ROADSIDE VERTICAL SOLAR-WIND ENERGY TOWER

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ABSTRACT

Fossil fuels and Nuclear power is responsible for about 82% of the current Energy Production in the US. While a small part is still being met by renewable energy sources, engineers are working hard on finding new sources of Energy. Another approach to the global clean energy crisis is that instead of looking for a new energy source, we should become Energy Efficient. Road power generation is a new technology where the wasted energy of a moving vehicle can be extracted and converted to useful work done. This paper presents such a technology which when employed at the corner of a road can send power directly to the grid or run streetlights depending on the mode of operation. This is done by constructing a Savonius Wind Turbine and then converting the wasted wind energy produced by a moving vehicle. In addition, a solar panel can also be placed on the top of the turbine and produce more energy. A microcontroller decides how Energy is to be sent to the grid or stored to be used for street lighting load. While the power production may vary depending on the traffic and conditions of the city, the S-rotor and solar panel have a maximum voltage of 19.1 V and 19.65 V respectively.

KEYWORDS

Savonius rotor, Inverter, Solar Panel, Wind turbine, Road Power generation, Charge Controller.

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1. INTRODUCTION

The need of alternate energy sources is not a debate but a necessity in this modern era. The demand of clean and affordable energy sources led to the breakthrough of renewable energy sources (Shah, Alandjani, & Asghar, 2020). Such is the scope of renewable energy sources that Road Power Generation (RPG) Technologies are being researched upon. One of the technologies involves extracting the wind gushes produced by nearby vehicles. The rotor design is a challenging design and many different types of rotors can be employed.

2. METHODOLOGY AND RESEARCH

This paper discusses an experimental work done to harness the wind energy produced by moving vehicles on a road and extracting the solar potential with a solar panel along with it. This is achieved by designing a Savonius wind turbine and placing a mono-crystalline solar panel together. The system takes input from both renewable energy sources and voltage sensors provide voltage values to the Arduino. This Microcontroller is programmed with a code which will be discussed later. The extracted voltages are sent to a nearby grid in the day and at night are used to power streetlights.

When the solar panel is operational, the voltages are sent to the MPPT (Maximum Power Point Tracking). This MPPT is connected to a reference battery which powers it. The MPPT stabilizes the voltages from the solar panel and charges the main battery. The power from the battery is then provided to the inverter which then converts DC to AC and sends it to the grid or streetlight as necessary.

When the wind turbine extracts the wasted wind potential from nearby vehicles, power is generated by the PMDC generator. The voltages from the PMDC generator are provided to the Buck/Boost converter which are either bucked or boosted depending on the situation. This DC power will then charge the battery and converted to AC by the inverter for any load.

The Vertical solar wind energy tower is a power generation unit which harnesses the wind potential of moving vehicles and the solar potential of the sun. It has the following parts:

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2.1. SOLAR PANEL

After careful observation and survey of the site where the power generation unit is to be installed; it was decided that a mono crystalline solar panel will be used. Since the selection of a solar panel depends upon heat tolerance and since the average temperature in Karachi usually remains in between 27-30°C, the choice made was the best available.

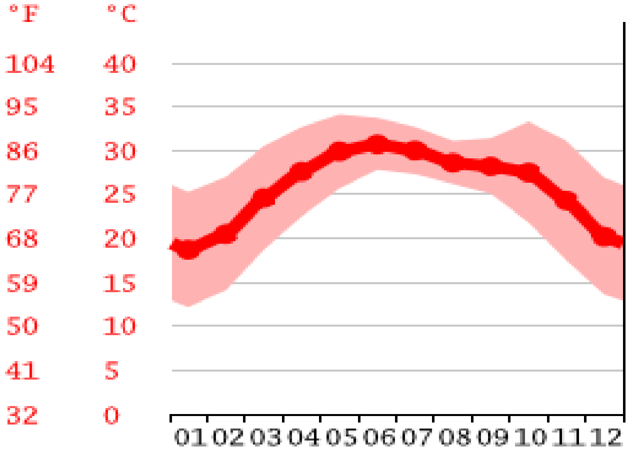

Figure 1. Graph of average temperatures in Karachi. **Source:** (Climate-Data.Org, n.d.).

2.2. S- ROTOR

A detailed discussion on the design and construction of Savonius rotor has been discussed in Shah and Alsibiani (2020).

