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Assessment of Wind Energy Development in Tamil Nadu and Kerala: Challenges and Preferences

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Abstract

This study conducts a comprehensive examination of the present state of wind energy advancement in the regions of Tamil Nadu and Kerala, situated in India. The primary objective of this research is to assess the current status of the wind energy industry, including the challenges faced and the overall advancements made. Moreover, this study offers efficacious measures to address these challenges and promote the progress of sustainable development within the industry. To optimise wind power generation in Tamil Nadu and Kerala, it is crucial for policymakers to establish a favourable regulatory framework that incorporates various incentives such as feed-in tariffs and tax benefits. Additionally, prioritising long-term power purchase agreements is essential.

Keywords: wind energy, sustainable development, climate change, bio energy, welfare

Introduction

The relationship between energy and economic development is of paramount importance, since the two are intricately interconnected. The impact of energy source accessibility, affordability, and reliability on several aspects of the economy, such as output, consumption, employment, and general welfare, is substantial. Energy is an essential and indispensable factor in all production processes, enabling companies to engage in the manufacturing of goods, provision of services, and creation of job opportunities. Nations endowed with ample and readily available energy resources tend to exhibit accelerated rates of economic expansion. As civilisations undergo expansion, there is a general tendency for their energy consumption to increase. The escalation of energy demand is driven by the growth of industrial output, commercial activities, transportation, and household energy usage. Decreases in energy usage might serve as potential indicators of economic downturns or enhanced energy efficiency. Elevated energy prices have the potential to augment the operational expenses of enterprises, hence potentially diminishing their profitability and resulting in escalated prices for consumers. Fluctuations in energy prices have the potential to create uncertainty and have an impact on investment choices within energy-intensive sectors. The provision of advanced energy services plays a vital role in mitigating poverty and promoting societal progress. The absence of stable energy supplies is a significant obstacle to economic possibilities, education, healthcare services, and general human development in many developing countries. The pursuit of economical and sustainable methods to expand energy access has the potential to foster economic empowerment and improve living circumstances.

The investigation into the significant role of energy in the context of economic development and its correlation with economic growth has been the focus of intense academic research (Stern, 2019). Energy is widely acknowledged as a significant driver of economic development in all nations. According to Rafindadi and Ozturk (2021), it has been observed that economic growth has a favourable impact on energy use, hence presenting difficulties in terms of price and economic progress as a result of resource constraints.

Economists commonly acknowledge the correlation between energy usage and economic development. Nevertheless, the widespread use of conventional energy sources presents ongoing difficulties in ensuring their availability. The substantial demand for conventional energy in contemporary consumption has significant implications on price and production, as well as environmental contamination, heightened infrastructure and administration expenses, and the worsening of traditional energy source shortages. As a consequence, several nations depend on the importation of energy resources, a circumstance that may lead to the reduction of foreign direct investment. The current energy crisis embodies a fundamental clash between inadequate energy resources and an overwhelming surge in energy use.

The global community is now seeing a notable proliferation of renewable energy sources, driven by nations' acknowledgement of the need to mitigate glasshouse gas emissions, address the challenges of climate change, and shift towards more environmentally friendly energy systems. Presented below is a comprehensive analysis of the current worldwide landscape pertaining to renewable energy. The objective of this study is to perform a thorough analysis of the developmental landscape of wind energy in the states of Tamil Nadu and Kerala. Specifically, the study aims to evaluate the cost and revenue structure of wind energy units, assess the profitability of wind mill units, and identify key challenges associated with this sector.

Review of literature

World scenario of renewable energy

According to the 2020 report by the International Renewable Energy Agency (IRENA), the proportion of renewable energy in the global power generation capacity was around 29.3% (Hasanuzzaman et al., 2017). The use of solar and wind energy for power production has seen substantial growth. Numerous countries have made substantial investments in utility-scale solar generating installations and distributed solar systems (Zhang et al., 2022). The establishment of onshore and offshore wind farms is being facilitated by advancements in wind turbine technology, decreasing costs, and favourable wind resources. Offshore wind power is gaining momentum, especially in countries such as the United Kingdom, China, India, and the United States. There is a growing focus on smaller-scale hydropower installations, such as run-of-river projects, in order to mitigate environmental impacts (Akuru et al., 2017). This is noteworthy considering the longstanding presence of large-scale hydropower facilities. Biomass resources are used in several sectors, including transportation, energy generation, and heating (Celebi et al.,

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2019). In order to ensure that the production of bioenergy does not have a negative environmental effect, it is essential to prioritise sustainable practises and the use of waste resources.

