EVALUATION OF AVERAGE MONTHLY WIND VELOCITY IN OWERRE-EZUKALA, ANAMBRA STATE, NIGERIA

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ABSTRACT

Energy exists in many different forms such as heat, kinetic, electrical, chemical, etc. A form of energy may not be useful in its crude form, and needs to be transformed into a different useful one. To convert the energy from one form to another, a tool is needed. Any moving object has a kinetic energy which causes the motion of the object. Since the wind moves, so it has a kinetic energy which is very important for natural applications such as vaccination of trees and rains. However, considering industrial applications, the kinetic energy of the wind will be more useful if it can be converted into electrical energy. This is done by using wind turbines. The main purpose of the wind turbines is to convert the kinetic energy of the wind into mechanical energy by the blades and then into electrical energy by the generator. This paper evaluates the average monthly wind regime in Owerre-Ezukala town, South-East Nigeria. Data gathering for this evaluation spans between March 2016 and March 2017; using the electronic digital anemometer, at an altitude of 10m. The highest and lowest measured wind velocities are 6.7m/s and 4.8m/s respectively. Subsequent determination of the V-calculated was perfected by the application of Betz' mathematical model.

Keywords: Anemometer, Wind Velocity, Wind Energy, Sustainable Energy

Introduction

Energy supply in Nigeria today is a major problem for both small scale and large scale purposes. The conventional energy supply has not equally been distributed, and is inadequate in meeting the economic needs of the populace. This looming problem had affected productivity in every facet of her economy. At one point or the other, government brings out scheme to better the efficiency of power and energy supply. These programmes often fail to materialize, perhaps, because of either managerial inadequacies or insufficient generation of energy to satisfy the need of the teaming Nigerian populace. Manufacturing and pharmaceutical industries, suffer serious regression in their operation, as a sequel. The quest to resolve the above identified problem set the researcher into thinking of an alternative energy source that can adequately satisfy the electricity need of the designated geographical area. However large Nigeria's energy resource of fossil fuel may be, it is being consumed at a high rate, and one day, the fuel resource will become so depleted that the normal existence of energy-dependent firms will be seriously disrupted, unless other energy sources have become available on the scale necessary to meet the country's energy demand. Many warnings have been given over the years about Nigeria's rate of fuel refining and consumption, and the prospects of future fuel shortage. Nevertheless, each time the crisis has passed and the nation has continued on its unrealizable strategies. There is a renewed awareness of the importance of harnessing other energy sources, and the need for a long-term planning for the country's future energy supply. Because of the effects produced by wind in Owerre-Ezukala over the years, the researcher is drawn to investigate whether such effects can be tapped for desired purposes. Wind energy is basically the harnessing of wind power to produce electricity. The kinetic energy of the wind is converted into electrical energy (Yunus and Michael, 2011). The relationship between the kinetic energy and electrical energy is a direct or linear one. Taking other mechanical factors for granted, the higher the speed of the wind, the higher the electrical energy; and vice versa. A large quantity of electrical energy is needed to sustain industrial growth, agricultural production, and domestic use. The existing sources of energy such as coal, fossil fuels, and geothermal etc. may not be adequate to meet the ever increasing energy demands. These conventional sources of energy are also depleting, and may be exhausted in no distant time (Gordon and Ron, 2011). Consequently, sincere and unrelenting efforts shall have to be made by scientists and engineers, in exploring the possibilities of harnessing energy from several non-conventional energy sources. According to energy experts, the non-conventional energy sources can be used with advantage for power generation as well as other applications in a large number of locations, and situations, in temperate countries like Nigeria. The geographical layout of Owerre-Ezukala encourages a sustainable wind velocity across the year. The natural vegetation of these sites ensures a high wind density. This condition, if well hacked into and harnessed, can favour the operation of a large wind turbine.

