

Understanding energy sector in india environmental sciences essay



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Chapter 1: Introduction
Energy security is an area of prime concern for India and considering the fact that the availability of conventional sources of energy are limited, promotion of renewable energy generation sources is a key focus area. Renewable Energy (RE) Sources primarily constitute wind, solar, small hydro (upto 25 Mega Watt (MW)), biomass, bio fuel and cogeneration. India has a federal structure of governance and " Electricity" is a concurrent subject where both the Central and the State Governments have jurisdiction. Legal mandate is provided in the preamble to the Electricity Act 2003 (the principal legislation governing the electricity sector in India) which mentions " promotion of efficient and environmentally benign policies" as one of the objectives. The Central Government has issued various Policy directives for promotion of renewable energy generation sources. The National Electricity Policy, 2005 provides direction to the policy initiatives to be taken for promotion of RE Sources. Tariff Policy, 2006 elaborates the role of Electricity Regulatory Commissions, mechanisms for promoting renewable energy generation sources and the time frame for implementation. The Rural Electrification Policy, 2006 for the first time provided policy framework for decentralized distributed generation of electricity based on either conventional or non-conventional resources or

methods of generation, thereby providing the relevant regulatory direction for off-grid/stand-alone small-scale renewable generation. Integrated Energy Policy 2006 discusses various policy initiatives for promotion of renewable sources of energy generation. It emphasizes the need to move from capital incentives to performance based incentives for promoting renewable sources. India has put in place a National Action Plan on Climate Change (NAPCC) to promote renewable energy generation sources and sustainable development. NAPCC has set a target of 5% renewable energy purchase for FY 2009-10, which is proposed to be increased by 1% for next 10 years. (Prime Minister's Council on Climate Change, 2008) According to the World Bank Report, at the financial cost of coal-based generation, renewable capacity in India is not financially viable. About 5GW of capacity is viable at the cost of gas-based generation; the entire capacity of wind, biomass, and small hydropower is viable at the cost of diesel-based generation. Solar energy is not financially viable at any of these opportunity costs and will require subsidies in the short to medium term particularly if renewable purchase obligations are enhanced rapidly in line with the targets of the NAPCC. The world bank Report also states that India could produce about 62GW—90 percent of technically feasible renewable capacity in wind, biomass, and small hydropower—in an economically feasible manner, if the local and global environmental premiums of coal-based generation are brought into consideration. About 3GW of renewable energy is economically feasible at the avoided cost of coal-based generation of Rs 3.08/kWh, all of it from small hydropower. About 59GW of renewable energy in wind, biomass, and small hydropower is available at an avoided cost of less than Rs 5/kWh. The full capacity of 68GW in these three technologies can be harnessed at a <https://assignbuster.com/understanding-energy-sector-in-india-environmental-sciences-essay/>

price of less than Rs 6/kWh.(World Bank Report, 2010)Small hydropower is the most economically viable form of renewable technology, with an average economic cost of Rs 3. 56/kWh and in India in hydro resource rich States, the cost of small hydro generation is less than the average economic cost of Small Hydro Power (SHP). The Report also states that the economic cost of biomass-generated power ranges between Rs 3. 9 and Rs 5. 7/kWh and the generation cost of wind projects is highly sensitive to the capacity utilization factor, which is quite low at about 23 percent. The economic cost of wind power ranges between Rs 3. 8 and Rs 5. 2/kWh. A substantial proportion of wind capacity (about 37GW) is available in the four states of Andhra Pradesh, Gujarat, Karnataka, and Tamil Nadu.

Figure 1: Economic competitiveness of wind, biomass, and small hydropower

Source: World Bank Report, Unleashing the Potential of Renewable Energy in India, 2010The Solar PV technology has seen drastic reduction in the module prices in the last two years. It appears that early grid parity can be achieved. According to the KPMG Report, " The Rising Sun", released in May 2011, it was anticipated that utility-scale Solar PV grid parity can be achieved in the timeframe of 2017-2019 for India. Subsequently, in its Report released in September 2011, states that the grid parity is likely to occur at the earlier end of that range i. e. 2017-2019 (KPMG, 2012). The point at which grid parity occurs is a function of two variables - the rate of increase in conventional power prices and the rate of decrease in solar power prices. Report considered that the landed cost of conventional electricity to consumers to increase at the rate of 4 percent per annum in the base case

and 5.5 percent per annum in an aggressive case. And solar power prices to decline at the rate of 5-7 percent per annum.

