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AN OVERVIEW OF ENVIRONMENTAL ISSUES ASSOCIATED WITH WIND ENERGY

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ABSTRACT

Wind energy, which is considered one of the most mature renewable energy sources, has seen tremendous growth in recent years. Many nations have shown interest in using wind power, although many are worried about the wind farms' environmental effect. The rapid expansion of the wind energy sector in many parts of the globe, particularly in developing nations and environmentally sensitive areas, requires a thorough knowledge of wind farm-induced environmental effects. In this article, previous studies were summarized to evaluate the environmental problems created by wind farms. This paper explored available mitigation strategies for reducing these negative environmental effects. The goal of this document is to offer wind energy planners and developers with up-to-date information on environmental problems connected with wind energy development, as well as mitigation methods.

KEYWORDS: *Animals, Associated, Environment, Issues, Wind Energy.*

1. INTRODUCTION

The use of fossil fuels is thought to be one of the main contributors to global warming. Renewable energy sources are rapidly attracting the attention of energy experts, industry professionals, and government decision makers in an attempt to decrease dependence on fossil fuels. Biomass, wind, and geothermal energy technologies are rapidly evolving and becoming more economically competitive[1]. According to the European Renewable Energy Council's estimates, renewable energy will account for about half of total world energy supply by 2040. Before 2050, Johansson et al. Projected a significant rise in renewable energy output and efficiency. This increased usage of renewable energy should result in a significant reduction in carbon dioxide emissions. Wind power has seen rapid development in the last decade as one of the most mature renewable energy sources[2]. Wind power has emerged as the preferred energy source for planners and national governments aiming to diversify energy supplies, decrease CO2 emissions, develop new businesses, and provide new job possibilities[3].

According to the most recent Worldwide Wind Report, the total global wind power installation at the end of 2013 was 318.105 GW. Wind energy development, on the other hand, does not come without negative environmental consequences. The wind energy sector, particularly in developing nations and environmentally sensitive areas, is concerned about a lack of knowledge of these environmental effects[4]. The authors of this article examined possible environmental problems caused by wind farm construction, evaluated data from previous case studies, and suggested methods to minimize these negative environmental effects. This review research informs energy

sector planners and developers on how an ineffective wind farm project design may have a negative impact on the surrounding ecosystem. To prevent harm to sensitive biological systems, mitigation measures should be performed throughout the design, building, and operating stages of a wind farm[5]. Turbines that convert wind energy into electrical energy or mechanical power in a wind power facility. The density of the air, the area swept by the turbine blades, and the cube of the wind speed determine a turbine's output power.

Wildlife safety, bio-system disruption, noise, visual pollution, electromagnetic interference, and local climate change are the main environmental concerns associated with wind turbine use [8,9]. These problems may be divided into three categories: ecological consequences, human impacts, and climate-related issues[6].

1.1 Effects On Animals:

- **Birds:** Wind turbines put birds at danger of death and disruption. Collisions with the spinning blades of a wind turbine may kill birds, while collisions with the turbine towers, nacelles, or other structures in a wind farm, such as guy cables, power lines, and meteorological masts, can inflict fatal injuries[7]. Scholars found that monopole wind turbine crashes killed an average of 234,000 birds per year in the United States. According to scholars, bird mortality rates for wind turbines with rotor diameters ranging from 33 m to 72 m in various parts of the United States average 2.3 birds per turbine per year. Despite the fact that birds have been killed by pesticides or accidents with other human-made buildings, such as fossil fuel infrastructures, the negative impacts of wind farms on birds must not be overlooked. Wind turbine towers have also been reported to have killed uncommon birds such as golden eagles, swans, and Cantabrian capercailzies. It's impossible to compare the mortality rates in these investigations since the researchers employed various techniques to determine the number of bird deaths. Variations in search area, searcher effectiveness, and predator clearance rates make an exact bird mortality rate difficult to determine [8]. The frequency of deadly bird accidents varies depending on where you are. Even within the same site, there are variations between various sets of wind turbines. Wind turbine design and layout, bird species, and meteorological variables all have a role in bird death caused by wind turbines. Bird mortality was greater for lattice turbines than for other turbine tower designs. The avian fatality rate is also influenced by the wind farm's location and structure. The angle of approach between the bird flight path and the turbine orientation was shown to have a substantial relationship with the likelihood of a collision. The most hazardous locations for birds were the ends of turbine strings, the edge of the gap in the strings, and the margins of the wind turbine cluster. Bird death rates rose in locations where turbines were built on ridges, upwind slopes, or along bird migratory pathway[9]. If a wind farm is located near a bird migratory path, for example, birds must avoid the wind farm and divert from their normal route. The additional deviation effort increases the birds' energy consumption and lowers their survival chances. The impact of wind farms on birds is species-specific. In fact, bird mortality has been linked to the species of bird.
- **Bats:** Moving items elicit greater responses from bats than stationary objects. However, a significant incidence of bat death has been reported around wind farms. Nearly a fifth of all bat species in the United States and Canada have died as a result of wind turbines. Wind turbines killed not just local bats, but also migrating bats, according to research. Researchers, on the other hand, disagree on the causes of bat deaths. Early research indicated that bats were killed by barotrauma and internal bleeding due by the rapid pressure decrease near the turbine edges. Internal bleeding caused by barotrauma was observed in more than half of the deceased bats. Impact trauma was shown to be the cause of the majority of turbine-related bat fatalities in more recent studies. Alternative theories were offered by other researchers. Bats may be

