0.2 MW/km2. Apart from this, attractive OTEC plant locations are available around Lakshedweep, Andaman & Nicobar Islands. The total OTEC potential around India is estimated as 180,000 MW considering 40% of gross power for parasitic losses. This indicates the promise of OTEC for India and points out the urgent need to develop OTEC technology. After initial tests near Kerala, the unit was scheduled for redeployment and further development in the Lakshadweep Islands in 2005. The demonstration project's experiences have limited follow-on efforts with ocean thermal energy technology in India.

6.6 Geo Thermal Energy

Geothermal energy is thermal energy generated and stored in the Earth. This energy lies embedded n the earth. According to various theories the earth has a molten core. The steam and the hot water come naturally to the surface of the earth in some locations of the earth. Thermal energy is the energy that determines the temperature of matter. India's geothermal energy installed capacity is experimental. Commercial use is insignificant. Two ways of electric power production from geothermal energy has been suggested.

1. Heat energy is transferred to a working fluid which operates the power cycle. This may be particularly useful at places of fresh volcanic activity, where the molten interior mass of earth vents to the surface through fissures and substantially high temperatures, such as between 450 to 5500 Deg.C can be found. By embedding coil of pipes and sending water through them can be raised.

2. Hot geothermal water and or steam is used to operate the turbines directly. Presently only steam coming out of the ground is used to generate electrical energy. The hot water is discarded because it contains as much as 30% dissolved salts and minerals. These cause serious rust damage to the turbine.

According to some ambitious estimates, India has 10,600 MW of potential in the geothermal provinces but it still needs to be exploited. India has potential resources to harvest geothermal energy. The resource map for India has been grouped into six geothermal provinces.

- Himalayan Province – Tertiary Orogenic belt with Tertiary magmatism
- Areas of Faulted blocks – Aravalli belt, Naga-Lushi, West coast regions & Son-Narmada lineament.
- Volcanic arc – Andaman and Nicobar arc.
- Deep sedimentary basin of Tertiary age such as Cambay basin in Gujarat.
- Radioactive Province – Surajkund, Hazaribagh, Jharkhand.
- Cratonic province – Peninsular India

India has about 340 hot springs spread over the country. Of this, 62 are distributed along the northwest Himalaya, in the States of Jammu and Kashmir, Himachal Pradesh and Uttarakhand. They are found concentrated along a 30-50-km wide thermal band mostly along the river valleys. Naga-Lusai and West Coast Provinces manifest a series of thermal springs. Andaman and Nicobar arc is the only place in India where volcanic activity, a continuation of the Indonesian geothermal fields and can be good potential sites for geothermal energy. Cambay graben geothermal belt is 200 km long and 50 km wide with Tertiary sediments. Thermal springs have been reported from the belt although they are not of very high temperature and discharge. During oil and gas drilling in this area, in recent times, high subsurface temperature and thermal fluid have been reported in deep drill wells in depth ranges of 1.7 to 1.9 km. Steam blowout have also been reported in the drill holes in depth range of 1.5 to 3.4 km. The thermal springs in India's peninsular region are more related to the faults, which allow down circulation of meteoric water to considerable depths. The circulating water acquires heat from the normal thermal gradient in the area, and depending upon local condition, emerges out at suitable localities. The area includes Aravalli range, Son-Narmada-Tapti lineament, Godavari and Mahanadi valleys and South Cratonic Belts. In a December 2011 report, India identified six most promising geothermal sites for the development of geothermal energy. These are, in decreasing order of potential:

- Tattapani in Chhattisgarh
- Puga in Jammu & Kashmir
- Cambay Graben in Gujarat
- Manikaran in Himachal Pradesh
- Surajkund in Jharkhand
- Chhumathang in Jammu & Kashmir

India plans to set up its first geothermal power plant, with 2–5 MW capacity at Puga in J&K.

