

Potential Ecological Effects of Onshore and Offshore Wind Farms for Electricity Generation in Nigeria: A Review

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Keywords

Wind Farm, Ecology, Electricity, Offshore, Onshore, Wind Turbine

Potential ecological effects of onshore and offshore wind farms for electricity generation as applicable to Nigeria are reviewed. This is against the backdrop that the nation contemplates diversification of existing energy sources. The article discusses succinctly what wind farms are, its beneficial and harmful impacts. Mitigation approaches centred on technological innovations and modifications, species-specific methods, habitat alteration and involvement of ecologists through research and consultancy are listed. It is concluded that a broad-based approach needs to be adopted that will collaboratively engage all related and relevant professionals in order to attain sustainable exploitation of this renewable energy source. This is because the much needed advancement can be attained through renewable energy sources that are environmentally sustainable.

Introduction

Wind farms are a source of energy contained in the force of the winds blowing across the earth's surface which can be converted into electrical energy for performing diverse tasks that benefits man to meet his needs (Gipe, 2008). Therefore the wind energy is transformed into electrical energy by the turbines and thereafter can then be transmitted to many facilities, mechanized farms and homes. It involves connecting a spinning rotor, which is basically an assemblage of rotatable blades to an electricity generator that converts the mechanical energy into electrical energy for onward transmission to wherever it is needed (Gipe, 2008). It is a renewable energy source that is highly sustainable for preserving the ecosystem especially in the ensuing environmental threat of climate change due to fossil fuel combustion (Tyokumbur, 2010a, b). Historically, wind energy has long been utilized in pulverizing grains, water pumping, timber milling and provision of mechanical energy (Gipe, 2008). Large wind farms usually consist of several hundred wind turbines and may cover a wide area depending on the spacing, although the interspersing area on land in between the turbines have been put to other uses such as agriculture, recreation and ecotourism. Wind farms may be located onshore on land or offshore in the oceans and seas depending on the force of the wind that can be harnessed into electrical energy. Ecologically, wind is a climatic factor. Ecology is the biological study of the interrelationships between living things and their environment which includes understanding the effects of man and his activities on the living and non-living components of his surroundings (Miller and Spoolman, 2010; Tyokumbur, 2010a,b,c). Human activities that have both beneficial and adverse impacts on man and his environment include agricultural, industrial, urban development and a host of other land uses. These human activities include wildlife exploitation for their genetic, meat and food resources, holiday camping; transportation, waste disposal and water management. In ecology, living things are grouped as biotic factors whereas the non-living things capable of influencing the natural biological components of the ecosystem are known as abiotic factors.

The biotic factors or components are basically divided into the animal and plant kingdom. Although these may be regarded as separate kingdoms in biological classification, a third group known as microorganisms has variously been categorized. This new group contains both animal or plant species that are microscopic in size and structure on the basis of a basic characterizing feature. In terms of nutrition, the freshwater protozoan *Euglena viridis* that is capable of photosynthesizing its own food in the presence of light due to the presence of chloroplasts that are rich in the green pigment known as chlorophyll. In addition it actively absorbs nutrients from its surroundings in the absence of light thereby showing its non-photosynthetic nature. On the other hand, abiotic factors include:

- i. Edaphic factors of the environment that influence the soil ecosystem through variations in soil profile, texture, chemistry and physical composition.
- ii. Topographic or landscape physical features such as rivers, valleys, hills, mountains, swamps, coastline and boulders that have the potential of influencing the biotic community. These characteristics are often regarded as physical relief features.
- iii. Climatic factors such as rainfall, wind, temperature, humidity, visibility, cloud cover and fog. Climatic factors affect weather conditions on a daily basis and can be predicted and forecast based on existing data.

The fact that biotic and abiotic factors have direct and indirect benefits to man makes them known as natural capital, while the accruing uses to which it is put to and the ecological value is regarded as ecosystem services. Thus electricity derivable from wind farms can be referred to as an ecosystem service to man. Since wind farms are a human intrusion on the natural stability of the ecosystem, it is bound to have some ecological impacts. The ecological principle underlying biotic survival lies in the ability to stay alive through accessibility to required environmental resources in order to produce quality offspring or transfer genes from one generation to the next. Since wind farms are human creations with potential impacts on the natural landscape, ecological or environmental safety issues do arise during installation and when the facility is used to generate electricity. Generally, environmental safety encompasses the management of noise, toxic substances, fires, explosives and other potentially harmful effects in the human environment in order to safeguard ecosystem and public health (Tyokumbur, 2010). Since wind farms are usually installed onshore and offshore with diverse ecological impacts, this review becomes necessary given the developmental peculiarities of some countries contemplating the use of wind turbines installed as wind farms to generate electricity.