attracted to wind turbine lights and ultrasonic emissions, according to Scholars. However, further study is needed to back up this theory. Another hypothesis is that the bats mistook the wind turbines for trees and attempted to use them as roosting places. Furthermore, a significant number of insects attracted by the intense heat radiation emitted by the wind turbine nacelles may induce hunting bats to congregate near the turbines. Although bat corpse search is simpler in grassland regions compared to agricultural landscapes or wooded ridge tops, discovered a high number of dead bats in utility-scale wind energy plants situated along forested ridge tops. According to Scholars, bats are more at risk from wind farms on wooded slopes. In addition, during the fall migration and the two-hour period after sunset, more bats were killed[10].

- **Marine Life:** Offshore wind turbines have the potential to harm marine life. Wind turbine foundations and towers are built on-site, making saltwater turbid and introducing new items to the bottom, which may harm benthic wildlife and vegetation and obstruct sunlight. Wind turbines and their scour protection may alter the distribution of fish in the area. The building of wind farms produces an artificial reef, which has an effect on biodiversity. According to research on two Danish wind farms, the number and variety of benthic communities grew more than the native infauna groups near the turbine foundations. Wind turbines constructed in saltwater have also been shown to significantly boost fish populations, perhaps due to increased resident food sources on the turbines on the other hand, felt that if the cumulative effect was taken into account, offshore wind farms would have a significant impact on fisheries. The chances of catching valuable species, in particular, would be greatly decreased. Other research, on the other hand, found that the investigated offshore wind farm provided neither a direct benefit nor a clear danger to fish variety or sandeels and their sand habitat during a seven-year time frame following construction. Fish may be harmed by the noise and electromagnetic waves produced by wind turbines. Wind farms may cause reactions in marine animals such as porpoises and seals, particularly during building operations such as pile driving. During the building and operation of the Nysted Offshore Wind Farm, researchers noticed a significant decrease in the number of porpoises, which lasted for two years. Maintenance operations on wind turbines, such as component replacement or lubrication, may cause oil or trash to leak into the surrounding saltwater, polluting it. Although research findings in the literature suggested that the potential impacts of wind farms on marine life occurred primarily during the construction phase, with impacts during the operational phase being more local, marine wind farms should be carefully planned to avoid major habitats of local sea animals.

- **Soil Erosion and Deforestation**: Some operations, such as foundation excavation and road building, may have an impact on the surrounding bio-system during the development of a wind farm. Surface soil would be exposed to severe wind and rainfall if surface plants were removed, resulting in soil erosion. Construction site wastewater and oil may leak into the ground soil, causing severe environmental issues. Grasslands, moorlands, and semideserts, which have abundant wind resources, usually have poor eco-systems with little bio-diversity. Heavy equipment construction may disrupt the local ecobalance, and recuperation of the local ecosystem may take a long period. According to a Chinese wind turbine building guideline, excavation should include as much human work as feasible to reduce the disruption caused by the heavy machinery. Trees and grasses should also be replaced as soon as feasible following construction, according to the regulation.

- **Noise:** One of the main environmental impediments to the growth of the wind power sector is noise. During calm nights, according to Van den Berg, individuals reacted significantly to wind turbine noise within 500 meters of the wind farm and reported annoyance within 1900 meters of the wind farm. People were likewise shown to be more irritated by wind turbine noise than by traffic noise. Furthermore, the visual and aesthetic effects of wind turbines on

the landscape may irritate people. However, research on the connection between irritation and wind turbine noise are limited in comparison to the vast amount of data on traffic noise-induced aggravation.