The development of renewable Energy in Nigeria is a matter of great interest. Wind, as a source of energy is gradually gaining prominence around the world, although backed by long history. The technology is still new unlike the sun and its availability, undoubtedly, is yet to be embraced by many countries. In fact, the desire to seek for a lasting solution to the energy situation of Nigeria has prompted the government as well as independent researchers to assess the nation's potentials for wind energy. The government appointed two groups of consultants to ascertain the potential for wind energy and also carry out wind resource surveys for the country (Ajayi, 2009). Individual researchers on their part have made various assessments of potentials and availability to determine the magnitude of wind resources. Asiegbu and Iwuoha, (2007) studied the wind in Umudike, South-East, Nigeria and assessed its economic viability at a hub height of 65 m above the ground with annual mean wind speed of 5.36 m/s using 10 years (1994–2003) wind speed data. Fadare (2008) carried out a statistical analysis of wind energy potential in Ibadan (a city in Oyo State of Nigeria), using the Weibull distribution function and 10 years (1995–2004) daily wind speed data. The outcome was that the city experiences average wind speed and power density of 2.947 m/s and 15.484 W/m^2. Ogbonnaya *et al.*, (2007) on the other hand worked on the prospects of wind energy in Nigeria using 4 years of wind data from seven cities (Enugu, Jos, Ikeja, Abuja, Warri, Sokoto and Calabar). The annual wind speed at 10 m above the ground varied from 2.3 to 3.4 m/s for sites along the coastal areas and 3.0 − 3.9 m/s for high land areas and semi-arid regions. It was also reported that monthly average wind power was reported as 50.1 W/m^2 and Sokoto is capable of a power potential as high as 97 MWh/yr. Each of these initiatives, in the limits of their uncertainties, have identified that great prospects exist for wind energy utilization for power generation. Moreover, wind speeds are generally weak in the south except for the coastal regions and offshore, which are windy. Offshore areas from Lagos through Ondo, Delta, Rivers, Bayelsa to Akwa-Ibom States were reported to have potentialities for harvesting strong wind energy throughout the year. Inland, the wind was reported strongest in the hilly regions of the North, while the mountainous terrains of the middle belt and northern fringes demonstrated high potential for great wind energy harvest. It was, however, observed that, due to varying topography and roughness of the country, large differences may exist within the same locality. The values for the wind speeds range from a low 1.4 to 3.0 m/s in the southern areas and 4.0 − 5.12 m/s in the extreme North, at 10 m height. Peak wind speed was shown to generally occur between April and August for most sites in the analysis (Ajayi, 2009). Further analysis of these wind resources also revealed that the North, Central and South-East of the nation possess enormous potential for harvesting wind energy, with possible wind speeds reaching as high as 8.70 m/s in the north (Ajayi, 2007).

It is unequivocal to aver that energy plays a central role in economic development and industrialization of any nation. Fossil fuels have been the major resources that supply the world energy demand. However, fossil fuel reserves are limited and usage of fossil fuels to generate energy has negative environmental effects. The world energy demand is continuously increasing with increasing population such that the present fossil fuel reserves cannot meet this demand (Kamau *et al.*, 2010). As a result, energy policies of many nations are geared towards ensuring a supply of reliable, economical and environmentally friendly energy resources in a form that supports the targets for growth and social development (Ucar and Balo, 2009). Wind energy applications have been recently (Weisser and Garcia, 2006) described as an economic and environmentally friendly solution to the urgent energy problems of many countries. Wind is an effect caused as a result of pressure differences over regions and heights in the atmosphere resulting in bulk motion of air masses. The force carried by the moving air mass (wind) can be harnessed for useful purposes such as grinding grain (in windmills) and generating electricity (in wind turbine generators). It is estimated that between 1.5 to 2.5% of the global solar radiation received on the surface of the earth is converted to wind (Vosburgh, 1983). Hence, wind energy, which contributes very little pollution and few greenhouse gases to the environment, is a valuable alternative to the non-renewable and environmentally hazardous fossil fuels (Taylor, 1983). Thus, the utilization of wind energy has been increasing around the world at an accelerating pace. The extent to which wind can be exploited as a source of energy depends on the probability density of occurrence of different speeds at the site, which is essentially, site-specific. However, the development of new wind projects continues to be hampered by the lack of reliable and accurate wind resource data in many parts of the developing world. This study is primarily concerned about the geographical and climatic conditions with respect to monthly and annual wind speed in Owerre-Ezukala axis of Anambra State. Therefore, the work is meant to evaluate wind velocity in Owerre-Ezukala, Anambra State, Nigeria; using a digital anemometer, at an altitude of 10m.

