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An Overview on Development of Policies and Barriers for Wind Energy Generation: Indian Scenario

Prasanth Venkatareddy
Nitte Meenakshi Institute of Technology, Bangalore, India.

Prakasha P. K.
Don Bosco Institute of Technology, Bangalore, India.

Vidyadevi G.Biradar
Nitte Meenakshi Institute of Technology, Bangalore, India.

Veena R.S.
RV Institute of Technology and Management, Bangalore, India.

***Abstract*---**In the past wind energy is harnessed for attaining some valuable work like grains grinding, water pumping, and even boat sailing over a long-time. However, times have been changed from conventional utilization of wind energy to electricity generation in modern days. Wind energy is believed to be one of the purest kinds of renewable energy. India's wind energy resource potential is estimated to be 102 GW at 80m and 302 GW at 100m of hub height. The immense potential of wind energy which has been kept uninvestigated can be accomplished through fair framed policies. The present paper focused on a comprehensive analysis of the Indian government planning to expand its wind energy business by offering financial incentives and development policies. In this paper, Indian wind energy policies have been intensely analyzed and various barriers to achieving the success of these schemes and programs have been discussed. The summary of the present paper is to reiterate the work carried on the wind energy sector in terms of enhanced fiscal incentives, minimized energy pricing, offshore wind farm prospects, and market growth stability by the Indian government (both central and state).

***Keywords*---**Wind Energy Generation, Policies, Energy Pricing, Barriers, Indian Energy Market.

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***Corresponding author**: Prasanth Venkatareddy; Email: prasanth.v@nmit.ac.in*
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Introduction

Energy production in India is most reliable on conventional energy sources. It is a known fact that India depends mainly on fossil fuels-powered thermal energy, and it is more than 60 % of the nation's overall energy production. Depletion of the ozone layer, emission of hazardous gases, exhausting of fossil fuels for energy generation causes severe damage to human life as well as the environment. Hence there will be instant swift in generation methods of energy from conventional sources to renewable resources (solar, wind, biomass, etc.,) is required. Wind energy is still a more established and mature alternative for reducing power use. The major technological focus has been on efforts to improve wind energy usage in a turbulent urban wind environment to satisfy energy demand. In previous study on wind resources and behaviour in urban areas, different designs of vertical axis wind turbines (VAWTs) and horizontal axis wind turbines (HAWTs) were explored. Different designs of vertical axis wind turbines (VAWTs) and horizontal axis wind turbines (HAWTs) were investigated in a prior research on wind resources and behaviour in metropolitan environments. The benefits of economics and the environment in urban regions using wind energy have been summarized. Although for daily sustainability in urban areas emerge with several new concepts and solutions for technical, economic, and environmental. Design challenges have been steadily overcome to take advantage of low and turbulent wind speeds in cities, installation space limits, noise reduction and vibration reduction, and other concerns.The present article addresses certain unique solutions that have been recognized and investigated on wind energy technology in urban areas(Ishugah, T. F et.al, 2014).

Currently, noteworthy research has been carried out on wind energy by focusing majorly on regional wind energy evaluation, the probability distribution function of wind speed, wind energy economic aspects, and policies of regional wind energy. Although there has been a lot of study and development into the aerodynamics and design of wind turbines, pollutant dispersion, and micrometeorology in urban areas, relatively few academics have looked into the use of wind energy sources in cities. The major focus on natural ventilation of urban environment through wind energy layout, its ability in energy generation, dispersion of pollution along with economic and environmental benefits has been discussed. Due to urbanization, suburbanization, and industrialization, energy security through sustainable development has become a major challenge to overcome this growth of wind energy worldwide is a solution. The first country to have a renewable energy ministry is India. Department of Nonconventional Energy Sources (DNES) has been renamed as Ministry of Nonconventional Energy Sources (MNES) by aiming at R and D in the file of renewable energy in 1992. In India a massive growth in wind energy has been noticed under the policies and guidelines framed by MNES, in terms of installed capacity, the market for wind energy has grown from 41 MW to 968 MW within a span of 6 years (i.e., 1992 to 1998). In 2006, MNES was retitled as Ministry of New and Renewable Energy (MNRE). MNRE's main goal is to ensure energy security, promote renewable energy, and make energy sources more affordable, accessible, and equitable. A grid-connected wind power of capacity 34.4 GW has been achieved in India through continuous efforts of MNRE. Several meteorological stations have been set up for monitoring and assessing the wind resources across the country aiming