In the contemporary global context, the use of wind energy for power generation has emerged as a feasible and environmentally beneficial alternative. The economic aspects of wind energy play a crucial role in facilitating its broader acceptance, particularly in light of escalating concerns over climate change and energy security (Stigka et al., 2014). This article explores the primary economic aspects of wind energy, including its cost-competitiveness, potential for generating money, and other factors that contribute to its financial viability.

One notable advantage of wind energy is its increasing affordability relative to other forms of energy. The capital expenditures associated with wind energy initiatives have seen a significant decline due to advancements in technology, economies of scale, and expedited project development processes. Moreover, the levelized cost of electricity (LCOE) associated with wind energy has seen a consistent downward trend, hence enhancing its economic attractiveness. As a result, wind power has emerged as a very cost-effective option for the establishment of new power facilities (Shields et al., 2021).

By the 19th century, both Denmark and Holland had a significant number of functioning windmills, exceeding 7,000 in each country. Between the years 1850 and 1970, a substantial quantity of miniature wind turbines with multiple blades was constructed in the United States, surpassing a total of 6 million units (Pachauri et al., 2014). Presently, it is approximated that around one million of these wind turbines remain functional. Fabric and wood windmills, which are affordable, continue to be used. The use of windmills is still seen in Thailand and the Valley of 10,000 Windmills located on the island of Create (Bili & Vagiona, 2018). The Danish government initiated a programme during the early 2000s aimed at establishing a series of wind-powered electricity generation facilities. Several European countries, such as the United Kingdom, France, Germany, and the United States, have initiated such projects(Wang et al., 2021). Nevertheless, the utilisation of wind energy had a decline and garnered little attention until the early 1970s, partly due to the widespread availability of inexpensive oil throughout the 20th century.

Methodology

Sampling strategy

The sampling strategy used in this research involves the selection of a sample consisting of 46 wind turbines for investigation. Specifically, 21 turbines were picked from the region of Kerala. The selection criteria for these turbines may be determined by several aspects, including but not limited to age, capacity, location, and operating history.

The study methodology includes the acquisition of primary and secondary data to assess the operational effectiveness and status of the chosen wind turbines.

The data collecting techniques

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1. Field Visits and Inspections: Researchers undertake site visits to wind turbine installations in order to do visual inspections, gather empirical data, and evaluate the operational status of the turbines. The components under examination include rotor blades, towers, nacelles, electrical systems, and control systems.

2. Data Collection Methods: The research employs interviews and surveys as primary data collection techniques. Interviews are done with key stakeholders, such as wind farm operators, maintenance employees, and specialists in the wind energy field. Surveys may also be used as a means of collecting data pertaining to maintenance practises, operational difficulties, and the experiences encountered when turbines achieve their intended lifespan.

3. Utilisation of Secondary Data: This study makes use of secondary data obtained from a range of reputable sources, such as publications from the Tamil Nadu and Kerala Electricity Boards, KSE Regulatory Commision, Centre for Monitoring Indian Economy, ANERT (Agency for Non-Conventional Energy and Rural Technology), Energy Management Centre, Kerala State Planning Board, Tamil Nadu State Planning Board, U.N. Environment Programme, Energy Audit Centre, TRAC (Technical Research Assistance Centre), IEA (International Energy Agency), and OECD (Organisation for Economic Co-operation and Development).

By including data sourced from esteemed publications, this research guarantees the dependability and authenticity of the material used for the examination and assessment of the wind energy industry in Tamil Nadu and Kerala.

