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## Wind Energy Potential, Challenges with Major Technical Issues

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### Abstract

Wind power is a pollution-free, sustainable, indigenous, and renewable source of energy. The principle of wind power is to convert the kinetic energy of the wind into electrical energy using a turbine and a generator. India has 125 billion populations, which is 17.5% of the total world inhabitants. Presently, India is the second most densely inhabited country in the world. Indian economy is the second fastest economy in the world. The population of India is continuously increasing. Therefore, the demand for energy resources is also increasing to fulfil the energy requirement of people. The renewable sources and wind energy is a great source for developing countries, such as India, to fulfil energy demands. Wind energy does not emit any greenhouse gases. It is the most valuable and environmentally friendly energy source. It has not any type of limitation of material for generating energy and is available without any cost. This paper presents the potential, technical growth and policies of various renewable energy sources in the last two decades.

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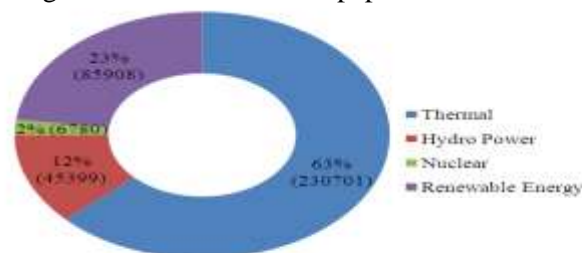
**Keywords:** Energy Sources, Renewable Energy, Solar Energy, Wind Energy, Wind Policies.

## 1 Introduction

The source that does not exhaust or can be refilled within a human's lifetime is termed as renewable energy. Productivity is rapidly increasing in industrial and farming areas [1]. It is supreme to give a cost-effective, well-managed alternative to electric power production to society. Renewable energy can be the only solution for the energy crisis in this new prosperity. It can enhance the economics of the nation. In our daily life, the role of electrical energy is increasing epidemically and can be safely managed at an individual level by society. There is no logic as to why 100% of our power needs could not be met from renewable energy sources. India, being a rising nation, has observed an acute growing power demanding payable to the speedy industrialization growth and increasing demographic framework.

The wind power age limit in India has fundamentally expanded lately. Starting on 29 February 2020 the all-out introduced wind power limit was 37.669 GW, the fourth biggest introduced wind power limit in the world [2-4]. The wind power limit is for the most part spread over the Southern, Western, and Northern locales. Wind power alone can deal with the entire power prerequisite of India is not so distant hundreds of years. With the help of this technology advancement and offshore potential, there can be an increased power generation in all areas [5-8].

Wind power saw a consistent development in India for around twenty years. As of now, wind power is one of the key sustainable power hotspots for the power age in India. Presently, wind energy has spread over the South, West, and North areas of India. The Indian government reported an aspiring objective of introducing 175 GW of environmentally friendly power (RE) by December 2022 [9]. Therefore, this paper completely presents a short survey of the arrangements, improvement projects, and the current status of the wind market in the nation. This paper is organized as section 2 provides the details of various sources of renewable energy; section 3 describes the Indian wind energy potential; section 4 explains the challenges in wind energy; section 5 presents the existing & future scenario. The paper concludes in Section 6.



**Figure 1** Various Sources based Installed Power Generation Capacity (MW) as on 31.12.2019

## 2 Literature Survey

### 2.1 Various Sources of Renewable Energy

Presently, India has a 5<sup>TH</sup> worldwide Position for the total installed renewable power competence [11]. India has planned the retinue by new Renewable Sources of Energy (NRSE) Schemes under the ministry of Non-conventional Energy by the ninth plan. The measure of total energy consumption is increasing as shown in Figs. 1 & 2 [10, 12, 13]. Figure 1 shows that currently, renewable energy has the second position for power generation. So day by day, the utilization of this technology is increasing. Figure 2 shows the quarterly development in power generation capacity with the help of different energy sources. The various renewable sources of energy can be described as:

#### 2.1.1 Solar Energy

- The radiant light and heat from the sun that is controlled using a range of ever involved technologies such as thermal energy, solar heating, etc [14].
- It is the ultimate source that is responsible for all weather systems on earth. India sustains solar energy equivalent to over 5000 trillion (1012) kWh / year, which is far more than the entire power expenditure of the nation [15].
- Various types of solar thermal devices like solar water heaters, solar cookers, solar stills, solar dryers, and so on are accessible [16].
- Sunlight based force is without contamination and makes no ozone harming substances be produced after establishment, decreased reliance on unfamiliar oil and non-renewable energy sources, and more secure than conventional electric flow [17].

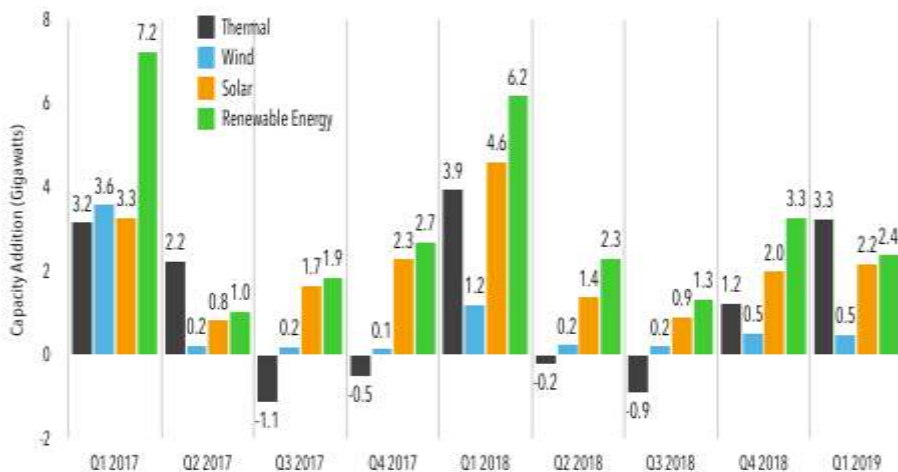


Figure 2 Indian Power Installation Capacity Development through Different Sources

### **2.1.2 Biomass Energy**

- An organic matter such as animal waste, crops, etc that can be used as an energy source is termed as biomass energy [18].
- Basically, four types of biomass are in use that are products, wood and agriculture, alcohol fuels, Landfills gas, and biogas [19].
- The span of this expertise covers the plants, which have a small number of watts to a few hundred megawatts.
- The development of biogas plants was done in India during the 1930s and 1940s.
- Biomass is consistently & broadly accessible as a sustainable wellspring of energy and less trash in landfills.
- Biomass energy is not as competent as fossil fuels. It is not completely spotless and needs a lot of areas [20].

### **2.1.3 Wind Energy**

- The use of wind to furnish the mechanical power through wind turbines to spin electric generators and to do other work like pumping or milling is termed as wind energy [21].
- Wind power is defendable and has a much smaller clash on the environment [22].
- Wind energy is available at no cost and with new technology, it can be captured proficiently.
- Once the wind turbine is built the power it generates does not cause greenhouse gases or supplementary toxins [23].

### **2.1.4 Geothermal Energy**

- The thermal energy that is generated and stored in the earth is termed geothermal energy.
- It is heat that is extracted within the sub-surface of the earth [24].
- It is reliable, cost-effective, and sustainable.
- High investment expenditures for the geothermal system
- A lot of land requirements for the installation of geothermal energy plants.

### **2.1.5 Ocean Wave Energy**

- It is to seize the energy of the wind-wave to do useful work.
- Examples of ocean wave energy are water desalination or pumping water, electricity generation, etc [25].
- Wave energy is a truly solid wellspring of energy. It is because waves are quite often moving. The measure of intensity that can be created from the waves is huge.