to promote renewable energy under the vision of MNRE, (website: https://www. https://mnre.gov.in/physical-progress-achievements, Accessed Feb 2022).
The major contributions of the current review article have three-fold. Firstly, it discusses the Indian history of wind energy and recent developments in Indian wind energy. Second, an attempt has been made to appreciate the dynamics of the wind market as well as the regulations enacted by numerous governmental organizations with the goal of achieving clean energy objectives through long-term renewable energy projects. Finally, the socioeconomic challenges that wind projects and policy must overcome in order to realise technological, economic, and environmental advantages. The purpose of this article is to provide a quick overview of the Indian wind energy sector, including its current state, rules in place, and impediments.

Wind energy status in India

Provide On February 28, 2021, India was placed fourth in the Global Wind Power Installed Capacity Index by the Global Wind Energy Council (GWEC). India has a total installed wind power producing capacity of 38.789 GW. China has a total installed wind power producing capacity of 281 GW. The United States has a total installed wind power producing capacity of 127 GW. and that of Germany is 62.85 GW. Table I represents country-wise wind potential from 2018 to 2020 (website https://www.tinyurl.com/global-wind-energy-council, Accessed Feb 2022). It is observed that India has a huge wind energy resource potential of 102 GW at 80m and 302 GW at 100m of hub height. The viable wind power projects output relies on various factors like site availability, wind speed (m/s), the power density of wind ($W/m2$) etc. An autonomous research and development center called the National Institute of Wind Energy (NIWE) is in Chennai, India assesses wind generation across the country. It successively illustrates various mast heights wind energy maps. NIWE is monitoring the direction and wind speed of 877 stations with various height levels. Also, it has 32 monitoring stations as of 31st August 2021 (https://niwe.res.in/department_wra_swms.php,Accessed feb 2022).

Wind energy development in the Indian market

A prominent engineer Manekal Sankalchand Thacker linked with the Council of Scientific and Industrial Research started a project in 1952 to explore and evaluate the scope of wind energy in India (CSIR). A sub-committee has been formed to analyze the wind resources across the country under this initiation. Due to the 1970's oil crisis a sudden rise in crude oil price and an imbalance between supply and demand, the world has started to think of development in renewable energy. In 1981, the Indian government established a commission for alternative energy sources with the primary purpose of establishing and implementing policies to stimulate technical growth and R&D in the renewable energy industry. Across the nation, several parts have demonstrated wind energy projects and evaluated the resource availability (Sangroya et.at.,2015) Wind energy development in India accelerated dramatically in 1986. Nearly, 600 wind monitoring stations were established to quantify wind resources in 25 Indian states. During the seventh five-year plan (1985–1990), the Indian government granted the go-ahead to create grid- quality wind electricity to help local businesspeople wanting to build grid-connected wind turbines. Wind

energy projects account for huge initial investment which is around 60–70% of the total cost. Hence, to reduce this burden of renewable energy projects DNES has started an Indian Renewable Energy Development Agency (IREDA) to offer financial aid. This country's wind energy market has seen a rapid boost and private investments have significantly increased. The eighth national plan (1992 – 1997) is known as the Indian wind energy growth golden period (Rajsekhar et.al.,1999). In 1998, MNES has institutionalized the National Institute of Wind Energy (NIWE). In Tamilnadu, the established capacity of wind farms reached 282 MW during 1995 – 96. In September 1998, India has achieved 4th place in the installation of wind energy across the globe with a 992 MW capacity. Stable progress in the wind energy sector has noticed during 1994 – 96. However, there was a drop in wind energy sector investments from private investors and the country has noticed wind energy decline due to government new tax policies during the end of the 20th century (Sangroya et at.,2015). Later, in 2006 establishment of MNRE boosted the various wind energy projects in the country especially in windy states in an exponentially impressive manner. India is targeting a total generation of 175 GW from renewable energy by 2022. Currently, the Indian government is aiming to attain 227 GW from renewable energy by 2022 which is much ahead of the previous target as per the Paris agreement. In India, it is predicted that 54% of the overall electrical energy production will be from renewable sources by 2022 (Gulagi et.al.,2017). In India, both NIWE and IREDA are aiding pillars of wind energy development.