Owerre-Ezukala, a border town in Orumba-South local government area of Anambra State, is located at the South-East of the capital territory. It is surrounded in the north by Awlaw in Enugu State; in the east by Isuochi in Abia State; in the south by Nneato also in Abia State. By the western axis of the town lies Ogbunka (also in Anambra State). Like Okigwe, and Isuikwuato, the town is located in longitude 6^{o} 1′ 0″ North, and latitude 7^{o} 19′ 0″ East. (www.maplandia.com/ng/owerre-ezukala). Owerre-Ezukala is the home of the famous Ogba-Ukwu cave and over 15m-high waterfall. It has an average population of 120,000 based on the 2006 census, with about 80% of the people living in the village. The satellite earth map of Owerre-Ezukala is shown in Figure 1.

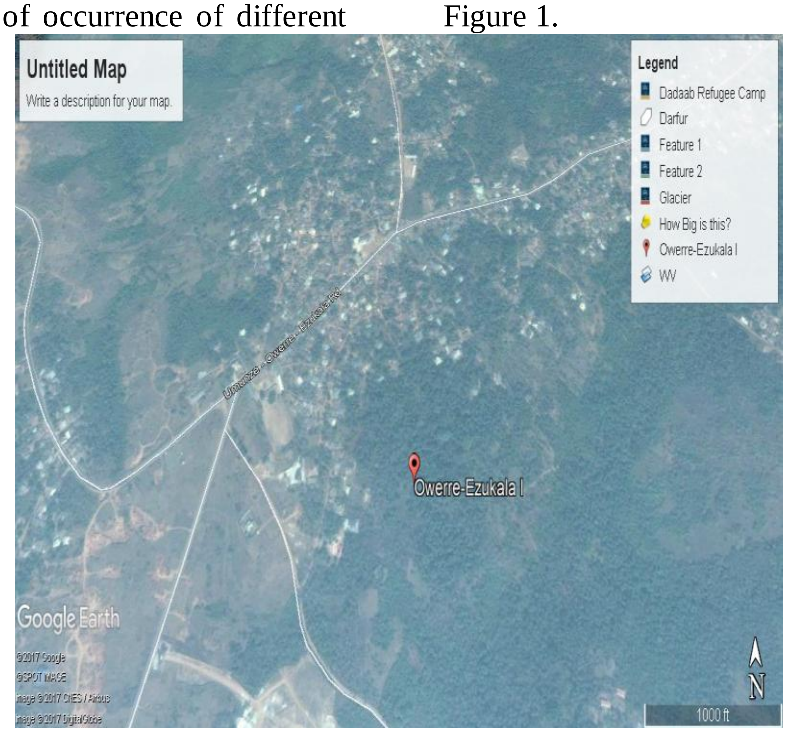

Figure 1: Satellite Earth Map of Owerre-Ezukala
Source: Google Earth Pro-Software

2.0 Methodology

The electronic digital anemometer was used to measure the average wind velocity in the designated areas, between March 2016 and March 2017. The anemometer used, is altitude free and insensitive; hence, it is an improved technology of the previous devices. The appliance, also, keeps records of daily relative humidity and mean temperature. Standing on the ground, a researcher only needs to key-in the required altitude or height (in meters), at which the device is to operate. If, for instance a 10m height is preferred, the device is kept on a place with minimal disturbance, where it can record the wind velocity and the other parameters, at the designated height. The contrivance keeps an average daily record of the wind velocity. These readings are collated every two days, and the process continues. A special lithium cell (battery) with a life expectancy of about five years ensures a smooth running of this instrument. The *modus operandi* of the anemometer can be summarized thus;

- Place a small table on a level land with minimal or no disturbance, in the site already mapped out.
- Power the anemometer
- Achieve a Bluetooth connectivity between the device and a laptop
- Key-in the altitude of interest in the device (in our case, 10 m)
- Press the start button for the appliance to begin to work.

3.0 Results and Discussion

The wind speed measurements were taken at three different sites in Owerre-Ezukala using a hybrid electronic anemometer. These readings (m/s), were obtained at various times of the day, and different seasons, at an altitude of 10m. This is represented in a chart in Figure 2. Betz, a German physicist, posits that the extractable power from wind, in any functional wind turbine is given by: $P_{avail} = \frac{1}{2}\rho A v^3 C_p$; where ρ = wind density, A = blade swept area, v = wind speed, and C_p = power coefficient. The values of V-calculated were determined using the Betz' mathematical model. These values are compared with V-measured in Table 1. The comparison is presented in the form of bar chart (for the three locations) as in Figures 3, 4 and 5.

