POWER GENERATION IN DIVIDER-LESS ROADWAYS USING VERTICAL AXIS WIND TURBINE

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ABSTRACT

Wind power is abundant for utilization and costs nothing to use. A wind turbine can produce, store, and use electrical power with little to no emissions. The wind flow due to the passage of vehicles is random, which is unused in the roadways. Conventionally, the highway windmills generate electric power in reasonable amount. Also, those windmills concentrate on power generation only. In this manuscript, the roadway wind power is rehabilitated to usable electricity by developing a vertical axis wind turbine (VAWT). An unconventional DC-DC converter by term Super-Lift Converter (SLC) is cascaded at the output terminals of the proposed VAWT. Contrasting the orthodox DC/DC converter, the presented SLC produces geometrically progressed DC tie voltage with ripple content a smaller amount than 1%. The features such as, mobility, power boost-up ratio, accident prevention by speed monitoring add major credits for the proposed work.

I. INTRODUCTION

The incident which makes me to initiate this project proposal is the time when stood at the crossing point of a national highway and realized that enormous amount of wind energy has been wasted in the highways. The idea behind the proposal is aerodynamic figures of four wheelers; if a human stay at the sideways of a roadway and a four wheeler badges by the person, the wind blown up by the four wheeler has a great impact on that person right later it has left. The wind's strength is directly proportional to the vehicle's velocity, structure, and weight. It's worth noting that wind will be produced proportionally regardless of the vehicle's speed. This force (wind) is commonly referred to as "Drag Force."

Another important factor that was observed in the highways is the accidents caused due to the absence of road dividers. In the divider-less roadways, the vehicles passing tries to overtake one another by crossing the halfway line which leads to severe accidents by clashing the vehicles coming in opposite direction. Hence, it is required to have the divider in all the roadways which is uneconomic. This problem initiates an idea to correlate the wind energy conversion system integrated in the barricade, which acts as a mobile road divider.

Comprehensive works has been published to justify the efficacy of the proposed system. The deficiency in the existing system motivates the investigator to integrate the Super-Lift converter in the highway wind energy system. Ali Zarkesh and Mohammad Heidari (2013) addressed a separate project for wind generators in highways, but their work does not meet the requirements. [1]. R. Sathyanarayanan, et al. created a small concept model of a wind turbine using air conditioner roller fins (2011) [2]. But the work presented is simple integration of vertical axis wind turbine in the existing road dividers.

Wind energy is plentiful and free. A wind machine can extract, preserve, and supplies electrical energy with little to no emissions [3]. The evolution of windmills technology to Europe was made during the middle age and during 11th and 12th century, the first windmill built at England [4]. In United States of America, the wind speed is stumpy during the summertime and it is robust during the winter season. As a result, the overall processing periods for solar and wind plants differ depending on the time of day and year [5].
Vertical axis wind turbine (VAWT) is a multi-purpose wind turbine; it is designed in such a manner that vehicles running on both ends of the road are able to smash the blades of the VAWT, which are connected to the rotor of the generator; it generates electricity; the power generated by the VAWT is then stored in a battery and used for various applications. If the efficacy of the wind machine is enhanced and extensive, the average person will save a lot of money on their power bills. There wind turbines has been classified into two types, mainly Horizontal axis wind turbine, and Vertical axis wind turbine. The VAWTs act in a virtuous manner based on the drag force. Lift and drag forces, on the other hand, play a role in the operation of horizontal wind axis turbines.

India is already regarded as a world leader in the production and consumption of renewable energy, especially in the field of wind energy development. Indeed, wind power generation has emerged as one of the most successful projects in the sustainable energy field and it has begun to contribute meaningfully to total power requirements in some states. With a total deployed capacity of 2483 MW, India is the world's fifth largest wind-power producer. The majority of this potential has come from commercial ventures funded by private capital. About eleven billion units of power have been supplied to various government grids from these initiatives, thanks to the world's largest wind resource assessment event. Re-evaluation and advancement of the wind energy data repository; establishment of a hub for Wind Energy Technology and encouraging large private companies businesses, government sector, and power grids to set up wind power initiatives have all received new attention. Wind turbines and wind turbine parts are being exported to the United States, Europe, and a number of developing countries. During the 10th Five Year Plan, it is expected to introduce further 1500MW of wind energy potential based on previous experience. The idea of putting wind turbines on highways is not entirely new in India. Several pathways and efforts to reprocess energy from highways have been made by individuals and organisations. The much more noteworthy is a concept featured in a YouTube video titled "Highway Helical Wind Turbine Project (Next Generation Highway's Wind Power Potential)". Though, it was an excellent implementation of VAWT in highways but fails to justify the withstanding capability and strength of the VAWT during heavy wind speed.