Need for wind energy policies in India

The energy resources capacity of the country shows its economic stability. Indian financial problems can be eliminated, if India maintains its economy in the upcoming 20 – 25 years with an expansion of 9% per annum (Sholapurkar et.al.,2015) Although India has initiated its research and development in the field of renewable energy in the early 80s, it was unable to achieve popularity because of public awareness lacking and inadequate technology (Chaudhary.et.al., 2015). A revolution has been started in India due to the exponential increase in emission of Greenhouse Gas (GHG) which causes a drastic change in climate, scarcity, and security for energy facilitated nation's renewable energy policies development. During the late 20th century an effective wind resource evaluation has been conducted and sustainable development has been made in various wind energy projects across the several windy regions of the nation. As the result, wind energy began to flourish in India. The growth in renewable energy resources was not noteworthy since people are unaware of climatic changes and traditional resources were highly reliable. Wind energy campaign programs received the least interest from the state and regional governments. Hence to promote and spread awareness among all groups about wind energy advantages in power generation, the Indian central government joined hands with MNES for assisting and making policies. These policies were implemented for attaining the goal of wind energy production through power and progress. Several state- wise nodal agencies have been established in various states to safeguard the appropriate involvement of state government. However, these policies are diverging from state to state (region to region) based on sites potential, evaluation of resource and connection with grid, etc. these guidelines by nodal agencies have been outlined under MNRE.

Policies and programs for wind energy in India

In Indian history, the era from 1994 to 1996 is known as the 'wind-rush,' since the wind market in India experienced rapid expansion due to a rise in investment from the private sector. However, this is happened because of central government fiscal incentives for private sector investors with zero tax planning benefits. MNES has formed wind energy development project guidelines to overcome the hurdles in 1995. In 1996, agencies at the state level were filled with subsequent addon charges that included appropriate examination of the specific projects before approval, in every six months notification of additional capacity, timely inspection on existing and commissioned projects. In 1997, it is noticed the start of decay in the growth curve of the wind energy sector which has slowdown due to the new tax policies of the government. The tax policies include a minimum increase in tax of 12.9%. The tax credit benefit margin has gone down to 35% in 1997, previously it is 43 – 46%.

Table 1
Leading windy states in the country with their wind development agency and projects

S. No.	State [Reference]	Nodal Agency	Projects
1	Andhra Pradesh	New & Renewable Energy Development Corporation of Andhra Pradesh Ltd. (NREDCAP) is a company owned by the state government. 7.53 GW capacity of wind projects had been commissioned till 2021.	The district of Anathapuramu has the most active wind projects. Suzlon Energy Ltd., in collaboration with the Axis Energy company, has been awarded a 4000MW wind project in several areas throughout the state.
2	Gujarat	Gujarat Power Corporation Ltd is the government agency in charge of the state's wind energy projects.	Gujarat, which is on India's Arabian Sea coast, has a lot of room for offshore wind development. In 2018, the Indian government intends to commercialize 1000MW of offshore wind energy projects.
3	Maharashtra	MNRE assisted the state government in establishing the Maharashtra Energy Development Agency (MEDA).	MEDA built 11.09MW capacity demonstration projects in Maharashtra. MEDA works with 50 different wind power companies on energy projects.
4	Rajasthan	Rajasthan Renewable Energy Corporation Limited (RRECL) is the state nodal agency. 4.33 GW capacity of wind energy as of 2021.	The government has hired Suzlon, Enercon (World Wind India), and Inox to build many projects in the state.
5	Tamil Nadu	Tamil Nadu Generation and Distribution Corporation (TANGEDCO)	The Tamil Nadu Electricity Board's subsidiary has sold 17.550MW capacity projects in the state, while the private sector has successfully installed 6530.340MW.

Barriers in India for development of wind energy

Technological Barriers

The wind energy capacity of 302GW is sufficient to fulfill a significant amount of the Indian market's daily energy demands. Wind resource finding, on the other hand, remains a tough undertaking due to environmental, technological, economic, and societal constraints. As a result, wind energy expansion has its own set of constraints, which may be stated as follows:

- Technological hurdles arise in poor nations due to a lack of infrastructure and institutions for R&D.
- European technology is used in India's wind turbine technology. Due to this, there will be always a mismatch between local goods manufactured in the Indian market that lacks local norms in turbine production (Kulkarni SH et.al., 2018).
- Individual turbine performance in wind farms has a detrimental influence on highly efficient contemporary turbines. As a result, a wind farm's total wind harvesting efficiency is lower than it would be if all of the turbines worked individually and independently. (Manwell JF et.al., 2010).