Table 1: Comparison of V-measured and V-Calculated

	Location 1		Location 2		Location 3	
Month	V_1 Measured (m/s)	V_1 Calculated (m/s)	V_2 Measured (m/s)	V_2 Calculated (m/s)	V_3 Measured (m/s)	V_3 Calculated (m/s)
January	5.5	5.49	5.6	5.69	5.4	5.39
February	5.6	5.6	5.6	5.6	5.5	5.49
March	6.5	6.49	6.5	6.49	6.4	6.39
April	6.7	6.7	6.5	6.49	6.5	6.49
May	5.4	5.39	6.7	6.7	5.3	5.29
June	5.3	5.29	5.4	5.39	5.3	5.29
July	5.6	5.6	5.7	5.69	5.5	5.49
August	5.7	5.69	5.8	5.79	5.5	5.49
September	5.3	5.29	5.3	5.29	5.2	5.19
October	5.2	5.19	5.1	5.09	5.0	5.0
November	5.0	5.0	4.8	4.79	4.8	4.79
December	5.3	5.29	5.5	5.49	5.4	5.39

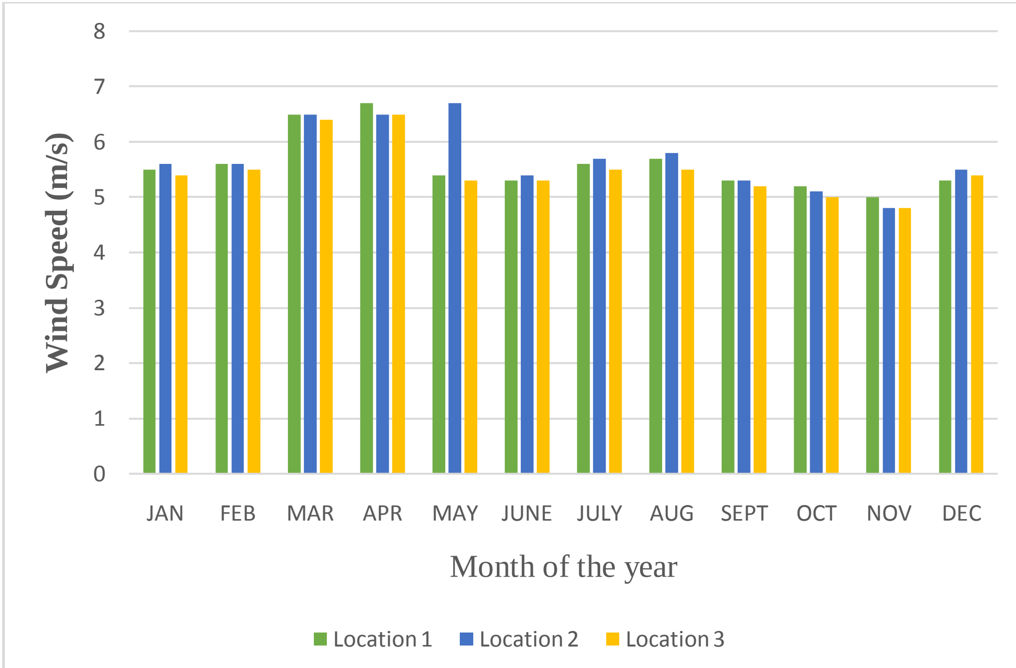

Figure 2: Wind Speed Distribution in Owerre-Ezukala

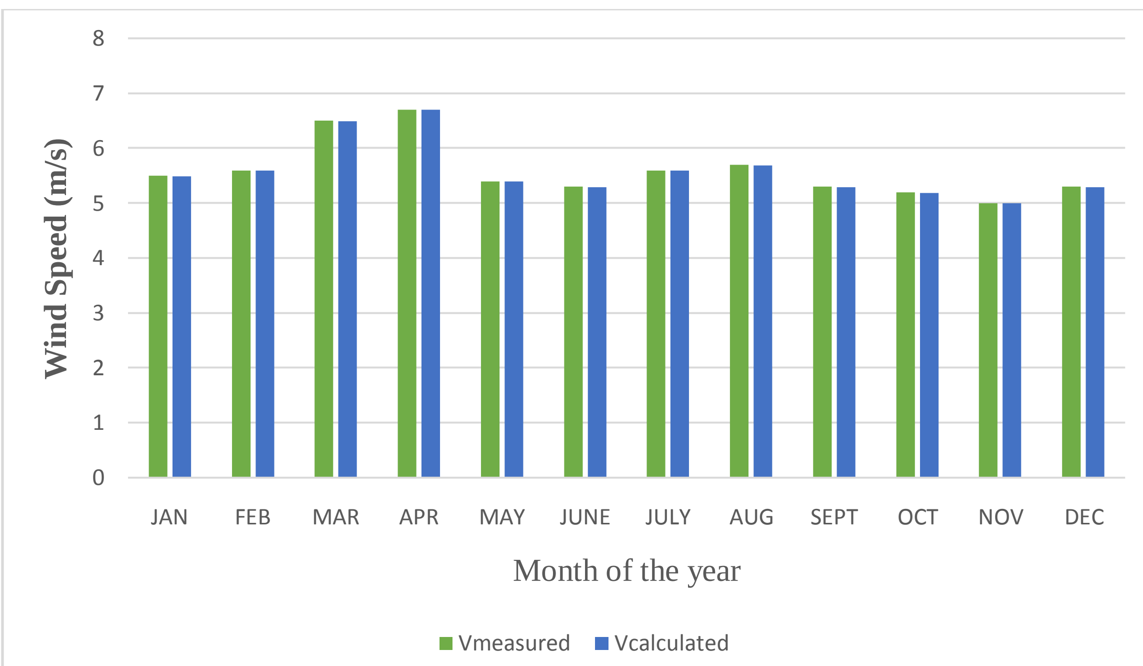

Figure 3: Location 1 (Ugwu-Osu)

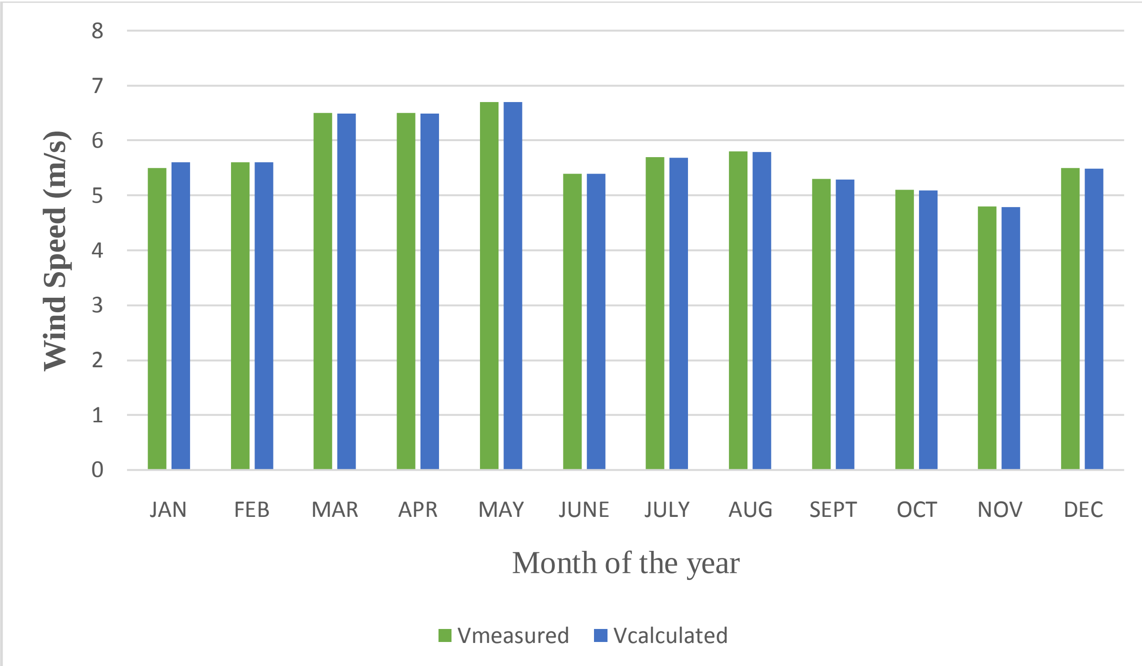

Figure 4: Location 2 (Okegbe)