2.3. INVERTER

An inverter is a circuit that changes DC to AC. The following components were used in its construction:

- IC CD4047, Transistor 2N3904, eight tip 35C transistors, Diodes, Transformer, Capacitors and Resistors.

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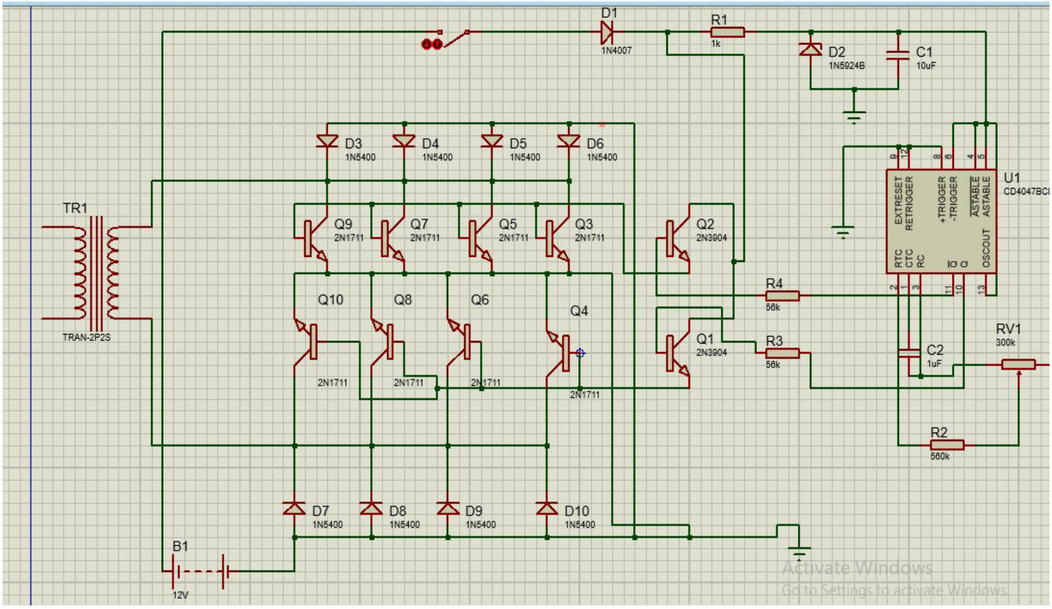

Figure 2. Simulation of an Inverter.

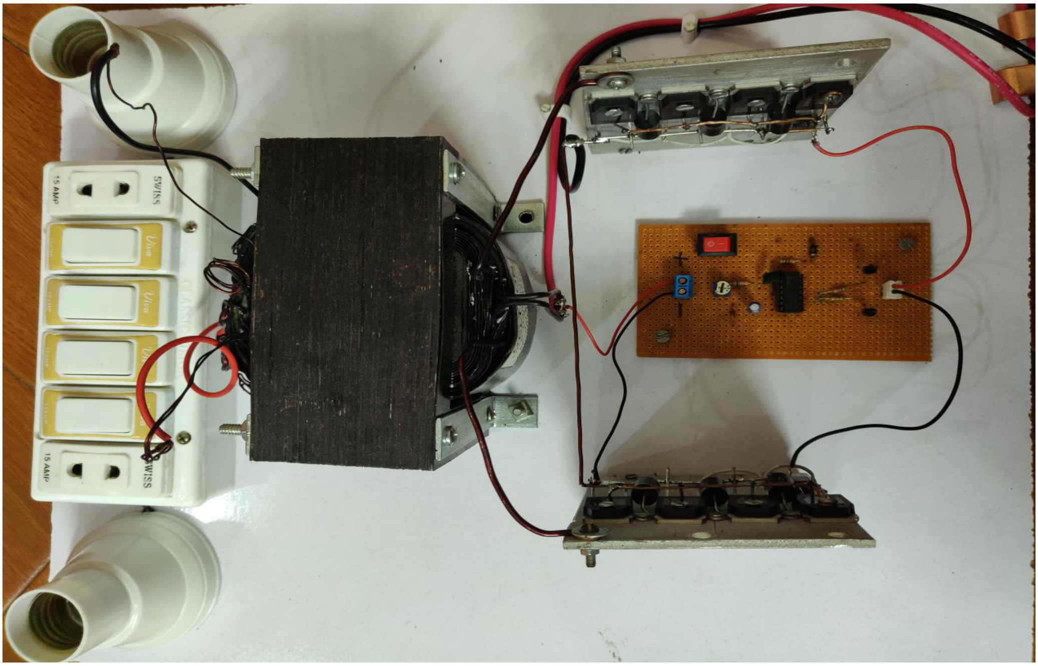

Figure 3. Inverter Hardware.

