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Renewable Energy in India: Potential and Challenges

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ABSTRACT

As India prepares to emerge as a five trillion-dollar economy its energy requirement is progressively increasing. Due to the restricted availability of resources and a significant amount of emission of pollutants from non-renewable energy, renewable energy has to be exploited to a greater extent.

So as to meet the growing energy demand Renewable energy sources such as solar, wind, hydropower, biomass, fuel cell technology and RF energy harvesting have to play a vital role. The present paper summarises the availability, potential, current status, major achievements and related government policies of renewable energy options in India.

Keywords: Renewable energy, Wind energy, Solar energy, Hydropower, RF energy harvesting

1. Introduction

The longstanding energy problems being faced by the developing countries like India can only be addressed by Renewable energy sources and technologies. Due to the fossil fuel energy becoming scarcer, India will face energy scarcities pointedly due to increase in energy prices and energy uncertainty in the coming decades. The use of fossil fuels has also caused major environmental problems both locally and worldwide. India has to obtain energy security without affecting the flourishing economy, and must switch from the non-renewable energy to renewable energy. Fast exhaustion of the fossil fuels and great surge in power demand and stern penalties of environmental deterioration has forced engineers around the world to consider the utilisation of renewable energy sources (RES) [1,2]. Although the installation cost of the RES is quite high, their minimum operational costs and non-polluting nature has intensified their use globally [3].

Nomenclature

A radius of
B position of
C further nomenclature continues down the page inside the text box

2. Wind Energy

In recent years Wind power generation capacity of India has substancially increased. In July 2022, the total installed wind power capacity has reached 40.788 GW, which makes India the fourth largest installed wind power capacity in the world [4]. There has been a rapid decline in wind power costs in India. The support from government in the form of tariff reached a record low of ₹2.43 per kWh (without any direct or indirect subsidies) in December 2017. However, it increased to ₹2.77 per kWh in March 2021 [5].

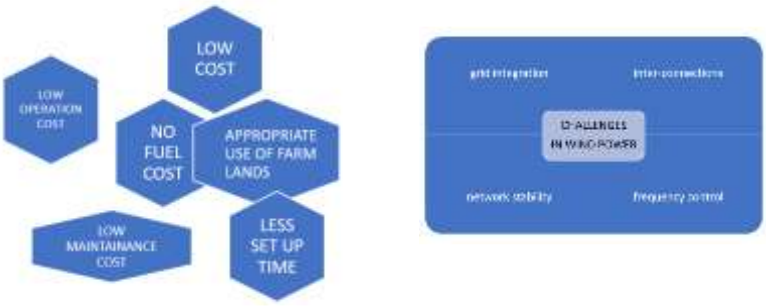

Figure 1: (a) Advantages (b) Challenges of Wind energy in India

To date, 40.1 gigawatts of wind power has been installed. In India, the main producers of wind energy are Adani Green Energy, Alfanar, SembCorp Green Infra and Renew Power

3. Solar energy

There has been a visible impact of solar energy in the Indian energy scenario during the last few years. Solar energy based decentralized and distributed applications have benefited millions of people in Indian villages by meeting their cooking, lighting and other energy needs in an environment friendly manner. National Institute of Solar Energy has assessed the Country's solar potential of about 748 GW assuming 3% of the waste land area to be covered by Solar PV modules. Solar energy has taken a central place in India's National Action Plan on Climate Change with National Solar Mission as one of the key Missions. National Solar Mission (NSM) was launched on 11^{th} January, 2010. NSM is a major initiative of the Government of India with active participation from States to promote ecological sustainable growth while addressing India's energy security challenges. It will also constitute a major contribution by India to the global effort to meet the challenges of climate change.