1.2 Environmental Concerns Associated With Wind Energy Mitigation:

- **Keeping The Impact On Birds and Bats to a Minimum:** Several methods may be explored to minimize bird deaths. Construction operations should be limited to non-breeding times to minimize the detrimental impacts of bird disturbance. Improvements in structural design have also been shown to reduce avian mortality. Enlarging the blades and reducing the rotational speed of wind turbines, for example, may reduce the number of birds killed. One of the reasons birds crash with turbine towers is the effect of wind turbines on their eyesight. Mc Isaac discovered that pattern painted blades may improve raptor optical acuity. With night illuminations, blades may be seen more clearly. However, there are differing viewpoints on the effect of this approach. The lights on turbine towers, according to Langston and Pullan, may attract birds, particularly in poor weather, and enhance the risk of collision.
- **Minimizing The Impact on the Maritime Environment and Climate:** The rotor-generated turbulences should be minimized to lessen the meteorological effects of wind farms. Turbulence may be minimized and hydro-meteorological effects can be managed through better rotor and blade designs, as well as appropriate turbine spacing and pattern design. It is also recommended that wind farms be built in areas where wind energy is plentiful and frictional dissipation is low. Wind energy will be collected instead of being lost due to friction. The goal of this approach is to make wind farms more efficient. Preliminary study suggested that noise from offshore wind turbine operations could not be heard 20 meters below the water's surface, and that visual effects of wind farms may be minimal at eight kilometers distant from the coast. However, since offshore wind farms are not usually situated far from the coastline, further research is required to better understand the impact of offshore wind turbines on the marine ecosystem. The environmental effects of wind farms, such as habitat fragmentation, sounds, vibrations, electro-magnetic interferences, and impacts on fish, marine animals, and benthos, are becoming more important as the height of wind turbine towers and the scale of offshore wind farms grows. As a result, the development of offshore wind farms should be carefully regulated to prevent polluting the environment. To reduce disruptions, pile driving should be avoided during porpoise migration seasons. Offshore wind farms should be geographically distributed using modeling and analysis to optimize income while preserving marine fish populations.
- **Noise Abatement:** Improved blade design is the key to reducing wind turbine noise. During the blade design phase, a compromise between noise radiation and energy output should be investigat. The aerodynamic noise may be substantially reduced if the blades are designed properly. The usage of upwind turbines to decrease low frequency noise is also beneficial. During operation, the insulations within the turbine towers may effectively reduce mechanical noise. Compared to conventional industrial gearboxes, customized gearboxes for wind turbines produce less noise. To guarantee strength, prolong the equipment's lifespan, and muffle noise, the steel wheels of the unique gearbox feature semi-soft and flexible cores with hard surfaces. Direct-drive wind turbines, which do not need a gearbox or a high-speed mechanical component, are quieter. At low wind speeds, variable-speed turbines produce less noise than constant-speed turbines. Aside from technological precautions, building wind farms near loud regions is another method to prevent noise-related issues. Road traffic, for example, may conceal wind turbine sounds if the traffic noise is at least 20 decibels higher than the turbine noise.

2. DISCUSSION

The study examined previously available information on the wind power industry's environmental effects and possible mitigating strategies. Several observations based on the talks are presented as follows: In the literature, various rates of bird and bat mortality have been recorded as a result of wind turbines. Turbine types, a wind farm's topography, bird/bat species, meteorological conditions, and a variety of other factors all influence the death rate. Although it is unclear how much of an impact offshore wind farms have on the marine environment, care should be used when placing offshore wind turbines near important sea mammal habitats. Wind turbines are still not subject to strict bio-system protection regulations in many countries. Environmental impact studies are often the responsibility of the developer. To completely comprehend the effects of wind farms on local ecological systems, further study is required. Wind turbine noise has been researched for many years, and a number of criteria have been published in various nations and areas. Following appropriate noise restrictions and distance requirements established from those scientific research is one acceptable way to reducing wind turbine noise nuisance. In contrast to thorough study on other noise sources, such as traffic noise, there is a scarcity of reliable data and quantitative scientific studies on wind farm sounds.

3. CONCLUSION

One answer to the global energy crisis is renewable energy**.** Renewable energy also has positive socioeconomic effects, such as diversifying energy supplies, expanding regional and rural development possibilities, and fostering domestic industry and employment [142]. Renewable energy, on the other hand, may cause environmental problems in a habitat or a community. Despite the fact that the environmental effect of wind turbines is still a contentious issue, it should not be overlooked. When wind energy becomes one of the primary energy sources, minor problems now may have severe consequences in the future. More scientific research on the possible environmental effects of wind farms are required, as demonstrated in this review study. The economic, social, environmental, biological, and ecological impacts of wind energy development and associated infrastructure building projects should be assessed. To minimize the environmental impacts of wind farm infrastructure development and operation, appropriate measures should be put in place. To guarantee that projects are built in a manner that avoids, minimizes, and mitigates environmental effects, developers, planners, and government officials must collect and convey full information to the public.

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