Fig. 2: Grid Parity for Solar Power – Utility Level

Source: KPMG's Solar Grid Parity Model Central Electricity Regulatory

Commission (CERC) at the Central level and the State Electricity Regulatory Commissions (SERCs) at the State level are the concerned Regulators in their respective jurisdiction. Distribution of Electricity is a State subject and SERCs specify a mandatory requirement in the form of Renewable Purchase Obligation (RPO), a percentage of the total consumption of electricity to be procured from Renewable Energy Sources. This is aimed at creating demand for renewable energy. The Regulators also determine preferential tariff for various renewable energy technologies thereby giving certainty of revenue recovery for investors in this segment of the power market. Another recent regulatory intervention towards promotion of green energy has been in terms of introduction of a market based instrument viz., the Renewable Energy Certificate (REC). Given the increasing importance of renewable energy, especially in the context of energy security and climate change needs, tracing various policy instruments deployed for promotion of renewable energy sources is highly topical. It is all the more contextual to probe into the latest policy and regulatory initiative of REC, to understand how it gels with and to what extent does it need refinement to align with the larger objective of green energy development.

Chapter 2: Understanding Energy Sector in India

2. 1India's Energy Scenario

Energy is a critical foundation for economic growth and social progress. We have been using conventional sources of energy. In the last six decades, India's energy use has increased 16 times and the installed electricity capacity by 84 times. India as a country suffers from significant energy poverty and pervasive electricity deficits. The Table below gives a comparison of India with other regions of the world with regard to Total Primary Energy Supply which has been normalized with respect to GDP and population for the year 2008. The electricity consumption per capita for India 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.

Table 1: World Energy Statistics

Source: International Energy Association In recent years, India's energy consumption has been increasing at a relatively fast rate due to population growth and economic development. 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. The per capita consumption of electricity in the country has increased from 15.6 units in 1950 to about 766 units during the year 2009-10. The National Electricity Policy of the Government of India stipulates envisages it to increase to over 1000 units per annum in 2012. (MNRE, 2012) India faces a formidable challenge in providing adequate energy supplies to users at a

reasonable cost. Thus the energy challenge is of fundamental importance.

(P. Garg, 2012)

2. 2India's Future energy needs

Various estimates indicate that India would need to increase its primary energy supply by at least 3 to 4 times and its electricity generation capacity by 5 to 6 times of the 2003/04 levels, by the year 2031. The Integrated Energy Policy report (Integrated Energy Policy Report-2006) brought out by the Planning Commission estimates that under an 8% GDP growth scenario, India's total energy requirements would be in the range of 1536 Million Tonnes of Oil Equivalent (mtoe) to 1887 mtoe by 2031 under alternative scenarios (Leena Srivastav, 2007) of fuel and technological diffusion. TERI's analysis based on the MARKAL model, indicates that under 8% GDP growth scenario with current plans and policies of the Government, commercial energy needs would increase to 2108 mtoe by 2031/32.

Figure 1: Commercial Energy Requirement of India

Source: India's Energy Security Report Given the current statistics of energy access and shortages and the likely needs for energy in the future, India faces a formidable challenge in meeting its energy needs and providing adequate and affordable energy to all sections of society in a sustainable manner. Although India has considerable coal reserves, with the current coal production technology, it is estimated that India's domestic coal production could increase to a maximum level of around 600 MTPA. Oil production has stagnated at around 33 MT in the past few years and is not expected to increase significantly. Further, while natural gas has emerged as a relatively clean option in the past decade, there is uncertainty regarding the level of its

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indigenous availability. Various possible commercial energy scenario of India in the year 2031-32 forecast that about 90% of the oil, anything up to 50% of the natural gas and between 11 - 45% of coal would have to be imported to meet India's energy needs for economic growth rate of 8% per annum.

Table 2: Energy Requirement of India by 2031-31

Source: Integrated Policy Report, Planning Commission of India As estimated by TERI, under a business-as-usual (BAU) scenario, the country is expected to increasingly become reliant on imports of all forms of commercial energy, with total energy import dependency increasing to around 80% by 2031 (Leena Srivastav, 2007).

Figure 2: India's likely Energy Dependency (BAU scenario)

Source: India's Energy Security Report Although the country has been dependent on oil imports for several decades, imports of coal and gas have started during the last decade. By 2031, TERI estimates indicate a dependency of 78% for coal (over a billion tonnes), 93% for oil (~700 million tonnes) and 67% for gas (~93 BCM) with current estimates of future availability of indigenous energy. This is clearly an unsustainable trend with implications not only in India's likely Energy Dependency (BAU scenario) terms of the large monetary outflows that the country would have to bear but also in terms of the infrastructural requirements for port development, handling and transportation of this energy not to mention access to these resources in, and inputs on, global markets.

