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Design and Development of Hybrid Electricity Generation for Highway Charging Station

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Abstract

The power of highways is the idea to transform highways into renewable energy sources by using the dynamics of the city. The system will generate energy by using the winds created by the vehicles as well as the natural winds and sunlight. The vertical axis wind turbine in this system uses the wind pressure generated by the fast-moving vehicles on roads that helps to rotate its blade. It is designed with vertical long blades such that it will use the utmost quantity of wind energy. The turbine used in the prototype covers less space on the ground and is simple to handle and can easily be assembled and disassembled which makes it more durable. Solar panel is also fixed at the top of the turbine to generate electricity; further this energy can be used to supply the EV charging stations for the charging of EV.As observed the shortage of coal and water in the country is increasing day by day so this idea can be used to help the existing power generating plants so that the load demand is fulfilled. We can also satisfy the need of household energy by simply putting it on a terrace or roof of the house as this is combination of both wind generator which will use the natural air to produce energy and a solar panel which will generate electricity from the sunlight. In absence of one element it is still able to generate sufficient energy to supply the household power consumption.

Keywords: *Renewable Energy, Wind turbine, Solar Panel, Charging Station*

1. Introduction

Keeping in mind the entry of electrical vehicles in the Indian markets along with the charging stations to charge them, the demand of electricity will increase and so will the load on the existing generating stations. To help the existing generating system the idea is to transform highways into renewable energy sources by using the dynamics of the city. The system will generate energy by using the winds created by the vehicles as well as the natural winds and sunlight. The vertical axis wind turbine in this project uses the wind pressure generated by the fast-moving vehicles on roads that helps to rotate its blade. It is designed with vertical long blades such that it will use the utmost quantity of wind energy. The turbine used in the prototype covers less space on the ground and is simple to handle and can easily be assembled and disassembled which makes it more durable. Solar panel is also fixed at the top of the turbine to generate electricity; further this energy can be used to supply the EV charging stations for the charging of EV.The proposed method is to design and develop a hybrid renewable energy system consisting of a vertical axis turbine and solar panels for electric energy generation and to utilize the wind energy provided by speeding vehicles for running the turbines day and night. The Indian government also allows the offshore wing plants power generations as the energy demands are increasing drastically. So, this method utilizes both wind and solar energy for its operation of power generation, which will be a great advantage.

2. Literature Survey

Many authors have done work in integrated hybrid electricity generation. The guidelines for generation of hybrid electricity are also given by Government of India through a Handbook of electric vehicle charging infrastructure implementation. Ilham Satrio Utomo (1) has calculated the wind energy from gusts produced by trains that are moving inside tunnels by placing Savonius rotors alongside the trains using an Open FOAM CFD analysis. The power production by utilizing the wind velocity in moving trains by using the converging conical shaped ducted turbine on the roof of the train and air suction system to fulfill their standby operation at different speeds of wind is discussed in (2) by B.Sindhuja. The important feature of this paper is utilization of encasing for the turbines called duct or shroud which is used to obtain increased wind velocity at turbine inlet.In (3) the author has used the vertical wind axis turbine with eight blades.8 blades are used so as to maximize utilization of wind and moving vehicles. The theoretical calculation shows that VAWT is designed and fabricated in such a way that it is able to capture wind from all directions. In (4) the design model of wind turbine has 3 blades. The system of VAWT is fitted to the street lamps on the divider. The comparative study of different types of vertical wind axis turbines is also done in this paper. The authors in (5) have used the combination of HAWT and VAWT to produce electricity. The horizontal wind mill is highly used for large scale applications which require more space and huge investment whereas the vertical wind mill is suitable for domestic application at low cost. The electricity production by using the wind produced by vehicle on the highway divider is discussed in (6). In this paper with the help of Impulse Savonius vertical axis wind turbine which is integrated with Solar system to produce electricity and to provide the constant air flow towards the blade of VAWT is discussed. The generation of electricity is affected by the geometry and orientation of the blade in the wind turbine. The design of windmill blades is the remarkable point of study conducted by N Venkata and M.L.S Deva Kumar,(7). The experimental result indicates that the blade plays a critical role in the performance and energy production of the turbine.