•The greatest hindrance to getting your energy from the waves is the area. As spotless as wave energy may be harmful for a portion of the animals close to it [26].

### 2.1.6 Tidal Energy

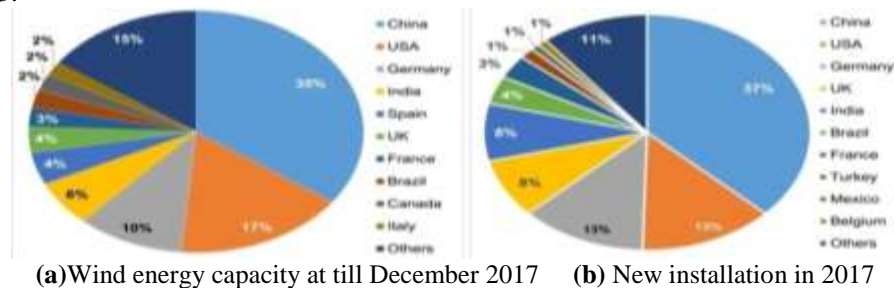
- It is the form of hydropower that transforms the power obtained from tides into valuable forms of energy [27].
- Tides are more obvious than the wind and sun.
- Operational and maintenance costs are low
- The tidal power plant creation costs are very high.
- The sea waves have more variable intensities.

## 3 Proposed Methodology

### 3.1 Indian Wind Energy Potential

India has expected offshore wind vitality potential to produce around 70,000 Megawatt (MW) power, the majority of that recognized in seaside Gujarat and Tamil Nadu, as indicated by the administration of new and practical force source (MNRE). "Initial examinations exhibit toward the ocean wind imperativeness capacity of around 70 gigawatts (GW) inside the recognized zones in the banks of Gujarat and Tamil Nadu in a manner of speaking," India recognizes offshore wind vitality capability of 70,000 MW along with Gujarat, TN coasts [28].

Wind power saw a consistent development in India for around three decades (1985-2015). The nation as of now positions fourth on the planet in wind power, with 37.5 gigawatts (GW) of limit introduced [29]. The greater part of which was driven by motivators, for example, quickened deterioration and age-based installments and alluring feed-in duties (FiT) as shown in Fig. 3.



**Figure 3** Power Production Situation through the Wind in World (As on December 2017) [30]

In 2015, India declared a goal-oriented objective of introducing 175 GW

of sustainable power source (RE) by December 2022. Be that as it may, it concurred to some degree the humble objective of 60 GW to twist as the center moved into sunlight based force. By then, the residential breeze industry had just developed, with an introduced limit of 25 GW.

The breeze area overwhelmed the RE limit expansion for very nearly three decades, however, its offer has been declining as of late. Wind limit expansion created in 2016-17, with about 5.5 GW of establishments as shown in Fig. 3. Utilizing this development, an objective of accomplishing 60 GW wind establishments by 2022 required 5 GW expansions for the following seven years, which was unambitious for the development the business was seeing [31].

### **3.2 Challenges in Wind Energy**

Nowadays, wind energy is one of the popular growing renewable energy sources which reduces the dependency on fossil fuels and helps to combat global warming. But several challenges are linked with harnessing this electrical power for grid application mostly due to its unpredictable nature. The major challenges are as follows:

#### **3.2.1 Location Challenge**

As construction of wind power plants requires large areas and these areas should be free from building obstructions and topology obstacles (because the wind speed is influenced by these obstacles). Therefore, these plants are usually located in rural or remote areas at sufficient height where there is adequate availability of land. In addition to this, the process of land acquisition and necessary paperwork is sometimes very lengthy which causes delays in projects.