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2.4. GENERATOR

A generator is required to convert the rotational motion of the wind turbine into Electrical Energy. The specifications of the Generator are as follows:

- Rated Power: 1hp
- Rated Speed: 1650 RPM
- Rated Voltage: 18 VDC
- Pole: 2-4
- Current: 4.8 Amp

Figure 4. PMDC Generator.

2.5. CHARGE CONTROLLER

A charge controller is needed since the voltages produced by the generator are unstable. To stabilize/buck/boost the voltages the charge controller is needed. The function of the Charge controller over here is to supply constant output while the input is varying due to different wind speeds generated by vehicles. It consists of the following components:

- NE555 timer, IC7805, Diodes, Relay, Resistors, Transistor 2N2222 NPN, Capacitors

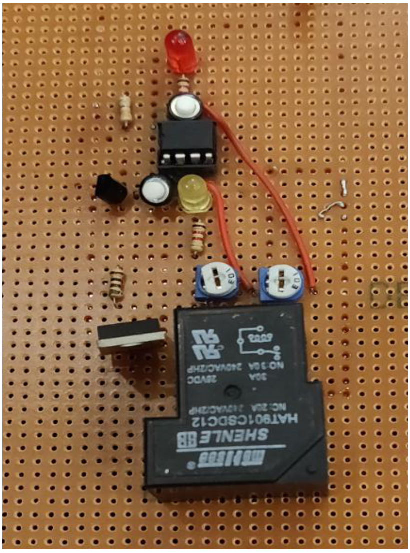

Figure 5. Hardware of Charge Controller.

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2.6. MICROCONTROLLER

Since the integration of both the power sources has not been carried out, only one source of energy can be stored in the battery, while the other must be sent to the grid for sale. For this obstacle the microcontroller is programmed with a basic code whose Algorithm is discussed below:

- From the time 9:00 A.M to 5 P.M the power output of solar panel is sent directly to the grid, while the output of the wind turbine is stored into the battery.
- If the weather is cloudy, the solar panel will not be able to extract any power from the sun and hence a message will be sent to the grid notifying no power output per hour.
- In the meantime, the wind turbine captures the gushes of wind from nearby vehicles and will store its power into a battery.
- At 6 P.M the nearby streetlights will be powered from all the wind energy collected in the 12 Hours of its operation.
- At 6 A.M, all the remaining power of the battery is sent to the grid for sale.

3. BLOCK DIAGRAM OF UNIT

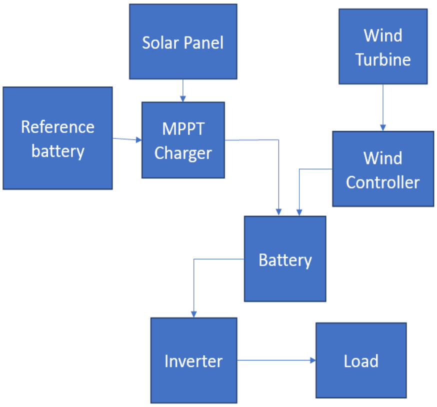

Figure 6. Block Diagram of System.

Figure 7. Hardware of System.

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4. CALCULATIONS

The power of a wind turbine can be calculated by:

$$P = \frac{1}{2} \times \rho \times A \times v^3 \times C_p$$

$$N = \frac{60}{2\pi} \times \omega$$

Torque:

$$T_s = \frac{P}{W}$$

Over Lap Ratio:

$$\beta = \frac{e}{D}$$

Swept Area:

$$Swept\ Area = Height \times Diameter$$

Height of the turbine is 1.24m

Diameter of the turbine is 0.375m

$$Swept\ Area = A = 1.24 \times 0.375$$

$$A = 0.465\, m^2$$

Over Lap Ratio:

$$\beta = \frac{e}{D}$$

Overlap distance is 0.0381m

Diameter of the turbine is 0.375m

$$\beta = \frac{0.0381}{0.375}$$

$$\beta = 0.1016$$

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Aspect Ratio:

