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Autonomous Rural Street Lighting Powered by Low-Wind VAWT Micro-Generation with Intelligent 555-LDR Light Control

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Abstract: Wind energy is the most necessary and clean renewable energy resource available all over the world. In India, it is highly available in coastal and high-wind regions. This paper presents a mini project model of a street lighting system powered using a vertical axis wind turbine (VAWT). It is a combination of natural wind and dynamic wind produced by moving vehicles on a roadway. The VAWT rotates a small DC generator and the output energy is rectified, regulated and used to power low-power LED street lamps. The hardware model is developed using a scaled roadway, small 12V DC motor as generator, LED street poles, rectifier circuit and basic power conditioning electronics. This work shows that small distributed VAWT systems can contribute to green smart-city infrastructure and can assist street lighting power requirement while reducing load on the conventional electricity grid.

Keywords: *Smart City Model; Street Lighting; Renewable Energy; LED; India.*

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I. INTRODUCTION

The increase in demand for electrical energy in India creates the need for alternative, clean and sustainable power sources. Wind energy is one of the fastest growing renewable energy sectors in India and has reached more than 44 GW of installed capacity according to MNRE. However, conventional large-scale wind turbines require wide open land areas, uniform wind direction and high installation cost. In contrast, small wind turbines can be installed inside urban environments and can utilize low-speed wind generated by natural breeze as well as from moving vehicles. In this mini project, a scaled roadway model is constructed in which a small VAWT is used to generate electricity to power LED street lights. This concept can be useful in smart cities to achieve decentralized generation of energy, reduce carbon footprint and lower electricity cost for street lighting.

II. LITERATURE REVIEW

Earlier research shows that Vertical Axis Wind Turbine (VAWT) is more suitable for cities because it does not need the wind to come from a fixed direction. It can rotate even with low wind speeds and it can fit in small places like road dividers and building roofs. Many mini projects used small DC motors as generators because they are cheap, available and can generate voltage easily when rotated. Some researchers have already tried combining solar + wind for street lighting, but only few focused mainly on small wind turbines that run from natural wind + wind created by moving traffic. Previous papers also mention that simple rectifier circuits using diodes and voltage regulators can convert the AC-like variable output of turbine into stable DC to charge a battery or power LEDs. From these studies we understand that small wind turbines can be useful for smart city projects in India, especially for powering LED street lamps in local areas.

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III. METHODOLOGY

In this project, a small Vertical Axis Wind Turbine (VAWT) is mounted on the roadside area of the model. A small fan is used to create wind in the direction of the turbine blades. When the fan blows air, the VAWT rotates continuously. This rotation drives a small DC generator which converts the mechanical rotational energy into electrical energy. The electrical output from the generator is not stable, so the output is passed through a rectifier circuit. The rectifier converts the AC-like variable output into DC voltage. After this, the voltage regulator and charge controller section ensures that the voltage is stable enough to power LED street lamps safely. The main idea is that if such turbines are installed in real life on road dividers, then the wind created by fast moving vehicles can rotate these turbines. This means street lights can get some portion of their power from small wind energy without depending completely on the electrical grid. In this model, the LED street lamps glow when the turbine is in operation, showing that even a small VAWT can generate usable energy. This demonstrates that small decentralized wind turbines can be a practical part of smart city renewable energy solutions.

➢ *Hardware Components Used*

- Vertical Axis Wind Turbine (VAWT) – this is the main rotating part that catches wind.
- DC Generator (12V type) – converts the rotation into electrical energy.
- Rectifier Circuit – used to convert variable AC-like output to DC.
- Voltage Regulator – used to stabilize the output voltage for LEDs.
- LED Street Lights – to show the practical use of the generated power.
- Small Fan – used as an artificial wind source to spin the turbine.

➢ *Working Flow of the System*

First the fan creates airflow which rotates the blades of the Vertical Axis Wind Turbine. When the turbine rotates, the DC generator also rotates and produces electrical power. This generated power is sent to the rectifier circuit to convert it into stable DC. After that, the voltage regulator and charge controller manage the voltage so that it is safe for charging the battery. Once the battery is charged, this stored energy can be used to turn on the LED street lights whenever needed. In this way, power is not wasted. Even if the wind stops, the battery still contains energy to run the LEDs for some time. This proves that small wind turbines can help support street lighting and reduce the dependence on the main electric supply.

➢ *Output Observation*

When the fan was turned ON and the wind directly hit the blades of the VAWT, the turbine rotated smoothly and continuously. Due to this rotation, the DC generator produced electrical power. After passing through the rectifier and regulator section, the battery started getting charged. After the battery got some charge, the LED street lights were connected and they glowed bright without any flickering. This clearly shows that even a small vertical axis wind turbine model can produce usable electrical energy. This experiment proves the concept that if such VAWT units are installed on real road dividers, the wind generated from vehicles can also be used to charge a battery and power street lights. It may not replace grid power completely, but it can definitely support and reduce energy consumption.

IV. CONCLUSION AND FUTURE SCOPE

This mini project shows that a Vertical Axis Wind Turbine can generate useful electrical power at small scale. By using a simple DC generator, rectifier and regulator, the energy generated from wind was stored in a battery and later used to glow LED street lights. This proves that small wind turbines can support street lighting and reduce load on the main electricity supply. The experiment also showed that the LEDs glowed bright which means the system is practically workable. In future, this system can be made more efficient by increasing the size of the turbine blades and using a more powerful generator. Solar panels can also be added to make the system hybrid. With a combination of wind + solar, the total power generation can increase and the reliability of the system will also improve. This type of solution is very suitable for smart cities and highways in India.

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