#### **3.2.2 Power Grid Connection Challenge**

Two main problems which are encountered in wind energy generation for the power grid are as follows: Firstly, limitations of grid infrastructure in many of the rural areas [30] and secondly the presence of weak power grid in these areas which leads to technical issues such as voltage fluctuations, voltage sags, voltage unbalances, faults, etc. due to the variable nature of wind [32]. Due to the limited grid infrastructure, the amount of electrical energy produced from windmills cannot efficiently transmit to the consumers which lead to the wastage of energy.

#### **3.2.3 Environmental Challenges**

Although wind energy is a clean source of energy and does less effect on

the environment as compared to conventional power plants, sound, and visual impacts are the two main health challenges associated with wind energy.

Sound or noise pollution is the most critical environmental challenge in harnessing wind energy. Because when the wind turbines operate, they produce noise that can be quite distracting to the nearby people [33]. Due to the noise, property value in that area also goes low.

Wind energy has visual or aesthetic impacts on the landscape. It depends upon the size, shape, and layout of the wind turbine. These impacts are specific to a particular site.

### **3.2.4 Cost Challenge**

The initial investment cost (approx.. 80% of the total project) of the wind power is significantly higher as compared to the conventional energy sources because of the wind turbines construction cost, transportation cost of wind turbines to the remote areas, packing, storage of all associated components is very high. Wind power plants have high production costs. Wind energy is intermittent which leads to the lesser plant capacity factor. A lesser plant capacity factor means a lesser output power which increases the overall production cost.

### **3.2.5 Turbine Design Challenge**

Proper design of the wind turbine is also an important challenge in harnessing wind energy [33]. The wind turbines must be properly designed to the blade loading and aerodynamically stability.

### **3.2.6 Variable Output Power**

The wind is variable (intermittently) due to weather patterns and cycles of day & night. Therefore wind power generated through wind also varies accordingly. Therefore wind power plants cannot be used as base-load power plants.

### **3.2.7 Major Technical Issues**

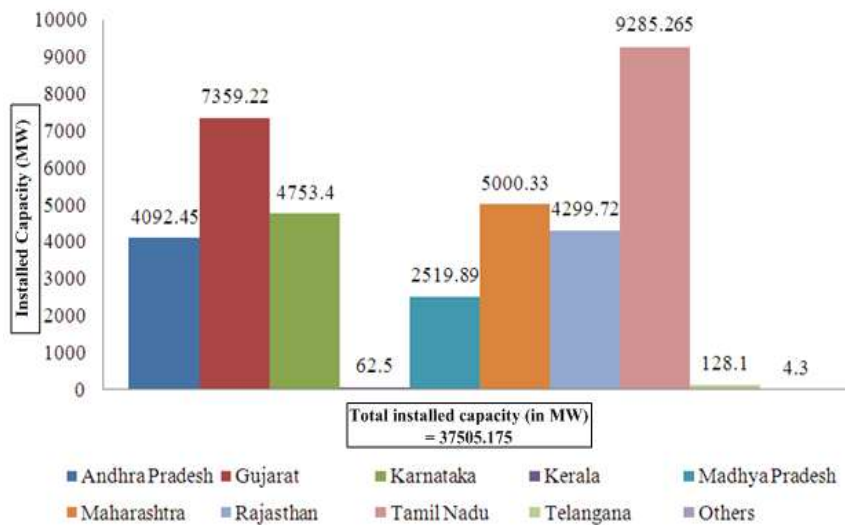
The integration of energy generated in windmills produces several technical issues due to the variable nature of the wind. This affects the power quality and power reliability [32]. Major parameters that affect power quality are as follows:

- (i) Voltage fluctuations
- (ii) Low power factor
- (iii) Electromagnetic interference
- (iv) Synchronizations
- (v) Power system transients and harmonics
- (vi) Reactive power etc.