$$\alpha = \frac{H}{D}$$

$$\alpha = \frac{1.24}{0.375}$$

$$\alpha = 3.3066$$

Rotational Speed:

$$N = \frac{60}{2\pi} \times w$$

Where,

$$\omega = 20.49\, rad / s$$

$$N = \frac{60}{2\pi} \times 20.49$$

$$N = 199.93\, rpm$$

Power

$$P = \frac{1}{2} \times \rho \times A \times v^3 \times C_p$$

sWhere,

ρ = density of air = 1.225

A = swept area

v = wind speed

C_p = coefficient of power

$$P = \frac{1}{2} \times 1.225 \times 0.465 \times 4.5^3 \times 0.21$$

$$P = 5.4502\ Watts$$

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5. RESULTS

The results of the project have been discussed below:

In Figure 8, the resultant waveform of a square wave was obtained. The square wave inverter converts solar DC power to AC power. This type of inverter is simpler in design and more efficient than a sine wave inverter.

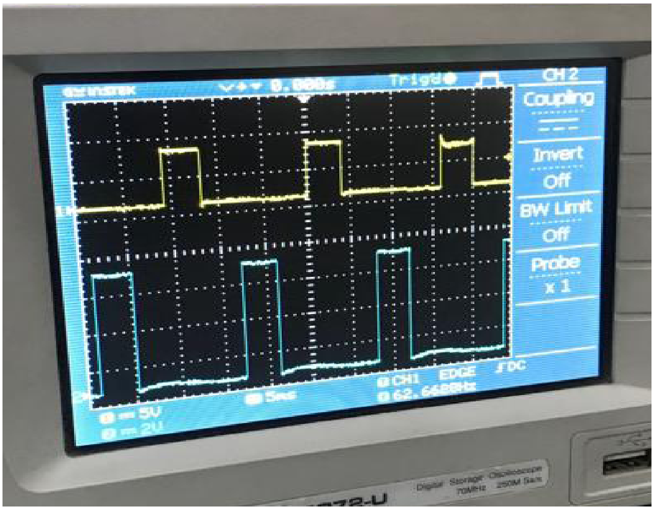

Figure 8. Waveform of Oscillation of Inverter.

In Table 1, the results for the wind turbine have been shown. The velocity of the wind was measured using an anemometer which was placed right in front of the rotor. The wind made the rotor move as intended. However, the maximum wind velocity that could be simulated was 5.4 m/s. On the Beaufort Scale, such a wind speed has a Beaufort number of 3 and is considered as a Gentle Breeze only. But due to the rotor being lightweight it was easily rotated, and enough Revolutions were generated.

Table 1. Results of Wind Turbine.

WIND SPEED m/s	RPM	VOLTAGES
4.1	200	14.91V
4.5	241	17.0V
4.9	253	18.17V
5.1	265	18.64V
5.4	302	19.1V

In the Table 2, the results of the solar panel are discussed. By placing the solar panel throughout the day and measuring the solar panel output using a multimeter following

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open source voltages were obtained. Since the panel was directed at a 90 degree angle at the peak hour (12:00 p.m.), the maximum voltage output of 19.65V was obtained.

Table 2. Results of Solar Panel.

TIME	VOLTAGE
8:00 a.m.	10V
10:00 a.m.	15.46V
12:00 p.m.	19.65V
14:00 p.m.	19.34V
17:00 p.m.	14.62V
20:00 p.m.	0.0V

Since the weather and traffic may vary and affect the power output, only the results which are definite have been discussed in this paper. In addition both the Energy sources do not have a common storage system and may be lethal if constructed in the wrong way.

6. CONCLUSION

This paper discusses the construction of a Road Power Generation unit, which when placed along a roadside can be considered as a green energy source. The mechanical system consists of a Savonius Rotor which captures the wasted energy produced by a moving vehicle and converts it into useful work done. Moreover, a solar panel converts the light energy from the sun to generate electricity through the Photovoltaic Effect. The project demanded designing and manufacturing of a wind turbine with solar energy tower. A wind turbine is essentially a vertical axis wind turbine specifically of the Savonius type. Research has been going on VAWT in order to study their performance parameters and introduce them in the market as a competitor to the conventional horizontal axis wind turbine (Menet, 2004). Furthermore, RPG units are the future of smart cities.

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