3. Proposed System

The energy can be generated through wind energy, solar energy, or the combination of the sources called as hybrid energy. In this proposed system we can install wind turbine anywhere as the size is small and as the generator used will be a permanent magnet synchronous machine which requires only minimum torque during starting. This turbine can be kept at any places like seashores, buildings and normally in wind vicinity areas. The proposed turbine is fixed on roads by utilizing the wind produced by the moving vehicles and also by the use of solar additional generation can be possible and interconnection of multiple models can be used to give the power

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to the charging stations located on highways. The fig 1 shows the block diagram of the system. As soon as the vehicle crosses with high speed the wind turbine starts rotating so do the shaft of the generator and hence emf is induced in the generator according the faraday's law of electromagnetic induction. As the generator output is not pure dc and not constant it is given to the booster circuit to get a constant 12V at the battery terminals. The solar panel located at the top of the system will also convert the sunlight into 12V DC electricity which is further given to a forward biased diode which prevents the reverse current flowing to the solar panel from battery and this is further given to the charging circuit of the battery. The charging circuit of the battery is the heart of any battery storage since it maintains the proper charging voltages of the batteries. The charging circuit regulates current from the solar and wind combination and charges the battery. It also prevents the battery from overcharging and undercharging conditions. The various components used are

Wind Turbine: A vertical axis wind turbine is a type of wind turbine where the main rotor shaft is set transverse to the wind while the main components are located at the base of the turbine. This arrangement permits the generator and casing to be located close to the ground, facilitating service and repair. VAWT ought not to be pointed into the wind, which removes the necessity for wind sensing and orientation mechanisms.

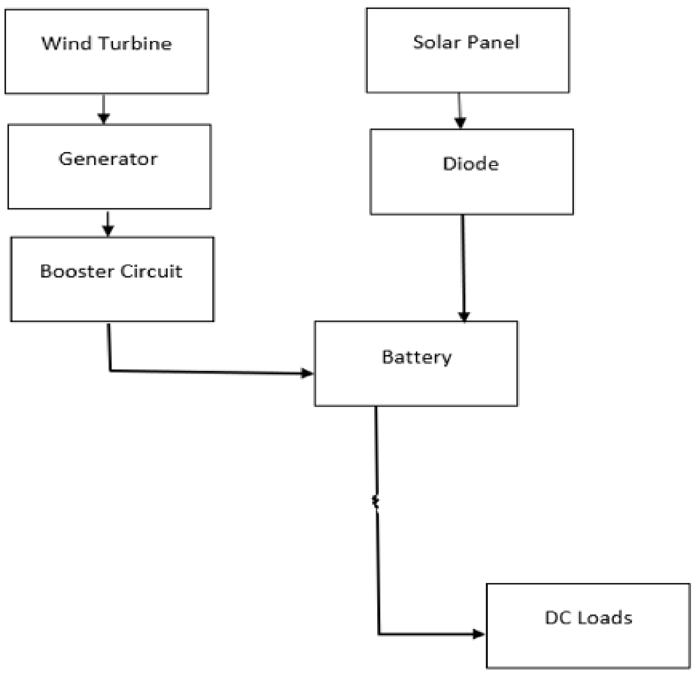

Fig 1: Block diagram of the system

The VAWT used in this system is the Savonius Style Vertical Axis Wind Turbine. The Savonius wind turbine is one of the simplest turbines. It is a drag-type device that consists of two to three scoops. Because the scoop is curved, the drag when it is moving with the wind is more than when it is moving against the wind. This differential drag is now what causes the Savonius turbine to spin. Because they are drag-type devices, this kind of turbine extracts much less than the wind power extracted by any other type of VAWT. The material used for

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the blades of turbine can be of PVC, Carbon fiber, Glass Fibre and Aluminum alloy. For our system we are using the PVC as it offers good weight to height ratio and is non corrosive. We are using 3 blade Savonius style VAWT as it is the most efficient for less velocity of air and also is independent of air flow direction. The blade pitch is 120 deg.,Angle of curvature is 180 deg and the width is 70 cms.