2.3 Overview of power sector

Power Sector is at a crucial juncture of its evolution from a controlled environment to a competitive, market driven regime which endeavors to provide affordable, reliable and quality power at reasonable prices to all sectors of the economy. The Gross Domestic Product (GDP) of our country has been growing at the rate of about 8% for the last several years. The liberalization and globalization of the economy has led to increased momentum in industrial and commercial activities and this, coupled with penetration of technology and I. T. in the day-to-day life of the common man, is expected to result in a high growth in power demand. It is accordingly essential that development of the Power Sector be commensurate with the overall economic growth of the nation. The Indian power sector is one of the most diversified in the world. Sources for power generation range from commercial sources like coal, lignite, natural gas, oil, hydro and nuclear power to other viable non-conventional sources like wind, solar and agriculture and domestic waste. The demand for electricity in the country has been growing at a rapid rate and is expected to grow further in the years to come. In order to meet the increasing requirement of electricity, massive addition to the installed generating capacity in the country is required. While planning the capacity addition programme, the overall objective of sustainable development has been kept in mind. Since its structured growth post-Independence, Indian power sector has made substantial progress both in terms of enhancing power generation and in making available power to widely distributed geographical boundaries. The Installed generation capacity in the Utility sector has increased to about 2, 07, 006. 04 MW at the end of August 2012. The Indian power sector is largely coal based with the <https://assignbuster.com/understanding-energy-sector-in-india-environmental-sciences-essay/>

total Installed Capacity comprising of 1, 17, 833. 38 MW (56 %) coal based, 18, 903. 5 MW (9%) gas based, 1200 MW (1%) diesel generation, 39, 291MW (19%) hydro, 4, 780 MW (2 %) nuclear and 24, 998. 46 MW (12%) from renewable energy sources.

Table 3: All India Generation Installed Capacity

Source: Central Electricity Authority

Figure 3: All India Generation Installed Capacity

Source: Central Electricity Authority

Figure 4: Overall Generation Mix

Source: Central Electricity Authority

In spite of the massive addition in generation, transmission and distribution capacity over the last over sixty years, growth in demand for power has always exceeded the generation capacity augmentation. Our country is persistently facing the energy and peak shortages. Although we have achieved capacity addition of about 2, 07, 006 MW over the last six decades and total electricity generated during the year 2011-12 was 876. 98 BUs, peak and energy shortages of varying magnitude are being experienced. During the year 2011-12, the country faced an energy shortage of 79, 329 MU(8. 5%) and a peak shortage of 14, 403 MW(11. 1%). (CEA, 2012) During 12th & 13th Plans, energy requirement and peak load requirement projected by the working Group on Power, Ministry of Power are as under:

Table 4: Demand Adopted for Generation Planning Studies

Source: Ministry of Power

The above projections by 12th Plan end are very close to the projections of the draft 18th EPS Report of CEA with peak demand of 1, 99, 540 MW and energy requirement 1354 BU. This shows that energy is a critical foundation for economic growth and social progress. We have been using conventional sources of energy which ultimately cater to the needs and requirements. The use of such resources not only limits the stock available for future generation but also cause serious environmental threats to the world. We might face serious energy shortages in the future as these resources cannot be renewed. This calls for some modification in the energy mix inviting the use of renewable resources to fulfill energy needs. Countries across the world are exploring this segment and trying to achieve maximum possible usage of these resources in the energy mix thereby contributing less to the green-house gas emissions. Developing renewable energy can help India increase its energy security, reduce the adverse impacts on the local environment, lower its carbon intensity, contribute to more balanced regional development, and realize its aspirations for leadership in high-technology industries. Vigorous efforts during the past two decades are now bearing fruit as people in all walks of life are more aware of the benefits of renewable energy, especially decentralized energy where required in villages and in urban or semi-urban centers.

Chapter 3: Overview of Renewable Energy (RE) Generation Resources in India

3.1 Renewable Energy Technologies and Sources

Renewable Energy Technology (RET) can be broadly classified into following broad categories: Grid connected RET, Off-grid RET, Decentralized RET Systems, New Technologies

1. Grid Connected Power

Grid-interactive renewable power projects are based on wind power, biomass, small hydro and solar. Almost all-renewable power capacity addition in India during the year has come through this route.

