# A Review on Development of Renewable Energy Sources for Effective Power Generation in India

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**Abstract:** ***Energy is the primary and most universal measure of all kinds of work by human beings and nature. The energy consumption is directly proportional to the progress of mankind. With ever increasing population, industrialization of the developing countries, recent trends and developments in various technologies/rapid technological improvements, the global demand for energy is expected to increase rather significantly in the near future. The primary source of energy is fossil fuel, however due to the limited supply of fossil fuels and large scale environmental degradation caused by their widespread use, particularly global warming, environmental pollution and acid rain, strongly suggests that harnessing of non-conventional, renewable and environmental eco-friendly energy sources is vital for steering the global energy supplies towards a sustainable path. This paper describes in brief the non-conventional energy sources and their importance for developing countries.***

**Keywords:** Renewable energy sources, Energy consumption, Environmental impact, Energy demand.

## 1. Introduction

Conventional energy sources based on oil, coal, and natural gas have proven to be highly effective drivers of economic progress, but at the same time damaging to the environment and to human health. The traditional fossil fuel-based energy sources are facing increasing pressure on a host of environmental fronts, with perhaps the most serious challenge confronting the future use of coal. The potential of renewable energy sources [1-2] is enormous as they can in principle meet many times the world's energy demand. Renewable energy sources such as biomass, wind, solar, hydropower, and geothermal can provide sustainable energy services, based on the use of routinely available, indigenous resources.

In fact, fossil fuel and renewable energy prices, social and environmental costs are heading in opposite directions. Considering the availability and the location of the material produced these conventional resources are regarded as an important energy supply for the rural areas in the near future. Furthermore, the economic and policy mechanisms needed to support the widespread dissemination and sustainable markets for renewable energy systems have also rapidly evolved. It is becoming clear that future growth in the energy sector is primarily in the new regime of renewable [4], and to some extent natural gas-based systems, and not in conventional oil and coal sources. Financial markets are awakening to the future growth potential of renewable and other new energy technologies, and this is a likely harbinger of the economic reality of truly competitive renewable energy systems.

## 2. Fundamental Principles for Energy Generation

All the energy we consume is generated by using some fundamental interactions of nature: by gravity forces, electromagnetism and nuclear reactions (fusion and fission). Most forms of terrestrial energy can be traced back to fusion reaction inside the sun. Geothermal energy is believed to be generated primarily by radioactive decay inside the earth. Radioactive decay energy is generated by both the nuclear and electromagnetic forces. Tidal energy comes from gravity and kinetic energy of the Earth/Moon system.

## 3. Non-Conventional and Renewable Energy Sources

### 3.1. Solar Energy

Solar energy is a time dependent and intermittent energy resource. The sun is the most powerful source of energy and this energy is free, as long as we exploit it. Technologies under this energy are categorized as either active or passive. Active technologies convert solar energy into a form, we can use directly either electrical or thermal. Such are photovoltaic cells that convert sunlight directly into electrical energy. Passive technologies seek to place buildings in a favorable orientation towards the sun or use special materials and architectural designs to exploit solar energy [7-8]. Because of its location between the Tropic of Cancer and the Equator, India has an average annual temperature that ranges from 25°C – 27.5 °C. This means that India has huge solar potential.

Solar energy has several applications: photovoltaic (PV) cells are placed on the roof top of houses or commercial buildings, and collectors such as mirrors or parabolic dishes that can

move and track the sun throughout the day are also used. This mechanism is being used for concentrated lighting in buildings.

**Figure 1:** India's 1st 1 MW Canal-top solar power project in Gujarat

Photovoltaic (PV) cells have a low efficiency factor, yet power generation systems using photovoltaic materials have the advantage of having no moving parts. PV cells find applications in individual home rooftop systems, community street lights, community water pumping, and areas where the terrain makes it difficult to access the power grid. The efficiency of solar photovoltaic cells with single crystal silicon is about 13 % - 17%. High efficiency cells with concentrators are being manufactured which can operate with low sunlight intensities. PV systems require little maintenance, making them an attractive renewable energy option.