6.7 Hydrogen Energy and Fuel Cells

In recent years hydrogen has been receiving worldwide attention as a clean and efficient energy carrier with a potential to replace liquid fossil fuels. Significant progress has been reported by in the development of hydrogen energy as an energy carrier and an alternative to fossil fuels. Depleting fossil fuel reserves, green house gas emissions and air quality are driving this global transformation effort towards a hydrogen based economy. Hydrogen has high energy content, when burnt; it produces only water as a byproduct. Therefore, it is environmentally benign. At present hydrogen is available as a by-product from several chemical processes, plants or industries.

VI. Target For Renewable Energy Program

Thus the country has significant potential of generation from renewable energy sources. All efforts are being taken by Government of India to harness this potential. The Installed capacity as on 30.06.2015 from renewable energy sources is 36470.64 MW. India ranks fifth in the world in terms of installed capacity of wind turbine power plants. Government of India has set target of for various renewable energy sources to achieve by 2022 as under:

Region	Solar	Wind	SHP	Bio-mass
North	31120	8600	2450	4149
West	28410	22600	125	2875
South	26531	28200	1675	2612
East	12237		135	244
North-East	1205		615	
Andaman & Nikobar	27			
Lakshadeep	4			
Total	99533	6000	5000	10000

In case a target for State-wise break-up of all Renewable Power sources (including above) be achieved by the year 2022, the cumulative achievement would be 1,75,000 MW.

Study Results for 13th Five Year Plan

Tentative Capacity Expansion EGEAS Studies were carried out to assess the total capacity addition requirement during the 13th 5 YEAR Plan to meet the demand within the confines of the reliability criteria. Seasonal Studies were carried out as in the 12th Plan. Hydro, Gas and Nuclear based capacity is given the foremost priority.

The capacity addition considered during the 13th Plan is as follows:

- Total Capacity - 79,200 MW
- Hydro - 12,000 MW
- Nuclear - 18,000 MW
- Thermal - 49,200 MW

VII. Conclusion

As the coal sector stands poised for greater growth, the need for more comprehensive & humane planning, implementation of coal mining projects and a transition towards sustainable development of the sector cannot be overemphasized. While this will require progress on a number of fronts, perhaps the most critical element will be the willingness of the various stakeholders and decision-makers to work together to reduce and manage the conflicts between the environment, the rights of local communities, and the demands of the coal sector. The fossil fuels are non-renewable and they are limited in supply and will one day be depleted. There is no escaping this conclusion. An urgent need for transition in phases from coal/petroleum-based energy systems to the energy mix with dominance of renewable resources due to decrease reliance on depleting reserves of fossil fuels and to mitigate climate change. Renewable energy has the potential to generate energy & create many employment opportunities at all levels including rural areas. However following actions are important to be implemented for renewable energy sources:

1. To Innovate finance for renewable energy technologies
2. Mainstreaming of renewable is very essential.
3. Energy security, economic growth & environment protection are to be national energy policy drivers.
4. To boost the efforts for further development and promotion of renewable energy sources.
5. To promote renewable energy technologies as a way to address concerns about energy security and economic growth.
6. To include specific actions for promoting deployment, innovation and basic research in renewable energy Technologies.

No single solution can meet our society's future energy needs. The solution instead will come from a family of diverse energy technologies that share a common thread — they do not deplete our natural resources or destroy our environment. India's quest for energy security and sustainable development rests a great deal on the ability to tap energy from best combination of alternate sources including the renewable sources.

Abbreviation

MIDR- Mining-Induced Displacement and Resettlement, IEA-International Energy Agency, OECD-Organization for Economic Co-operation and Development, GCV- Gross Calorific Value, TcF-trillion cubic feet, PLF- Plant Load Factor, GW-Gega Watt (1000MW), NHPC- National Hydroelectric Power Corporation, NEEPCO- Northeast Electric Power Company, SJVNL-Satluj Jal Vidyut Nigam, OTEC-Ocean Thermal Energy Conversion, SNG-Synthetic Natural Gas, CAGR-Compound Annual Growth rate

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