Wind Power

The use of wind as a renewable energy involves the conversion of power contained in masses of moving air into rotating shaft power. The conversion process utilises aerodynamic forces (lift and/or drag) to produce a net positive turning moment on a shaft, resulting in the production of mechanical power which can be converted to electrical power. The amount of wind power (P) harnesstable at a particular site can be expressed as,

$$P = \frac{1}{2} \rho A V^3$$

Where, P

=

The density of air, kg/m³. V

=

The wind speed in m/s. A

=

Swept area of the blades through which the wind blows, in m². h

=

Efficiency of conversion (< 40%)The wind speed therefore plays a vital role for energy generation as there is a non-linear (cubic) relationship between wind speed and available power. The energy content in wind at different region varies with latitude, land - sea disposition, altitude and season. In India the factor which mostly governs the availability of wind energy at a particular site is its geographical location with respect to the monsoon wind. The availability of data on wind speed being a basic requirement for determining the feasibility of wind power generation at any site and due to the highly uneven distribution of wind speed over the country, an assessment of the wind resource over different regions was undertaken before any plans of harnessing the wind energy were drawn for implementation. (IREDA, 2012)

Bio-power

Bio power and/or heat produce from agricultural, agro-industrial residues and plantations and urban & industrial wastes. Bio power generation technologies can be classified as under:

Biomass power and Bagasse cogeneration

Biomass being a product of natural resources viz. land, water, air and sun's energy, is a reliable renewable source of energy. Biomass is an organic matter produced by plants, both terrestrial and aquatic and their derivatives. Plant materials use the sun's energy to convert atmospheric carbon-di-oxide

to sugars during photosynthesis. On combustion of the Biomass, energy is released as the sugars are converted back to carbon-di-oxide. Thus energy is harnessed and released in a short time frame, making Biomass a renewable energy source.

Biomass gasifier

Biomass is a natural substance available, which stores solar energy by the process of photosynthesis in the presence of sunlight. It contains cellulose, hemicellulose and lignin, with an average composition of $C_6H_{10}O_5$, with slight variations depending on the nature of the biomass. Theoretically, the ratio of air-to-fuel required for the complete combustion of the biomass, defined as stoichiometric combustion is 6: 1 to 6. 5: 1, with the end products being CO_2 and H_2O . In gasification the combustion is carried at substoichiometric conditions with air-to-fuel ratio being 1. 5: 1 to 1. 8: 1. The gas so obtained is called producer gas, which is combustible. This process is made possible in a device called gasifier, in a limited supply of air. Such gas can be utilised for generation of electricity with the help of gas engine.

Biogas

Biogas technology is a manure and biomass management tool that promotes the recovery and use of biogas as energy. The biogas can be used as a fuel source to generate electricity for on-farm use or for sale to the electrical grid, or for heating or cooling needs. The biologically stabilized byproducts of anaerobic digestion can be used in a number of ways, depending on local needs and resources. As per Environment Protection Agency (EPA), USA, successful byproduct applications include use as a crop fertilizer, bedding, and as aquaculture supplements.

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Urban & Industrial wastes

Various technologies are available to harness energy or power by treatment of urban & industrial wastes. Some of the basic technologies for treatment of solid wastes are as follows

<http://www.ireda.gov.in/images/bulletblue.gif>Incineration

<http://www.ireda.gov.in/images/bulletblue.gif>Pelletisation

<http://www.ireda.gov.in/images/bulletblue.gif>Pyrolysis / gasification

<http://www.ireda.gov.in/images/bulletblue.gif>Sanitary Landfill

<http://www.ireda.gov.in/images/bulletblue.gif>Biomethanation

Incineration is a process of controlled combustion for burning of wastes and residues containing combustible material. It is generally used for solid wastes. The heat generated during incineration is recovered and utilised for the production of steam, heating water and generating electricity. Pelletisation is a process of production of fuel pellets from solid wastes. Fuel pellets are also referred as Refuse Derived Fuel (RDF). On an average 30 tonnes of fuel pellets per day can be produced by using 100 tons of solid wastes. Fuel pellets do have a calorific value of about 3500 to 4000 kcal/kg and can be used as a fuel for heating plants, boilers etc for generation of steam, which in turn can be used for generation of power. In pyrolysis/gasification process segregated combustible matter is allowed for drying/dewatering and thereafter it is shredded in a hammer mill. The end product includes combustible gas called producer gas which can be utilised for production of power. In Biomethanation technology, organic matter of solid wastes is segregated and after segregation it is fed into bio-reactor, wherein presence of methanogenic Bacteria, and under anaerobic condition, fermentation takes place and biogas is produced which can be used in biogas engines to generate electricity.

