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A review the Potential of Wind Energy in India Including Challenges and Policies

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Abstract - Renewable energy source, wind energy has enormous potential; it offers not only a viable alternative to traditional fossil fuels, but also promising early indicators of being able to mitigate negative environmental impacts. There is a tremendous energy potential from offshore wind. For offshore wind farms in deeper water, (FOWT) is an option. The use of wind power in the energy sector has increased intensely over the past two decades. The indigenous wind power industry in India has been at the forefront of the country's renewable energy revolution. A vibrant ecosystem, project operating capabilities, or manufacturing base of around 12000MW per annum have emerged from the growth of the wind industry. A clean & indigenous source of power for the people of India may come in the form of wind power, which has quickly become one of the country's most significant sources of renewable energy for energy production.

Keywords - Wind Energy, Offshore, Potential of Wind Energy, Policies

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INTRODUCTION

The indigenous wind energy industry in India has been at the forefront of the country's renewable energy revolution. A robust ecosystem, project operating capabilities, & manufacturing base of around 12000MW per annum have emerged from the growth of the wind sector. Today, the country possesses the world's fourth-highest capacity for wind power.

By offering fiscal and financial incentives like Accelerated Depreciation advantage & concessional custom duty exemption on specific components of wind electric generators, the government is encouraging private sector investment in wind power projects across the country. In addition, wind projects that were operational by March 31, 2017 were eligible for the Generation Based Incentive (GBI) Scheme.

To further encourage the installation of wind capacity in the country, the government has adopted the following measures in addition to the fiscal & other incentives already mentioned above:

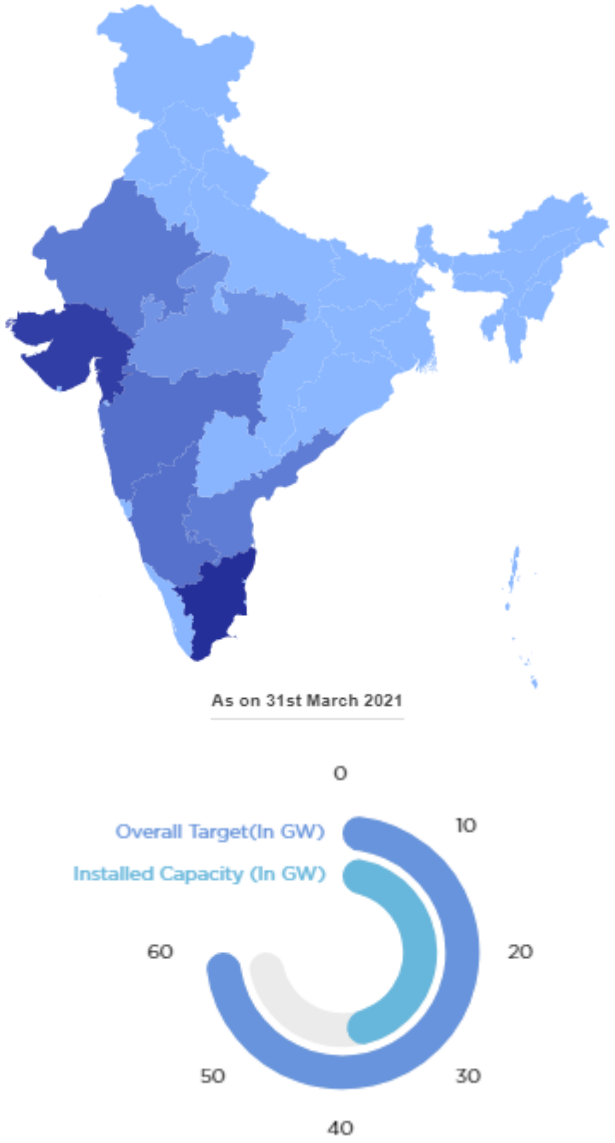
- Projection of future Wind Renewable Purchase Obligation (Wind RPO) through 2030;
- Projects that will generate solar or wind power and will be ready for interstate sale by June 30, 2025 will not have to pay the fees associated with using the Inter State Transmission System (ISTS).
- With the intention of providing a structure for the logistics of wind power through a transparent process of bidding, such as standardization of the process & identifying of roles and responsibilities of various stakeholders, the government has issued guidelines for a tariff-based competitive bidding process for the purchase of electricity generated by grid-connected wind power projects. The Distribution Licensees can save money and time by following these guidelines, which were written so that they can buy wind electricity at market rates.
- The National Institute of Wind Energy in Chennai provides technical assistance in the form of wind resource assessment & site identification.