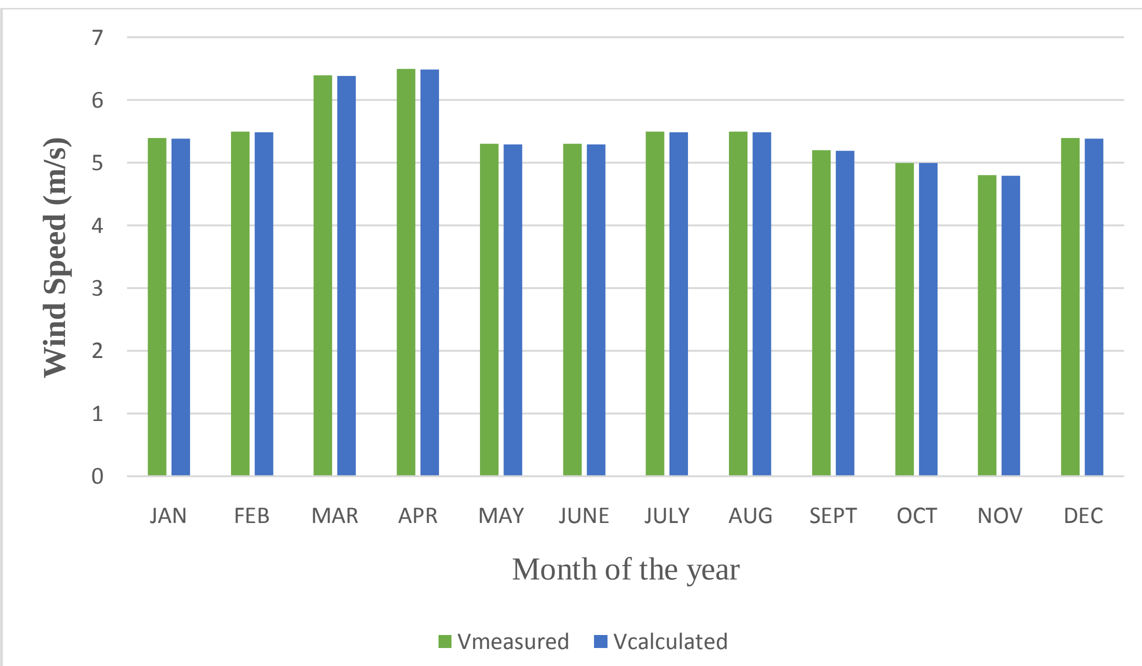

Figure 5: Location 3 (Ogba-Ukwu)

With reference to Fig. 2, the measured wind speed, for location 1 (Ugwu-Osu), is highest in the month of April with a value of 6.7 m/s, while November has the lowest value of 5.0 m/s. Location 2 (Okegbe) recorded a highest wind speed of 6.7 m/s in the month of May, and receded to 4.8 m/s in November. Similarly, location 3 (Ogba-Ukwu) reached its peak value of 6.5 m/s in April, and came down to 4.8 m/s, also, in November. One can then conclude that a shift from one season to another brings about a significant change in the recorded wind speed. The measured wind speed compared with the calculated wind speed, for location 1, gave the highest value in April (6.7 m/s: 6.7 m/s). For location 2, the comparison gave the highest value in May (6.7 m/s: 6.7 m/s). In the same vein, the evaluation gave the highest value in April (6.5 m/s: 6.49 m/s), for location 3. The lowest values for the three locations occurring in November, correspond to 5.0 m/s: 5.0 m/s (Ugwu-Osu), 4.8 m/s: 4.79 m/s (Okegbe), and 4.8 m/s: 4.79 m/s (Ogba-Ukwu). The measured wind speed and the calculated wind speeds correlate, indicating that the Betz' Mathematical Model used in this comparison is in tandem with the projected outcome of the analysis. Furthermore, the values of the measured wind speed, reveal the high prospects of the research locations for sitting wind farm.

4.0 Conclusion

The wind turbine industry is a fast growing one where constant research is needed in order to maximize the efficiency of the contrivance. It is more expedient than ever, for more reliable renewable energy sources because of depleting fossil fuels. Some work has been done on wind farm layouts, but further research is needed for a wide-spread applicability. Even though the existing research is a good starting point, a lot more grounds needs to be explored so that more communities would benefit from the new technology. Wind energy assessments are stochastic and hence are limited in terms of accuracy due to the non-linear variability of wind characteristics in space and time. Using a minimal number of locations and sampling points to average for the whole nation may affect the accuracy and utilization of the results. Therefore, a joint effort of group of energy enthusiasts is expedient for a more widespread *in situ* evaluation of wind velocity across the country.

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