Results

The term "installed capacity" pertains to the highest power output that wind farms are capable of generating under optimal circumstances. This metric denotes the aggregate power generation potential of the wind turbines situated at various locations. Wind farms are a kind of renewable energy infrastructure that harnesses the power of wind turbines to transform the kinetic energy of wind into electrical energy. The Muppandal wind farm, located in Tamil Nadu, has a total installed capacity of 1,500,000 kilowatts, equivalent to 1.5 gigawatts. The Thoothukudi wind farm, located in Tamil Nadu, has a total installed capacity of 50,400 kilowatts, equivalent to 50.4 megawatts. The Tirunelveli wind farm, located in the state of Tamil Nadu, has a total installed capacity of 51,000 kilowatts, equivalent to 51 megawatts. The Kanjikode KINFRA industrial park in Kerala is home to a wind farm with an installed capacity of 22,000 kilowatts, equivalent to 22 megawatts. The Muppandal wind farm, located in Tamil Nadu, has a total of 1,622 turbines and has a capacity to produce 1,500,000 kilowatts, equivalent to 1.5 gigawatts, of electrical energy. The Thoothukudi wind farm, located in Tamil Nadu, consists of 54 turbines that together provide an energy output of 50,400 kilowatts, equivalent to 50.4 megawatts. The Tirunelveli wind farm, located in the state of Tamil Nadu, has a total of 55 turbines and has the capacity to produce 51,000 kilowatts, equivalent to 51 megawatts, of electrical energy.

Table 1. State wise Wind farms and installed capacity

State	**Wind farm**	**Electricity generated**	
Tamil Nadu	Muppandal wind farm	1500MW (93.8%)	0.0003% of total

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	Poolavadi wind farm	50.4MW (3.1%)	electricity utility of state
	Kayathar wind farm	51MW (3.1%)	
Kerala	Kanjikode KINFRA industrial park	22MW (19%)	0.00005% of total electricity utility of state
	Kozhikode	96MW (81%)	

State	**Wind Farms**	**Installed Capacity**
Tamil Nadu	Muppandal wind farm	1500000 KW
	Poolavadi wind farm	50400 KW
	Kayathar wind farm	51000 KW
Kerala	Kanjikode KINFRA industrial park	22000KW
	Kozhikode	96000KW

Source: secondary data

Kerala, a state in India, is home to the Kanjikode KINFRA industrial park. Within this industrial park, there exists a wind farm consisting of 23 turbines. This wind farm has the capacity to produce a total of 22,000 kilowatts, which is equivalent to 22 megawatts, of electricity. The wind farm located near Kozhikode, Kerala, has a total of 103 turbines, which together produce an impressive 96,000 kilowatts (or 96 megawatts) of electrical energy. The numerical value of turbines represents the quantity of wind turbines that are situated inside a certain wind farm. The turbines in question are designed to harness the kinetic energy present in wind and then transform it into electrical energy. The energy production value denotes the quantity of electricity generated by individual wind farms, often measured in kilowatts (KW) or megawatts (MW), under regular operational circumstances.

The Muppandal wind farm, located in Tamil Nadu, is responsible for the generation of 1,500 megawatts (MW) of electricity. This capacity represents a significant portion, roughly 93.8%, of the total wind energy utility available in the state. The Muppandal wind farm plays a substantial role in augmenting the renewable energy capacity in Tamil Nadu, constituting a considerable proportion of the state's electricity production.

The Thoothukudi wind farm, located in Tamil Nadu, has a capacity to produce 50.4 megawatts (MW) of power, contributing around 3.1% to the overall energy supply in the state.

Table 2 Electricity generated annually from wind energy

State	**Wind farm**	**Electricity generated**	
Tamil Nadu	Muppandal wind farm	1500MW (93.8%)	0.0003% of total electricity utility of state
	Poolavadi wind farm	50.4MW (3.1%)	
	Kayathar wind farm	51MW (3.1%)	
Kerala	Kanjikode KINFRA industrial park	22MW (19%)	0.00005% of total electricity utility of state
	Kozhikode	96MW (81%)	

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Source: Primary data

The Tirunelveli wind farm, located in Tamil Nadu, has a capacity to produce 51 megawatts (MW) of energy, contributing to around 3.1% of the overall power supply in the state. Kerala, specifically the region of Kanjikode, is a subject of interest in this discussion. The KINFRA industrial park in Kerala is equipped with a wind farm that has a capacity to produce 22 megawatts (MW) of electricity. This wind farm plays a significant role in the state's wind energy electrical utility, providing around 19% to the overall total. It is noteworthy, if very modest, in terms of its contribution to the total energy production in the state of Kerala. The wind farm located near Kozhikode, Kerala, has a capacity to produce 96 megawatts (MW) of power, which accounts for a substantial portion of around 81% of the whole wind energy electricity production in the state. The Kozhikode wind farm significantly contributes to fulfilling the energy requirements of local industries in the state of Kerala. The percentages represent the relative contribution of each wind farm to the overall power generation from renewable sources. This study offers valuable insights into the comparative importance of wind power within the broader energy composition of Tamil Nadu and Kerala.