## 4 Wind Energy Present and Future Results

### 4.1 Wind Policies

The largest state in the country, Rajasthan has come up with a draft of a solar-wind hybrid policy that aims to achieve 2000 MW Wind Power capacity. The target is set for the fulfillment of Renewable Purchase Obligation (RPO) of State DISCOMs in respect of wind energy as determined by the RERC up to 2023-24. The National Institute of Wind Energy (NIWE) has assessed a Wind Power potential of 18770 MW in Rajasthan. Figure 4 shows the wind energy-based capacity in different states [10]. In this figure, Tamil Nadu has the maximum installed capability in the nation with around 9.3 GW and its state regulations are very much favorable to wind power generation. Wind power yearly generation is shown in Fig. 5. From this figure, we can say that the growth of wind power generation is continuously increasing yearly.



**Figure 4** Wind Power based Installation Capacity as of December 2019 in the Different States

The state will allow the setting up of the projects that were already approved before 31.03.2016 (31st March 2016) by the State Level Empowered Committee under Wind Policy, 2012. For the sale of power to DISCOMs of Rajasthan at the weighted average tariff determined through competitive bidding from the first lot of wind power projects for the fulfillment of Renewable Purchase Obligation (RPO) target. Rajasthan state wants to promote wind power projects with storage devices to decrease the variability of wind power outcomes into the grid and to make sure the accessibility of firm power. Therefore, 5% of RPO targets in MW including



Solar/Wind-Solar Hybrid with Storage and will be in addition to the RPO target.

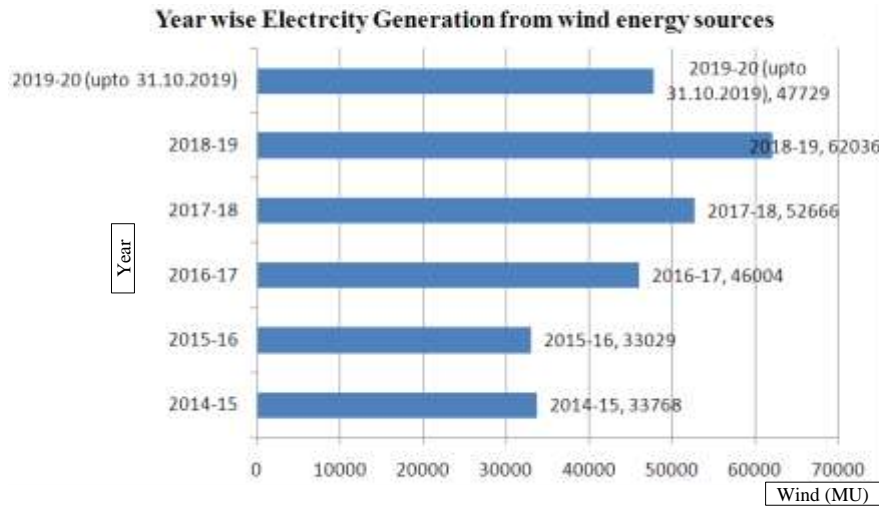


Figure 5 Electricity Generation Yearly from Wind Power

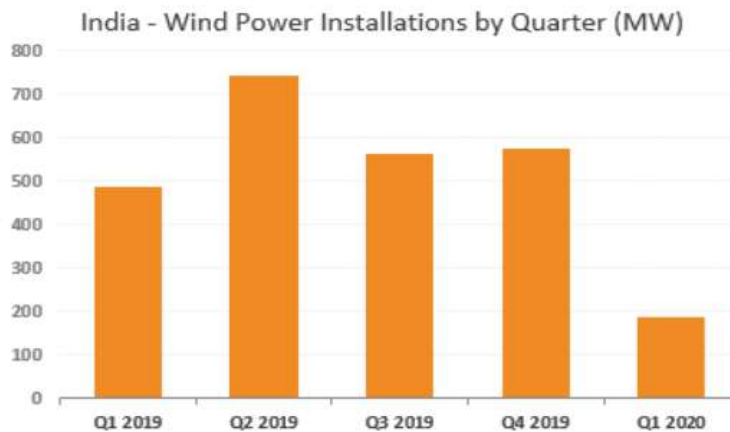


Figure 6 Wind Power Installations in the Previous Year with Quarterly

Quarterly wind power installations are shown in Fig. 6 [34]. For the already functioning wind energy projects, the state will promote repairing of existing wind turbines of capacity below 1MW which have remained in operation for at least 10 years. For the wind power projects with storage systems, additional land will be allotted as per the rules of the Revenue Department, Govt. of Rajasthan. In the case of land allotment, submission of cash security deposit of Rs. 3 lakh/ MW will be required. The state will also look into private lands for setting up wind projects.

