Developing Mobile Wind Energy Unit for Supplying Power for Hurricane Affected Community

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Abstract

Hurricanes, also known as tropical cyclones, are storms that produce strong winds along the coast and pose a serious threat to urban areas. Because hurricanes can create large power outages due to trees collapsing and knocking down power lines, the populace of the coastal region suffers from power outages on a yearly basis. Texas has been hit by numerous hurricanes, and it is the US state with the second-highest number of hurricanes, trailing only Florida. In April 2020, a tornado outbreak swept through Texas, knocking down electricity to 4.3 million consumers and affecting an estimated 9.3 million people for three days. As a result, it is therefore imperative that mobile infrastructure be developed to provide electricity in these extreme situations. Renewable energy sources are not widely used in the aftermath of hurricanes. Generators that run on fossil fuels are the most frequent. One of the key reasons for this desire is because renewable energy sources' generators are often of static structure. Another factor is that renewable energy sources are not always reliable. This explanation, however, shifts in coastal places, particularly in Texas, where wind intensity is considerable. As a result, a small-scale wind turbine, either pre-installed or movable in nature, can be used to provide electricity to hurricane-affected communities, particularly for lighting, warmth, and cooking. Hence, in this study an attempt has been made to propose a suitable mobile wind energy infrastructure for providing power in such post hurricane situation.

1. Introduction

Hurricanes also known as tropical cyclones are storm with violent wind at coastal area regarded as hazards with major impacts on population centers [1]. In the United States (US), 164 million population- more than 50 % of the total population live in densely populated coastal counties, which are also major centers of economic activity contributing 58% of the national gross domestic product (GDP)[2]. As a result, these population on costal region yearly suffers from power outage problem as these hurricanes can cause massive power outages from trees collapsing and knocking down power lines. Hurricanes are also the major cause of power outage in US as 9 of the 10 largest blackouts are due to hurricanes [3].

Figure 1: Number of hurricane hits on different states of the US between 1851-2020[4]

The Texas state has had many hurricanes affect as it is the US state with the second most hurricanes affecting it, only behind Florida [5, 6]. After 1980, 81 tropical or subtropical cyclones affected different counties of Texas. According to weather forecasting center, a hurricane affect the coastal region about three times every four years [6]. Recently in April 2020, a tornado outbreak moved from Texas causing 4.3 million customers to lose power, affecting an estimated 9.3 million people for about 3 days [7]. Therefore, it is now high time to develop mobile infrastructure to supply electricity in these extreme conditions. This will not only prepare for such event but also mitigate several problems that may arises due to blackouts.

2. Objectives

The primary objective of this research is to provide a sustainable green electricity supply for a neighborhood in Texas that lost power due to a storm. This study also aims at providing a measure that provide preparedness and loss mitigation due to power outage cased from hurricane and would help in rapid recovery by supplying power from renewable energy resource. Other objectives are as follows:

1. To review the past power outage problems in Texas and attempts made to supply alternative power source.
2. To conduct the resource assessment on the area where there is possibility of occurrence of hurricane.
3. To purpose a suitable mobile renewable energy system (wind) for the area.
4. To conduct the technical and economic study of installation of purposed renewable energy system.

3. Methods

Renewable energy sources are not widely used in the aftermath of hurricanes. Generators that run on fossil fuels are the most frequent. One of the key reasons for this desire is that renewable energy generators are often of static structure. Another problem is the inconstancy of renewable energy sources. This, however, is changing in coastal locations, particularly in Texas. Because this area has high wind intensity. Hence, a small-scale wind turbine pre-installed or mobile nature can be used to supply electricity to those hurricanes effected community especially providing small amount of power needed for lightening, heating, and cooking purposes. In this study we study a feasibility of small-

scale mobile wind turbine units to supply power to hurricane effected community.

Resource Assessment

Wind energy resource assessment is crucial before designing suitable wind turbines and other infrastructure. Ground Structure of mobile wind energy unit is less robust due to mobile/emergency in nature. So, wind speed at low hub height is taken for resource assessment. Costal area of Texas has lower wind speed at 10 m hub height i.e below 4 m/sec as shown in figure 2[8].

Figure 2: Wind energy potential at 10-m hub height in the US.

Description of Mobile Wind Energy Unit

The most important aspect is to construct wind turbines that can operate in low-speed winds. Horizontal axis wind turbines are the most common type of wind turbine today, and they are typically employed in very flat locations with consistent wind conditions throughout the year. The main components of these systems are a tower, blades situated at the top of the tower and moving in the horizontal axis, and energy-generating machines. Vertical axis wind turbines, unlike horizontal axis wind turbines, have blades that revolve in the vertical axis. Although it is not as efficient as wind turbines in generating huge amounts of energy, it can be employed in regions with more erratic wind patterns, such as the coastal strip.

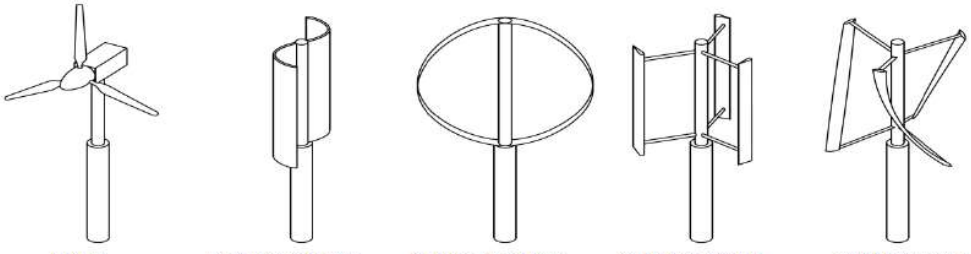

Figure 3: Different types of wind turbines [9]

For emergency use in hurricane-affected areas, a tiny 4-bladed vertical wind turbine that may be placed on a ground vehicle (4WD) is proposed[10]. The movable wind turbine can readily catch the wind in any direction and strength due to the design of the blades. As a result, energy generation will be achievable even in the presence of changing wind intensity, as seen in hurricane-affected communities along the coast. A pre-installed small wind towers can also be used during the emergencies after hurricane. For such pre-installed wind towers mobile electrical system should be built for supply to individual homes. The usage of many mobile wind turbines can be used to create a wind farm. As a result, energy needs can be met not just in the aftermath of a hurricane, but also in other emergency situations. The cost of the planned mobile wind turbine is expected to be similar to that of typical static wind turbines.

Figure 4: Proposed mobile wind energy unit.

4. Conclusion

In this study, a transportable wind turbine made consisting of a 4WD truck is proposed for use in supplying electric power using wind energy during hurricane emergencies. Mobile wind turbines have the added benefit of being mobile while still providing sustainable electricity in remote locations. One of the most crucial aspects of the mobile wind turbine design phase is ensuring that the system can be mounted and moved using a mobile ground vehicle. As a result, the constructed vertical axis wind turbine is presented for this proposal.

5. References

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