India's Potential for Wind Energy

Considering that wind is both intermittent & location-dependent, a thorough Wind Resource Assessment is necessary before any suitable sites can be chosen. Over 900 wind-monitoring stations have been set up across the country by the government's National Institute of Wind Energy (NIWE), & wind potential maps have been released at 50m, 80m,

100m, and 120m above ground level. The most up-to-date estimate puts the country's total wind power potential at 302 GW at 100 meters & 695.50 GW at 120 meters. Here are the seven windy states where this potential is concentrated:-

S. No.	State	Wind Potential at 100 m (GW)	Wind Potential at 120 m (GW)
1	Gujarat	84.43	142.56
2	Rajasthan	18.77	127.75
3	Maharashtra	45.39	98.21
4	Tamil Nadu	33.79	68.75
5	Madhya Pradesh	10.48	15.40
6	Karnataka	55.85	124.15
7	Andhra Pradesh	44.22	74.90
	Total 7 windy states	292.97	651.72
8	Others	9.28	43.78
	Total	302.25	695.50



Renewable wind turbines in India

On the 31st of December, 2021, India had a total installed capacity of 151.4 GW for renewable energy (MNRE data).

- Solar Power: 49.34 GW
- Large Hydro: 46.51 GW
- Wind power: 40.08 GW
- BioPower: 10.61 GW
- Small Hydro Power: 4.83 GW

In terms of installed capacity, India's wind farms rank fourth in the world as of March 31, 2021, with a total of 39.25 GW (Following China, USA & Germany).

According to the Global Winds Report 2022, India surpassed the 1.1 GW of installations from the previous year with 1.4 GW of wind power in 2021.

The 7,600 kilometers of coastline in India are ideal for producing offshore wind energy, which may provide 127 GW.

The government of India has set renewable energy (RE) goals of 175 GW by 2022 and 450 GW by 2030, including targets of 60 GW and 140 GW for wind power respectively.

Seven states—Andhra Pradesh, Gujarat, Karnataka, Madhya Pradesh, Maharashtra, Rajasthan, and Tamil Nadu—hold more than 95 per cent of the world's commercially exploitable resources.

The top five states in India for potential wind energy are Tamil Nadu, Gujarat, Maharashtra, Karnataka, & Rajasthan (As of March, 2021, Source- MNRE).

Manifestation pedagogy: India has made significant progress in recent years at expanding access to modern energy. India has more than twice its electricity rates since 2000, & number of people living in the country without access to electricity has decreased by more than half. China, the United States of America, & Germany lead the globe in total wind installations, but India ranks fourth. In the next decade, wind power has the potential to play a significant role in providing a clean & indigenous source of power to the people of India, where it has quickly become one of the most important RE sources for electrical generation.

Types of Wind Farms/Onshore

Land-based wind turbines are referred to as "onshore wind." Wind turbines are able to convert the kinetic energy of wind into usable power.

- Offshore turbines can be found in saltwater or freshwater environments.
- A wind turbine with a floating foundation is constructed in deeper waters, while a fixed-foundation turbine is installed in shallower water and its base is moored to the seafloor. The development of floating wind farms is only getting started.
- The minimum required distance for offshore wind farms is 200 nautical miles, & minimum required depth is 50 feet.
- Electricity generated by offshore wind turbines is transmitted to land via cables built beneath the water.

- As of April 11, 2022, wind energy accounted for 27% of global renewable electricity generation capacity, per the RENA.