Discussion

The objective of this study is to examine the overall status of wind energy development in the regions of Tamil Nadu and Kerala. The provided information encompasses the challenges faced by the industry, the financial performance, and the current state of wind energy development. The objective of the study is to provide remedial measures to effectively tackle these concerns and foster the advancement of sustainable development.

The wind farms located in Tamil Nadu and Kerala, namely Muppandal, Thoothukudi, Tirunelveli, Kanjikode KINFRA industrial park, and Kozhikode, exhibit diverse characteristics in terms of the quantity of turbines and their corresponding energy generating capacity. They together contribute to the mitigation of carbon emissions, the advancement of clean energy technologies, and the facilitation of renewable energy objectives. The examination of the age profile shows that a majority of the turbines within these wind farms fall within the 1 to 16-year age range, suggesting a consistent practise of maintenance and upgrades. The Muppandal wind farm in Tamil Nadu and the Kozhikode wind farm in Kerala are notable for their significant contributions to the respective states. They fulfil important functions in the renewable energy provision of their respective states. According to the statistics, it can be seen that in both Tamil Nadu and Kerala, the prevailing wind energy generator (WEG) size stated by the participants is 225 kW. The aforementioned size is indicative of a significant proportion of the installations in both states, indicating a notable inclination towards 225 kW wind energy generators (WEGs).

In the state of Tamil Nadu, the prevalent size for wind energy generators (WEGs) is 250 kW, ranking second in popularity, while the subsequent size is 500 kW. The aforementioned sizes are likewise significantly represented among the participants. The presence of WEG sizes of 600 kW and 850 kW is comparatively smaller in Tamil Nadu. Likewise, in the state of Kerala, the 250 kW capacity emerges as the second most prevalent size for wind energy generators (WEGs),

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followed by the 500 kW variant. No participants in Kerala reported WEG sizes of 600 kW and 850 kW, suggesting that these levels are not widely used or favoured in the region. The distribution of wind energy generator (WEG) sizes is indicative of the preferences and installations within each state. The prevalence of 225 kW wind energy generators (WEGs) in Tamil Nadu and Kerala indicates that this particular capacity is often favoured by stakeholders in the wind energy sector, possibly owing to its optimal combination of power generating capability and operational effectiveness.

Moreover, the data underscores the possibility for diversity and the exploration of other sizes of wind energy generators (WEGs) that may be inadequately represented in existing installations. Evaluating the viability, benefits, and obstacles related to various sizes of wind energy generators (WEGs) may contribute to the maximisation of renewable energy production, the optimisation of resource utilisation, and the promotion of a sustainable energy transition in both Tamil Nadu and Kerala.

The results of the study emphasise a notable preference for shorter payback durations, the significant contributions of wind farms to renewable energy, the financial success and revenue prospects of wind energy firms, and the employment generation and economic advantages brought about by wind farms. The aforementioned insights have significant value for stakeholders, politicians, and investors as they engage in the evaluation of the financial feasibility, effect, and prospects of wind energy initiatives in both geographical areas.

Conclusion

To promote and optimize wind power generation in Tamil Nadu and Kerala, policymakers should maintain a favorable policy environment with incentives like feed-in tariffs and tax benefits while prioritizing long-term power purchase agreements. Scaling up renewable energy targets, regional planning, and grid integration efforts are crucial for expanding wind farms. Investing in research and development to improve turbine technology and engaging local communities for their benefit is essential. Encouraging small-scale wind farms and fostering cross-state collaboration can further enhance the sustainable growth of wind power in these regions. In essence, this study not only provides an in-depth understanding of the current wind energy landscape in Tamil Nadu and Kerala but also highlights opportunities for further growth and diversification in the pursuit of sustainable energy development. It offers valuable insights for decision-makers and industry stakeholders to foster the advancement of clean and renewable energy in these regions.

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