As described in previous Section in this paper, many policies and programs have been implemented throughout the country to increase the stability and interconnection of wind projects to the grid. However, when penetration levels are very high, the grid may be unable to absorb wind-generated power. As a result, wind farms in Tamil Nadu used to stay closed while output was at its height, resulting in a waste of valuable energy. Wind clusters/farms in Tamil Nadu produced 12 billion units of electricity in the fiscal year 2017/18, compared to just 7 billion units in 2016/17. This was accomplished via the use of effective forecasting and scheduling strategies. As a result, monitoring stations must have a daily metering scheme. So that difficulties caused by the changeable nature of wind power plants might be addressed.

Economic barriers

The primary investment in the projects of wind energy is relatively significant, and there is always a risk component involved in doubting the project's guaranteed viability (Kumar Y et.al.,2016). The issues of equity and debt develop inflation and non- uniform interest rates. Distribution corporations build barriers by most probably being able to acquire the plants' surplus energy and every so often postponing payments that are already due (Mehra C et.al.,2016). The wind project refinancing is considered a risk task owing to the low rewards at the start of the project. The contest between diverse energy sources confuses other's operations.

Ecological barriers

Subsection Even though it is known that electricity generated from wind energy is eco-friendly and clean form, it does have certain adverse environmental consequences. Wind farms have several environmental issues which are discussed as follows:

Wildlife risk: The traveling of birds through wind farms is in danger. The two most common causes of bird fatality are transmission lines electric shock of birds and collision with turbines are related to activation of a wind farm. Other issues that wild animals confront include degradation of habitat, changes in migratory, breeding patterns, and nesting, and so on.
Visual issues: Visual disruptions are generated by wind farms positioned near highways. Both shadow flickering created by flashing of revolving blades induced by sun rays reflected from the gleaming blade surface cause eye pain.
Noise pollution: In a wind farm as the turbine installations increases, so does the intensity of the noise. This undesired sound (noise) involves annoyance, the trouble of sleeping, hearing problems, and other issues in humans.
Other issues: The areas where wind farms are located will have severe climatic changes. The blade rotation induces hot air and vapor mixing, resulting in some unfavorable climatic changes (Bajoji S et.al.,2016). Production of hazardous wastes and their inappropriate dumping harms the ecosystem.

Policy consequences, conclusion and future directions

The pattern of exponential increase in the country's annual capacity additions demonstrates the efficacy of the government's initiative to support wind energy projects. New laws have emerged as a crucial driver of India's extraordinary growth in the wind energy industry in recent years. Renewable purchase obligations require customers to use renewable energy. The implementation of GBI and renewable energy certification systems proved to be vital measures, resulting in a substantial drop in wind energy costs, providing conventional sources a severe fight. Incentives and subsidies for locally made goods should be encouraged, lowering the long-term cost of wind turbine components. E-bidding takes three months for wind projects, and the project is finished in one and a half years. Because the bidding procedure was just recently implemented, the results are yet unknown. However, the bidding method is seen as a game- changer since it has simplified the industry, and hence an increase in investment is projected. However, in comparison to the present wind potential, the growth and accomplishments seem modest. Technical, environmental, economic, and socioeconomic constraints, as well as policy concerns and uncertainties, must be removed for policy implementation to be effectiveOffshore wind generating was almost unknown in India until 2015, and little progress has been made in this area. Offshore wind farms are one of the most efficient ways to use the wind to create power. As a result, rigorous regulations and resource assessments should be considered to commercialize offshore projects. The Indian government hopes to have 60GW of installed wind capacity by 2022. According to recent patterns, yearly capacity expansion is no more than 5 GW, and to obtain 100 GW, yearly capacity accumulation is about 10 GW. This can be achieved through improved infrastructure, technology, and management integration in the energy industry. The development of financially viable institutionalized research centers in each windy state might be useful for promoting research and innovation. Regular inspections and monitoring of current ongoing projects must be carried out on a more frequent basis. Repowering of projects, an initiative that may aid in reaching the intended goal, needs an autonomous policy framework. New government efforts, although having long-term impacts, must be closely monitored, and policy implementation must be ensured by the government in order to meet the 60GW

target by 2022. A solid grid-connected infrastructure, clever project incentives, and good regulatory implementation are all important. Market-driven changes in electricity pricing and regulations, and devoted research advances might catapult India's wind sector ahead of the competition.

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