## **4.2 Wind power vision of Government**

- To promote wind power projects and required storage systems.
- Promotion of "Repowering" of wind power projects.
- Promotion of Wind Resource Assessment Program.
- To promote industries in the manufacturing of wind energy equipment.
- Hybridization of wind & solar technologies to meet the challenge of grid security and stability along with optimum utilization of land resources and transmission systems [35].
- The state aims to accomplish the 2 GW of wind power capability to perform a renewable purchase obligation (RPO) of state DISCOMs as determined by the RERC up to 2024-25 with the land distribution for the wind energy as per the provisions of Rajasthan Land Revenue Rules, 2007 [36].

## **4.3 Future scope**

In India wind energy has scope for innovation, translating to real-world application and better economic opportunity. For the economy's purpose, it is the most important source of energy. If India takes a major step to improve the generation of energy through wind energy sources the economy will boost up and create decent jobs for people and play a major role in a fast-growing economy. In 1950-1985, the electricity generation in India was very slow but since 1990 the electricity generation in India has been very fast. The biggest advantage in the field of wind energy generation in India is that it has a large coastline which is approximately 7600 km. That is very useful to the wind generation system to get a major amount of fresh air. India is the third-largest energy consumer in the world and is the backbone of the economy. The IEA predicts that India's consumption rate of energy in 2040 will be more than double the total present consuming energy. It is more important for India as our economy continues to evolve and we must ensure every Indian has access to opportunity, a decent job, and livelihood. India plans to add 60 gigawatts of wind power installed capacity by the year 2022.

The recent survey indicates that a gross wind power potential based on 302 GW at 100mtr above ground level is mostly used in only seven states of the country. These are Gujarat, Rajasthan, Maharashtra, Tamil Nadu, Madhya Pradesh, Karnataka, and Andhra Pradesh. The government is promoting the wind power projects in the entire country through private sector investment by providing financial support like subsidies and many types of benefits like concessional custom duties exemption on certain components of wind electric generators.

The government through NIWE has installed over 800 wind monitoring stations all over the country. The main future scope for India is to provide a clean energy generation and energy security field of electricity or energy

generation. Promote the benefits of wind energy and the big role it can play to provide a sustainable path for economic and social development in the country.

Make sure that the industry develops sustainably by protecting the interest of all stakeholders. To make wind energy the primary source of energy for the people of India. In the future, the main focus of energy generation will be on renewable energy sources in India because India has some favorable geological conditions and they play a major role in the economy of India to grow up faster with better results.

## **5 Conclusion**

In a wind power plant, the kinetic energy of the wind is converted into mechanical energy by using a wind turbine, and this mechanical energy is converted into electrical energy by using an induction generator. Wind energy helps to reduce the carbon emission and has huge potential to supply the energy requirement. It also represents an attractive source of employment. But there are several challenges associated with wind energy projects. Therefore, to harness wind energy in the most effective manner, these challenges must be mitigated through research and developments, innovations & technological advancements in wind turbines, strengthening of grid infrastructure, improvement in storage technique, etc. If India takes a major step to improve the generation of energy through wind energy sources the economy is boosted up and creates decent jobs for people and plays a major role in a fast-growing economy. In the future, the main focus of energy generation will be on renewable energy sources in India. Because India has some favourable geological conditions and they play a major role in the economy of India growing up faster with better results.

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