Wind energyAdvantages

- In contrast to power plants that burn fossil fuels like coal or natural gas, which release particulate matter, nitrogen oxides, & sulfur dioxide into the air & cause health concerns for people and financial losses for businesses, solar power is both renewable & sustainable. By increasing the production of offshore wind energy, it may be possible to cut annual carbon dioxide emissions by 0.3 to 1.61 gigatonnes by the year 2050.
- As its power is delivered at a fixed price over a long period of time or its fuel is free, wind energy helps reduce the price unpredictability that fuel expenses contribute to conventional energy sources.
- The wind business is increasing, and the role of wind turbine technician is one of the quickest expanding in the sector.
- Wind turbines can be added to an already established farm or ranch. Since most of the best wind sites are found in rural areas, this has profound ramifications for the economy there. Due to the limited space that wind turbines require, agricultural and ranching activities can continue unimpeded.

Strategies & Policies for Wind Energy

- To promote big grid-connected wind-solar PV hybrid systems for optimal & efficient exploitation of wind and solar resources, transmission infrastructure, & land, the National Wind-Solar Hybrid Policy, 2018, sets forth a framework for doing so.
- A new plan to create Wind-Solar Hybrid Parks has been presented by the Ministry of New & Renewable Energy. The National Institute of Wind Energy will decide where to put up the wind-solar hybrid parks (NIWE). There will likely be more than 500 MW at the park.
- The National Offshore Wind Energy Policy was issued in October 2015 with the intention of fostering the growth of offshore wind farms in the Indian Exclusive Economic Zone (EEZ) along the country's length of 7,600 kilometers of coastline.
- For instance, the National Institute of Wind Energy can help with a technical evaluation of wind resources & identification of possible locations.
- To encourage the cross-border selling of wind electricity, the government has agreed to forego interstate transmission fees for wind projects that are commissioned by June 2025.
- Concessional custom duty exemption on some equipment of wind electric generators; Accelerating Depreciation advantage.

Wind energyChallenges

- Less Profitable: Solar energy's lowest bid price is Rs 2.23 per unit, whereas wind energy's is at Rs 4.50 per unit. Solar energy investment is increasingly attractive to investors because of the industry's high potential returns.
- Intermittent: Power output is low when wind speeds are low.
- During the last three years, wind power has failed to advance at all. A total of 5.5 GW was added to India's grid in 2016–17, however only 2 GW were added in 2017–18.
- Requires a lot of money to get started.
- Obtaining land is also a significant obstacle.
- With DISCOMS in such a precarious financial position, it is unlikely that they will be able to fulfill their renewable purchasing commitment in full, and since solar energy is priced more favorably, it is the favored option.
- Wind farms may have an effect on local wildlife. Numerous birds have been killed as they flew into spinning turbine blades. In addition, similar to other energy sources, wind projects have the potential to alter the local ecosystem.
- It's possible that developing wind resources is not the most financially viable option for the land.
- Competing uses for land with wind turbine potential include those that may be more lucrative than electricity production.
- Huge amounts of money need to be invested in developing the auxiliary infrastructure in order to generate wind energy from offshore. High winds & waves can cause significant damage to wind turbines, especially during storms & hurricanes. The marine environment is vulnerable to the effects of offshore wind farms.

LITERATURE REVIEW

Anand Vijay Satpute ET AL. (2020) In order to reduce carbon emissions from coal-based power plants, meet the growing demand for electricity in developing countries like India, and alleviate poverty, this study will examine the part played by government initiatives in the growth of the country's wind power sectors. This analysis looks at the state of wind energy production in India right now. Clean energy promotion policies on the part of governments are also examined, along with the issues that arise from them. In order to meet the requirements of the Kyoto Protocol & Paris

Agreement of the UN Framework Convention on Climate Change, however, supplementary methods are favored in terms of vigilance regarding the care of the environment's hazardous aspects and the reduction of the major economic aspects. As a renewable & ancient energy source, wind has enormous potential for power generation and other modern applications, such as agriculture & water management. Wind turbine blades and their features were examined to see how maximum power could be extracted at times of low and changeable wind speeds. As much progress as India has made in the wind power sector, it still has some work to do before it can catch up to China and become a global powerhouse in this area. This calls for progress in a wide range of areas, including trained labor, improved research & development, grid and turbine installation, equitable distribution, easy acquisition of land, cutting-edge infrastructure, substantial investment, and, most importantly, government policies that are supportive of the energy industry. This research examines how using wind power, a renewable energy source, can lessen the impact of the current energy crisis. Wind power's potential to improve quality of life is bolstered by its status as a RE source or its low cost. Using critical analysis, this study examines the case for the immediate & future deployment of renewable energy sources. India is a developing nation, so balancing its energy crisis requires innovative research like this.