### 3.2. Wind Energy

Wind possesses energy by virtue of its motion. Wind energy is converted to electricity when wind passes by blades mounted on a rotating shaft. As the wind moves the blades, the rotation of the shaft turns a generator which converts the rotational movement into electricity. Three main factors affect wind machine power [3]: the length and design of the blades, the density of the air and wind velocity. Longer blades produce more power output. Cold air is denser than warm air, which means it produces more force, or ability to turn the blades. Also, in general, as elevations increase wind turbines will encounter greater wind velocities.

Using wind energy to create electricity can have both positive and negative impacts on the environment. One of the major benefits of this technology is that it does not create air pollution. Unlike power plants that burn coal or natural gas, wind turbines do not emit sulfur dioxide ($SO_2$), nitrogen oxides (NOx), carbon dioxide ($CO_2$), particulates or heavy metals into the atmosphere.

**Figure 2:** 130 MV Wind power project in Maharastra

**Figure 3:** 39.6 MW Wind power project in Karnataka

These emissions from fossil fuel-burning power plants contribute to acid rain which damages lakes, streams, forests and ozone which affects human health and climate change. Because the process of generating electricity from wind does not use water, potential negative impacts sometimes associated with producing electricity such as thermal pollution of water bodies and impacts to surface waters and groundwater are avoided. Wind energy does not create waste byproducts, avoiding issues connected with the transportation, treatment and storage of these wastes. Additionally, because wind power requires no fuel, the cost of wind-generated electricity is not affected by volatility in fuel prices.

Additional issues that are associated with the operation of wind turbines pertain to interference with radar and television signals, noise, shadow flicker and aesthetics. Some of these impacts may be partially mitigated with proper siting and setbacks of turbines from residences, radar facilities and other land uses.

### 3.3. Biomass/Biogas Energy:

Biomass has always been an important energy source for the country considering the benefits it offers. Biomass energy is the release of energy stored in wood, herbaceous plants, or other biological materials. Biomass can be burned (like coal) to produce steam. Common biomass fuels include waste wood and dedicated crops. Waste wood may come from construction projects, demolition projects, or as a waste from wood product manufacturing and is the most available source of biomass.

The most successful forms of biomass are sugar cane bagasse in agriculture, pulp and paper residues in forestry and manure in livestock residues. It is argued that biomass can directly substitute fossil fuels, as more effective in decreasing atmospheric $CO_2$ than carbon sequestration in trees. Biomass may be used in a number of ways to produce energy [5]. The most common methods are Combustion, Gasification, Fermentation, and Anaerobic digestion. India is very rich in biomass. It has a potential of 19,500 MW (3,500 MW from bagasse-based cogeneration and 16,000 MW from surplus biomass). Currently, India has 537 MW commissioned and 536 MW under construction.

**Figure 4:** 10 MW Biomass Power Project, Gadchiroli Dist. (Maharastra)

Biogas is a clean and efficient fuel, generated from cow-dung, human waste or any kind of biological materials derived through anaerobic fermentation process. The biogas consists of 60% methane with rest mainly carbon-di-oxide. Biogas is a safe fuel for cooking and lighting. By product is usable as high-grade manure. India has world's largest cattle population-400 million thus offering tremendous potential for biogas plants.

**Figure 5:** 18 MW Biomass power project in Tamilnadu

The payback period of the biogas plants is only 2/3 years, rather in the case of community and Institutional Biogas plants is even less. Therefore biogas electrification at community/panchayat level in all rural areas is required to be implemented. The development goal for renewable energies in India is listed in below Table 1.