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Small Hydro Power

Small hydro power (upto 25 MW station capacity) is constructed in combination with water utilisation or irrigation purposes. In an SHP, the function of the hydro turbine is to convert hydraulic potential energy of water into the mechanical kinetic energy of the turbine runner, which in turn is converted into electrical energy by the generator. Small hydro projects can be broadly classified in the following two types

Small Hydro Projects on Hill Stream

Small streams with steep bed slopes are available in the hills, giving rise to medium as well as high head projects utilising small discharges. These schemes are normally run of the river type with a small diversion structure to divert the flows through the head regulator located in the intake portion of the diversion structure. The water conductor system would usually comprise of a diversion and head regulator, a power channel, a desilting basin, forebay, penstock, power house and a tail race leading from the power house to the stream.

Small Hydro Projects on Canal Falls / Dam Toe

Irrigation canals carrying relatively high but assured discharges have several falls along their route. Small hydel projects utilising low heads can be constructed at such falls. Small hydel projects can also be located just downstream of a dam, barrage or similar structure to utilise the difference in the water level in the reservoir and in the canal downstream. A bypass channel to bypass the flows adjacent to the fall structure is constructed and

the power house is constructed in the bypass channel. The bypass channel is suitably connected to the main channel.

Type of Turbine for Small Hydro Projects

Type of Turbine	Class of Head	Head range for large/ medium sets (m)	Head range for small sets (m)
Pelton (Impulse)	High Head	Above 300 m	Above 150 m
Francis (Reaction)	Medium Head	30 to 500 m	20 to 200 m
Kaplan (Axial Flow)	Low Head	3 to 40 m	3 to 25 m

Solar Power

Solar Thermal

Solar thermal electric energy generation concentrates the light from the sun to create heat, and that heat is used to run a heat engine, which turns a generator to make electricity. The working fluid that is heated by the concentrated sunlight can be a liquid or a gas. Different working fluids include water, oil, salts, air, nitrogen, helium, etc. Different engine types include steam engines, gas turbines, Stirling engines, etc. Following technologies are available for generation of power: Parabolic trough designs, Power tower designs, Dish designs, Linear Fresnel reflector technologies.

Solar Photovoltaic Power

Solar photovoltaic (PV) technology uses sunlight to produce electricity. Individual solar cells, each made from semiconductor materials, connect together to form PV modules and produce electricity. These solar modules, in turn, combine and connect to form PV arrays.

2. Off-Grid Power

Distributed/decentralized renewable power projects using wind energy, biomass energy, hydro power and hybrid systems are being established in the country to meet the energy requirements of isolated communities and areas which are not likely to be electrified in near future.

Off-grid Renewable Energy / Power:

Biomass based heat and power projects and industrial waste to-energy projects for meeting captive needs
Biomass gasifiers for rural and industrial energy applications
Watermills/micro hydro projects - for meeting electricity requirement of remote villages
Small Wind Energy & Hybrid Systems - for mechanical and electrical applications, mainly where grid electricity is not available. Solar PV Roof-top Systems for abatement of diesel for power generation in urban areas
The main objectives of the programme are: supporting RD&D to make such systems more reliable and cost-effective, demonstration, field testing, strengthening manufacturing base.

3. Decentralized Systems

Renewable energy technologies are ideally suited to distributed applications, and they have substantial potential to provide a reliable and secure energy supply as an alternative to grid extension or as a supplement to grid-provided power. Over 400 million people in India, including 47.5% of those living in India's rural areas, still had no access to electricity. Because of the remoteness of much of India's un-electrified population, renewable energy can offer an economically viable means of providing connections to these groups. Some of the renewable energy technologies that are used in villages

and rural areas as decentralized systems are: Family-size biogas plants. Solar street lighting systems. Solar lanterns and solar home lighting systems. Solar water heating systemsSolar cookers. Standalone solar/ biomass based power generators. Akshay Urja / Aditya Solar ShopsWind pumps. Micro-Hydel plants. Many of these systems have been found useful in urban and semi urban areas also to conserve the use of electricity and other fossil fuels. Solar water heating systems have helped in demand side management of electricity in various cities and towns during peak hours. Standalone roof top SPV systems are getting popular for day time diesel abatement in areas where power cuts are very high.