Rajvikram Madurai Elavarasan ET AL. (2020) Harvesting energy in a way that doesn't harm the environment is a hot topic right now since it speeds up social progress & raises people's living standards, all while being one of the primary enablers in attaining the SDGs. With a total population of 1.35 billion people, India is the world's second most populous country and also one of the top consumers of fossil fuels, a major contributor to climate change. Population growth is expected to continue unabated until 2050, and this will spur both more industrial activity & higher energy needs over the next few decades. The Indian government has set a goal of 175 GW through renewable energy sources, &MNRE is working toward this goal with the help of the NITI Aayog. In an effort to keep up with anticipated increases in energy consumption, many Indian states are expanding their use of renewable sources of power. In-depth information about the three leading states in India in terms of renewable energy production—Karnataka, Gujarat, and Tamil Nadu—is included in the review paper. Comparisons between the Indian energy situation and the global one were made. The issues facing India & other countries are examined in length, as are the strategies of the Indian government to stimulate renewable energy generation across India and the world. In order to aid the nation's academics, researchers, and policymakers, this study assessed the country's renewable energy prospects. This study provides a glimpse into the nation's current renewable energy scenario.

Paul J.Burke ET AL. (2019) A greater percentage of worldwide investment in new electricity generation capacity is going toward solar & wind energy technologies now that they are competitive in price. Both India & Indonesia aim high when it comes to implementing these technologies into their daily lives, with India's current rate of acceptance being particularly noteworthy. However, there are significant difficulties to overcome, such as the ingrained positions of coal and other fossil fuels, regulatory impediments to market access, and the insufficient ability of electrical utilities to manage intermittent renewables. In this paper, we discussed the challenges & talk about ways to work around them. We highlight tax and subsidy reform choices, regulatory & incentive-design strategies, approaches to bolster grid management capacities, and the significance of minimizing protectionist barriers, as well as the usage of reverse auction processes that can deliver low-price solar & wind contracts, as are being performed successfully in India. Both micro and large scale systems are considered in our approach.

Muhammad ShahzadNazir ET AL. (2019) Government & legislative authorities throughout the world are worried & contemplating the pollution-related difficulties and criteria that influence the energy paradigm, as environmental & socioeconomic awareness continues to rise. To lessen the environmental impact of electricity generation, renewable energy sources including wind, solar, and hydro are increasingly being put to use. Now is the time for the world to take urgent, fair, substantial, and effective climate action. To use renewable energy sources, there is a growing body of scientific information that has accumulated over many years. Wind power is one such global resource that is becoming increasingly popular as a viable alternative to traditional energy production. Wind power schemes for generating electricity may provide a crucial alternative to the use of traditional fossil-based fuel resources, depending on the specifics of the implementation. Though the expense of constructing a solar system is considerable up front, the ongoing expenses are minimal. Here, we took a look at how the current paradigm for developing wind energy technology could affect the environment, including the major challenges it poses, especially for Pakistan. Initiating this discussion with the hope that it will lead to additional negotiations between decision-makers & bringing attention to the environmental features & set of challenges related to the development of Pakistan's wind power industry is the goal of this conversation.

Muhammad Irfan ET AL. (2019) Energy is crucial to a country's economic growth. Most South Asian countries, particularly Pakistan, India, and Bangladesh, have seen the gap amongst energy demand & supply widen as a result of their massive

populations, stifling economic development in the region. Power plants in these nations rely almost exclusively on fossil fuels, which are not only finite but also prohibitively expensive. Wind energy is particularly abundant in the South Asian region. With forethought, the area may put this natural resource to use to close the energy gap & head off the energy conundrum in the future. This article seeks to delve into the topic of low carbon development by examining the current standing, future possibilities, and official regulations regarding the expansion of wind energy in this area. In the study, we analyzed the potential for wind energy in Pakistan, India, & Bangladesh. The most up-to-date information available on wind energy in these three countries has been presented. The renewable energy strategies of these countries have been explained in length in the article.