**Table 1:** Development Goals for Renewable Energies in India

| *Energy source* | Goals 11th five-year Plan (2007-2012) | Goals 12th five-year Plan (2012-2017) | Goals 13th five-year Plan (2017-2022) |
|---|---|---|---|
| *Wind power* | 10,500 | 11,000 | 11,000 |
| *Biomass* | 2,100 | 2,100 | 2,000 |
| *Small-scale water plants* | 1,400 | 1,600 | 1,500 |
| *Solar energy* | 1,000 | 3,800 | 16,000 |
| *Sum* | 15,000 | 18,500 | 30,500 |

### 3.4. Hydro Power

The hydroelectric power refers to the energy produced from water (rainfall flowing into rivers, etc). Consequently, rainfall can be a good indicator to investors looking for a location to implement or build a new hydroelectric power plant in India.

India utilizes twelve primary hydroelectric power plants: Bihar (3), Punjab, Uttaranchal, Karnataka, Uttar Pradesh, Sikkim, Jammu & Kashmir, Gujarat, and Andhra Pradesh. Hydropower is the largest renewable resource used for electricity. It plays an essential role in many regions of the world with more than 150 countries generating hydroelectric power. Small, mini and micro hydro plants (usually defined as plants less than 10 MW, 2 MW and 100kW, respectively) also play a key role in many countries for rural electrification. Hydropower continues to be the most efficient way to generate electricity. Modern

hydro turbines can convert as much as 90 percent of the available energy into electricity. The best fossil fuel plants are only about 50 percent efficient.

**Figure 6:** 200 MW Hydal power project in Gundia (Karnataka)

Although hydroelectricity considered a clean energy source, it is not totally devoid of greenhouse gas emissions (GHG) and it can often have significant adverse socio-economic impacts. There are arguments now that large-scale dams actually do not reduce overall GHG emissions when compared to fossil fuel power plant. To build dam significant amounts of land need to be flooded often in densely inhabited rural area, involving large displacements of usually poor, indigenous peoples. Mitigating such social impacts represents a significant cost to the project, which if it is even taken into consideration, often not done in the past, can make the project economically and socially unviable. If the large hydro industry is to survive it needs to come to grips with its poor record of both cost estimation and project Implementation.

## 4. Advantages and disadvantages of renewable energy sources

**4.1**. The advantages of electric production from renewable resources include:

- The potential for low or no fuel cost (except for some biomass)
- The possibility of shorter lead-times for planning and construction as compared to
- Conventional power plants
- The potential to utilize relatively small, modular plant sizes
- Significantly reduced environmental effects compared to fossil fuels
- For many renewable resources, a non-depletable resource base
- Public support for use of renewable resources
- The potential for use in distributed generation applications

**4.2.** The disadvantages of electric production from renewable resources include:

- Public concern for land use, biodiversity, birds and aesthetics in siting a facility
- Relatively high capital cost to construct a renewable facility
- Uneven geographic distribution of renewable resources
- Intermittent availability of some renewable resources for electric production
- Lack of maturity or commercial availability of some technologies
- For some biomass resources, the need to consider environmental implications of the fuel supply

## 5. Conclusion

India is a nation in transition. Considered an "emerging economy," increasing GDP is driving the demand for additional electrical energy, as well as transportation fuels. Unique in the world, India has the only Ministry that is dedicated to the development of renewable energies: Ministry of Non-Conventional Energy Sources (MNES). This bodes well for the acceleration of renewable development throughout the nation -both to meet the underserved needs of millions of rural residents and the growing demand of an energy hungry economy.

The development and deployment of renewable energy, products, and services in India is driven by the need to;

- Decrease dependence on energy imports
- Sustain accelerated deployment of renewable energy system and devices
- Expand cost-effective energy supply
- Augment energy supply to remote and deficient areas to provide normative
- Consumption levels to all section of the population across the country
- And finally, switch fuels through new and renewable energy system/ device deployment.

This paper provides an overview of various renewable sources available and hopes that it will encourage even more rapid and extensive development of the renewable energy resources on the Indian subcontinent.

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