In the above review, some of the research problems observed and are as follows,

- VAWT implemented in highways are not movable.
- There is no special power boost up arrangements made.
- The schemes related to highway wind mill concentrates only on generation of electrical power and not focusing on road safety.
- The models implemented in the above review works requires huge cost to be invested for generating minimum power.
- Design complication.

II. PROPOSED VAWT

To use the wind generated by moving vehicles to produce energy, it is proposed to build a vertical axis wind turbine integrated in road divider along with PV panels, which is movable. These turbines would be located along highway roads near remote villages with a high amount of fast moving traffic. Batteries will then be used to store the produced electricity. That's because the electricity generated is direct current (DC), it should be transformed to alternating current (AC) before being used in remote villages. Also a part of the electrical power from the battery is directly used for lighting loads in the roadway, where the proposed model is located. Fig.1 shows the diagram of the anticipated work.

In the first stage, severe storm from the highway's middle section hits wind turbine blades, causing them to rotate. The wind turbine blades are built in such a way that they rotate in a clockwise manner regardless of which side of the highway the vehicle is on. The shaft of the wind turbine is coupled to two DC generators through proper gearing arrangements. One is at the top of the wind turbine shaft, and the other is at the bottom. The attached generators will produce electricity in both directions as the turbine blades spin, and the power will be fed to the charge controller.

The charge controller maintains the rate of charging and discharging of battery. However, the power in the output terminals of charge controller will have oscillations. The fluctuations in voltage and current signals will affect the
charging and discharging time of the battery. To eliminate the oscillations in the voltage and current signals at the output terminals of charge controller, a DC-DC converter is used. The DC-DC converter uses a simple semiconductor switches for stabilizing the DC output from it. Then the stabilized DC power is converter to AC power by means of a voltage source inverter (VSI). A power electronic interface using Field Programmable Gate Array (FPGA) is used to cascade DC-DC converter and VSI. The grid lines are directly linked to the AC control of remote villages. Finally, the power from the battery can be used for lighting loads in the roadways. Since the complete model (road divider) is movable, the stored electrical power in the battery can be used for remote village residential application with proper inversion of power.

Fig.1 Schematic of the proposed work

Global Augmented and Virtual Reality Market

The gaming section ruled the general market in 2017 and is relied upon to proceed with this pattern during thefiguretime frame, becauseof the development of the versatile gaming industry.

Video game is one of the significant uses of virtual and augmented reality innovation. Previously, the quantity of gamers worldwide has expanded at a quick speed. This is credited to expanded interest for increased and augmented reality-based games, along these lines driving the market development.

III. MODELLING AND THEORETICAL CALCULATIONS

The power output (mechanical) from the proposed wind turbine is given by,

\[ P = \frac{1}{2} \mu ACV \] (1)

where, \( \mu \) is the air mass in kg/m\(^3\), A is area and V is wind rate in m/s.

The above equation (1) in terms of tip speed ratio (\( \alpha \)) and angular velocity (\( \omega \)) can be given by

\[ P = \frac{1}{2} \mu AC \left( \frac{\omega R}{\alpha} \right)^3 \] (2)

The aerodynamic performance (C) is a good indicator of \( \alpha \) and hence not uniform at all wind velocity unless the rotor has variable speed to maintain constant. As a result, the requirement for a continual prime tip speed ratio can be construed as the requirement to keep \( C = C_{\text{max}} \), and the finest mechanical energy derived from the wind can then be calculated as a function of rebellion speed as

\[ P_{\text{opt}} = b \omega^3 \] (3)

The proposed concept in this project is absolutely feasible, according to the predictive estimation, and the result is remarkable. If this proposed model is extended to a 10-kilometer road in a rural place, it is feasible to deliver a few kilowatts to megawatts of electricity in a single day, effectively turning the highway into a power plant. If
each hybrid solar-wind turbine housing has a length of 2 meter, then there will be 10 housings. These housings at the center of the roadway, mounted on the road divider.