3.1 Potential

India's solar energy sector provides a massive opportunity for growth. The country is endowed with vast solar energy potential with most parts of the country receiving 4-7 kWh per sq. m per day. India achieved 5th global position in solar power deployment with installed capacity of 54GW, grown by 20 times from 2.6 GW in 2014 [6]. This includes ground mounted, roof top and off-grid/ distributed solar power. India's ultra-mega solar park model has been successful in upscaling solar capacity deployments. The states Rajasthan, Karnataka, Gujarat and Tamil Nadu together accounted for 60% of the total installed capacity.

3.2 Challenges

The utility-scale solar PV sector continues to face challenges like land costs, high T&D losses and other inefficiencies, and grid integration challenges. There have also been conflicts with local communities and biodiversity protection norms. One of the biggest challenges is Land Scarcity

4. Hydro Power Energy

In India, hydro power plants of 25MW or below capacity are classified as small hydro, which have further been classified into micro (100kW or below), mini (101kW-2MW) and small hydro (2-25MW) segments. Hydro Power was being looked after by Ministry of Power prior to 1989 mainly with the help of State Electricity Boards. In 1989, plant capacity up to 3MW and below was transferred to the Ministry of New and Renewable Energy (MNRE) and as such 63 MW aggregate installed capacity of 3MW and below hydro projects came within the jurisdiction of MNRE. Many initiatives were taken by the Ministry since then for the promotion of small hydro which included implementation of a UNDP-GEF assisted Technical Assistance project entitled "Optimizing Development of Small Hydro Resources in Hilly Regions of India" and India-Renewable Resources Development Project with IDA credit line having interalia small hydro development component with target of 100MW canal based small hydro power projects through private sector participation. Subsequently plant capacity up to 25MW and below was entrusted with the MNRE in November 1999 [7].

4.1 Potential

The hydropower potential of India is around 1,45,000 MW and at 60% load factor, it can meet the demand of around 85, 000 MW. India's Northeastern states, with their mountainous topography and perennial streams, have the largest hydropower potential in all of India. Together, Sikkim, Arunachal Pradesh, Assam, Meghalaya, Manipur, Mizoram, Nagaland and Tripura account for almost 40 percent of the total hydropower potential of the country.

River basin	Catchment area	Hydropower potential	Watershed area
Karnali and Mahakali	49,811 km² and 16,097 km²	36,180 MW	India and Nepal
Gandaki	36,607 km²	20,650 MW	India and Nepal
Koshi	57,700 km²	22,350 MW	Tibet/China and Nepal
Southern Rivers	3,070 km²	4,110 MW	-

Figure 2: (a) Potential (b) Challenges of hydropower energy in India

5. RF Energy (RFE) Harvesting

An emerging technique of RF energy harvesting wherein Radio frequency (RF) energy emitted by sources like TV signals, wireless radio networks and cell phone towers are captured and converted into usable DC voltage. Available RF energy in the ambient or areas close to transmission towers provides an opportunity to harvest that energy [8,9].

5.1 Potential

RF energy harvesting systems can provide renewable energy by converting radio waves to DC power for IoT applications. This energy is obtained from the Radio Frequency (RF) and Microwave Frequency (MWF). There is abundant energy transmitted from nearby base stations, wireless local area networks, FM/AM radio and TV broadcasting towers, especially in urban areas. These transmissions are prevalent throughout the seasons. . It is scalable to many nodes without a change to source and can even be embedded between walls. Hence, it is evident that RFE has an edge over other harvesting techniques.

5.2 Challenges

Not all the energy transmitted by these sources is used. Here, the challenge lies in utilizing or storing this petite ambient energy which can be employed as a secondary power source for battery recharging or remote power with battery backup. They can be utilized as direct power for battery free systems such as wireless sensors Harvesting energy from these sources poses some challenges [3]; the ambient power available from ambient RFE is very low as it is an inverse function of distance from the source which calls for high gain antennas. Further, RF to Direct Current (DC) converters with low power dissipation should be employed in order to achieve high efficiency. Reflection and absorption of RFE is possible due to obstacles along the transmission path. Also in case of multiband RF harvesting, broadband impedance matching is of utmost importance for maximum power transfer at all desired frequencies in the band.

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