The aim of this review therefore is critically analyze the potential ecological effects of onshore and offshore wind farms for electricity generation.

Ecological Effects of Wind Farms

Technological advancements have made wind energy a viable source of alternative energy production and the number of wind plant facilities are being increasingly adopted and implemented in many countries with its potential ecological impacts (Osborn, *et al*, 2000, Don-Pedro, 2009). Although the benefits of wind farms are by far overwhelming due to the multiplier benefit chain that is accruable from electricity generation, some ecological impacts have been reported with others very likely as more countries adopt the renewable energy source. For the purpose of this review, the ecological effects or impacts can be grouped into beneficial and adverse impacts. There is no doubt that the beneficial effects far outweigh the adverse impacts on the ecosystem.

Beneficial Effects of Wind Farms

The beneficial effects of wind farms on the ecosystem include the following: i. Electricity generation: There is ample evidence that electricity generated from wind farms have the potential of impacting beneficially on the human environment through job creation, utilization on farms, domestic and industrial use and a host of other benefits to humans (Gipe, 2008).

ii. Ecotourism- Wind farms have the potential of attracting tourists thereby becoming a tourist destination for fun seekers to view the technology and observe bird flight patterns within the farm.

iii. It is assumed that the establishment of offshore wind farms could stimulate interest and the growth of the hitherto untapped potential of mariculture in the marine environment through the availability of an affordable and sustainable energy source within the vicinity.

iv. Environmental sustainability- Since wind turbines do not consume fossil fuel and emits no air pollutants, it a sustainable energy source that eliminates environmental outfalls that would impact adversely on the environment (Tyokumbur, 2010b).

v. Research and development opportunities- As wind farms are implemented, there is bound to be new frontiers of opportunities in research and development for the academia, policy makers, communities, land owners, industry, commerce and technology (Personal Communication).

Potential Adverse Effects of Wind Farms

i. Bird and bat strike:

Bird and bat mortalities associated with wind farms have been reported by Osborn, *et al* (2000), Manville and Albert (2005), Kunz *et al*, (2007) and Barea (2012). Osborn, *et al* (2000) reported that during 20 months of monitoring they found 12 dead birds while collisions with wind turbines were suspected for 8 out of the 12 birds collected with an indication of observer efficiency trials estimated at 78.8% while scavengers removed 39.5% of carcasses during scavenging trials. The study estimated that 36 ± 12 birds (<1 dead bird per turbine) were killed at the Buffalo Ridge wind farm in 1 year. Manville and Albert (2005) technical paper asserted that more than 15,000 wind turbines may be killing an estimated 40,000 or more birds annually in the United States of America with the majority in the State of California. This is one aspect of the impact of onshore wind farms that may be very challenging to mitigate.

ii. Temperature variability has been reported near wind farms without any significant ecological impacts (Roy, 2010).

iii. Potential adverse effects of offshore wind farms include the following:

- a. Obstruction of migratory routes of marine animals such as the fish salmon (*Salmo spp*) during turbine installation and use.
- b. Destruction of breeding sites of benthic animals (benthos) during installation and servicing due to an upsurge in total suspended solids (TSS) in marine water. This also has the potential of reducing light penetration thereby impeding photosynthetic activities of the phytoplankton.
- c. In the event of malfunction or failures of the installed turbines, animal mortality may increase due to electrocution (Manville and Albert, 2005).
- d. Although the wind farm may eventually serve as an identifiable landmark on the migratory routes of marine birds, it could pose a threat of bird strike when initially installed (Barea, 2012).
- e. Installed shafts of wind turbines in the marine environment could encourage the attachment of invasive invertebrates and migratory planktonic organisms thereby disrupting the ecological balance that may have previously existed therein.
- f. Marine pollution from outfalls from wind turbine installation, servicing and tourist vessels within the vicinity of the offshore facility.

iv. Disruption of aesthetic beauty of the landscape and noise nuisance- Wind farms has the potential of altering the visual beauty and quality of the landscape. The noise associated with the spinning wind turbine rotors has equally generated health concerns from some communities, although technological advancements could mitigate the impact (Gipe, 2008).

Mitigation of Ecological Impacts of Wind Farms

Mitigation of bird strikes involves species-specific approach, habitat alterations or modifications and technological innovations which are turbine-specific (May *et al*, 2015) amongst others. Funding research for baseline data acquisition and long-term studies by ecologists and other related human impact-based professionals.

Conclusion

It can be seen that potential impacts of wind farms are diverse and in order to implement, install and mitigate the effects on the ecosystem, a broad-based approach has to be used that will involve ecologists, wind energy engineers, policy makers and other professionals. This is because the much needed advancement can be attained through renewable energy sources that are environmentally sustainable. ■



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