Subhojit Dawn ET AL. (2019) Wind power has showed significant promise over the past few decades, both in terms of expanding capacity & widespread adoption. Wind power has been making a comeback or being positioned as an important renewable energy source since the late 1990s. Over the last several years of the 20th century, the installed capacity of wind power around the world has doubled about every three years. This paper illustrates the critical factors, together with the promotion policies made by the Indian government, for increasing the country's own energy security through the efficient use of available renewable energy sources. The utility of wind power in India is twofold: first, it generates electricity, and second, it distributes that electricity at a lower cost than other sources. This analysis also includes specifics on India's total electricity generation, demand, and the contributions of different renewable sources. Indian wind power potential has been compared to that of other top countries.

Prem Kumar Chaurasiya ET AL. (2019) Wind energy is just one of India's abundant renewable energy sources. In order to build wind turbine installations in the near future, it is crucial to assess the potential of wind energy resources in altering the energy scenario in the country. As of the end of September 2018, around 34605 MW of wind power plants had been installed. India is ranked number four in the world for its use of wind energy. The report here describes the current & future state of wind power in India. This studysearches the potential & threats associated with the growth of wind energy in the country, as well as several strategies for maximizing the efficiency of wind power.

K. UshaRao ET AL. (2019) Due to its unique properties, including high initial prices and a lack of a fair playing field, as well as their significant advantages from energy security, environmental, & social perspectives, the spread of renewable energy technologies (RETs) is driven by policies & incentives. Only 20-25% of their potential has been fulfilled after three decades of advancement. Diffusion modeling theory permits examination of spread processes, as well as research into the development rates of various technologies & elements that contribute to their diffusion. Their use in RETs has been limited as opposed to commercial & consumer devices including televisions, vehicles, and information technology. Barriers to RET acceptance, along with techno-economic, learning curve, & experience curve perspectives, have informed analyses of RET diffusion. However, it has been noted that when these models are implemented to commercial items, they fail to address the crucial questions of policy influences on the spread of RET. Because policies are the primary factor in RET diffusion, it is important that the models used to study RET diffusion allow for the establishment of explicit links between the diffusion parameters & policies and their effect on diffusion rates. This research aims to review alternative diffusion theory based models and their application to RET diffusion analysis, given the promise of RET for sustainable development.

VikasKhare ET AL. (2013) The expansion of India's solar & wind energy infrastructure faces a number of unique challenges. But India has enough sunshine & steady breeze to make up for it. As a result, "Grid Parity" provides a promising pathway toward the widespread adoption of RE sources like solar & wind in the Indian context. The aim of this study is to offer a unified & comprehensive account of the main obstacles that have slowed the growth of renewable energy in India.

Naveen Kumar Sharma ET AL. (2012) Developing countries like India have struggled for decades with their energy infrastructure, but renewable energy sources & technology may hold the key to a permanent solution. India plans to enhance its capacity, improve its energy security, address environmental issues, and take the renewable energy industry by storm, and solar energy can play a key role in this. Concentrating solar power (CSP), or solar thermal electricity (STE), is a relatively new renewable energy technology that has the potential to be developed in India in the near future as a means of powering the country's electrical grid. The object of this study is to access a summary of the many solar energy options in India, including their availability, current state, tactics, viewpoints, promotion policies, important achievements, & future potential.

CONCLUSION

India is one of the world's fastest growing economies, and its rapidly expanding population means that the country's energy infrastructure must expand at a speedy pace to keep up with demand. As a renewable energy source, wind power has enormous potential; it offers not only a viable alternative to traditional fossil fuels, but also promising early indicators of being able to mitigate negative environmental impacts. This document lays out the problems that can arise while using wind energy and some possible solutions. India's onshore wind industry is well-established, and the country has experience with diversifying its energy supply to include renewable sources. India is the world's fourth-largest producer of wind power, with more than 34 GW of built onshore wind generating capacity. The country has the potential to build another successful renewable economy offshore, with a total of 70 GW6 of additional offshore wind energy capacity. India's international allies including the United States, Norway, Japan, Denmark, and the European Union are pushing for renewable energy, and wind power should take advantage of this.

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