The wind generator suggested for this project has appraised velocity of 1000 rpm with appraised current of 19.5 A (for continuous rotation) which is able to produce 200V AC. The investigation has been conceded on tiniest output of the AC voltage, therefore:

\[
\text{Power} = VI \cos \Phi
\]

Where, \( \cos \Phi \) is power factor and it is almost equal 0.8, therefore:

\[
\text{Power} = 200V \times 19.5A \times 0.9 = 3510 \text{ W}
\]

If the yield power of each wind generator restrained as 3500 W (approximately), then:

\[
\text{Total Power} = 10 \text{ wind generators} \times 35000 \text{ W} = 35 \text{ KW}
\]

As the proposed project involves the contribution of power from solar panels, the addition power of 65 KW per day is extracted from it. An optimized algorithm for extracting maximum power from both VAWT and solar panels is suggested. On the whole, the power generation will ranges between 50 KW to 0.1MW per day.

The typical power curves of the proposed wind turbine for different wind speed conditions is revealed in Fig.2.

For greater \( b \) (b1), the power regulator extracts undue electrical energy and slows the VAWT's revolution speed, reducing the airstream's effect on the turbine blades and thereby lowering turbine power competence. For regulators with narrower \( b \), the energy in the airstream is subsided in tumultuous motion and whirlwind weeping (b3). The blades of a VAWT functioning at finest \( b \) (b2) are highly influenced by the storm and can draw more power from the wind.

**IV. DESIGN AND CONTROL OF POWER CONVERTER**

To achieve the best aerodynamic performance, the rotational speed of the wind turbine should be limited to the optimum power-velocity curve. The generator's electrical power can be used to control the wind turbine's rotational speed. Figure 3 depicts the planned wind energy conversion system's control scheme.
The electrical energy provided by the generator is first converted using the Maximum Power Point Tracking (MPPT) algorithm by a phase controlled rectifier. In terms of power factor and current harmonics, the phase regulated rectifier is more efficient than the bridge rectifier. The ac current type of a PWM rectifier can be optimised using extreme frequency switching and phase-locked loop approaches. The super-lift converter raises the DC voltage rate such that the PWM inverter can switch to the voltage level on the power grid.

V. RESULTS AND DISCUSSIONS

To verify the performance of the projected wind energy conversion system, a Simulink model using MATLAB software is developed. The generated voltage is restrained across the terminuses of the suggested wind generator and the respective result is displayed in Fig.4. As the wind speed kept is not a constant, the generated voltage is oscillating throughout the time period.

![Generator Voltage](image)

The generator current is shown in fig.5 and it indicates that as a result of changes in wind speed, the current oscillations at the terminals of the generator cannot be eliminated.
The power generated at the terminals of the generator ranges between 200 W to 300 W and the respective results are shown in Fig.6.

Figure 7 depicts the implemented wind energy conversion system's DC connection voltage. The DC connection voltage result validates the proposed super-lift converter's supremacy in the DC line. The generated 20 V is converted to 70 V with ripple free (<1%). The ripple free DC line voltage ensures the performance of the inverter in the back end of the proposed system.
The proposed wind energy conversion system is practically tested for its performance analysis and the table 1 shows the generated power output for different wind velocity.

Table 1 Generated Power for different wind velocity

<table>
<thead>
<tr>
<th>S.No.</th>
<th>Wind Velocity (m/s)</th>
<th>Power Generated (W)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.</td>
<td>4</td>
<td>180.35</td>
</tr>
<tr>
<td>2.</td>
<td>6</td>
<td>200</td>
</tr>
<tr>
<td>3.</td>
<td>8</td>
<td>220</td>
</tr>
</tbody>
</table>

VI. CONCLUSION

The performance of VAWT fabricated in the barricades for highway wind energy conversion system is discussed in this manuscript. A VAWT’s output will suffer as a result of an incorrect b factor. In a strict sense, not only atmospheric pressure and moreover blade distortion after long periods of operation affect the optimum b. This paper describes the development of controller design for determining the output of a small VAWT that has been mounted. To illustrate the effectiveness of the recommended method under unpredictable wind velocity, a 1.5kW VAWT was modelled using MATLAB. In attempt to reach the control specifications power converters were also employed to condition the VAWT’s output power. The test results reveal that the improved approach can significantly differentiate the aerodynamic productivity between b factors under unpredictable wind velocity conditions. In addition, the proposed super-lift converter in the DC bus sustains the voltage ripple less than 1% and leads to the enhanced life of inverter in the back end of the system.

REFERENCES

8. https://www.youtube.com/watch?v=8g5G0LXCNDM.