Fig 2: Wind turbine system

Solar Panel : A solar panel absorbs sunlight as a source of energy to generate electricity. Photovoltaic modules represent the photovoltaic array of photovoltaic systems that generates and supplies solar electricity in commercial and residential applications

Fig 3: Solar Panel

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Table 1: Specifications of Solar Panel

Sr.No.	Parameters	Specification
1.	No. of Cell	18
2.	Size(mm)	287*185
3.	Rated Max. Power (Pmax)	10(+-3%)
4.	Open Circuit Voltage (Voc)	20 V
5.	Short Circuit Current (Ise)	0.65 A
6.	Rated Voltage (Vmax)	16.5 V
7.	Rated Current (Imax)	0.58 A
8.	Maximum Power Tolerance (%)	5%

Generator: A permanent magnet synchronous generator is a generator where the excitation field is provided by a permanent magnet itself instead of a coil. The term synchronous refers here to the actual fact that the rotor and magnetic field rotate with the identical speed, as the magnetic field is generated through a shaft mounted permanent magnet mechanism and current is induced into the stationary coil.

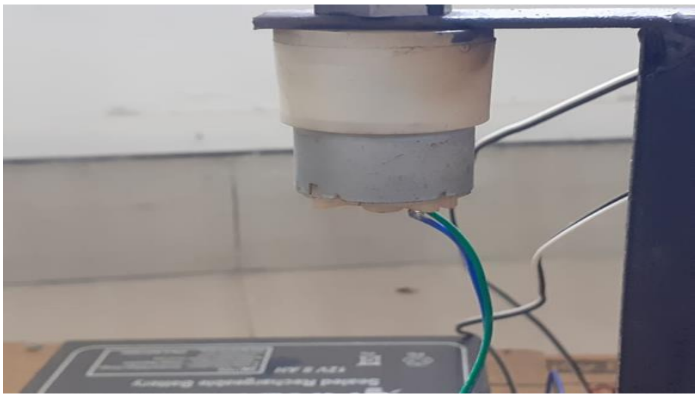

Fig 4: A DC Generator

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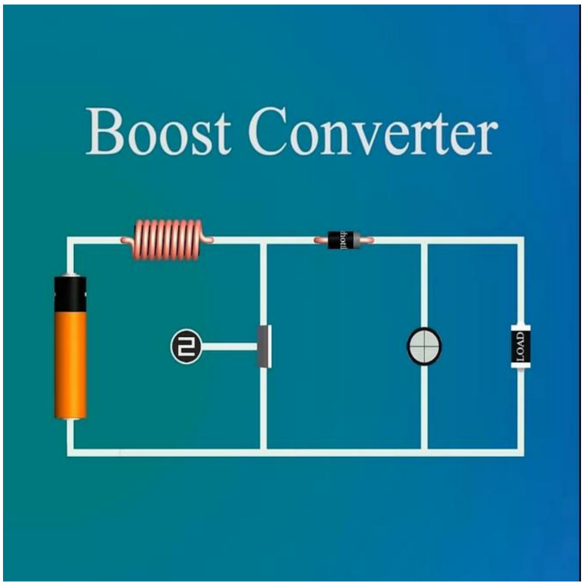
The specifications of DC generator are as follows: No. Of Poles: 4,Speed: 300 rpm,Operating Voltage: 12V DC, Attached Plastic (spur)Gearbox, Shaft diameter 6mm with internal hole, Torque: 2 kg-cm,No-load current = 250mA (Max),Load current = 400 mA (Max)

Booster Circuit: A Booster Circuit is designed to get the desired voltage to the terminals of battery as we know the generator output is not constant and also it is less which cannot be given to the battery directly so to get a constant high voltage a booster circuit is used.



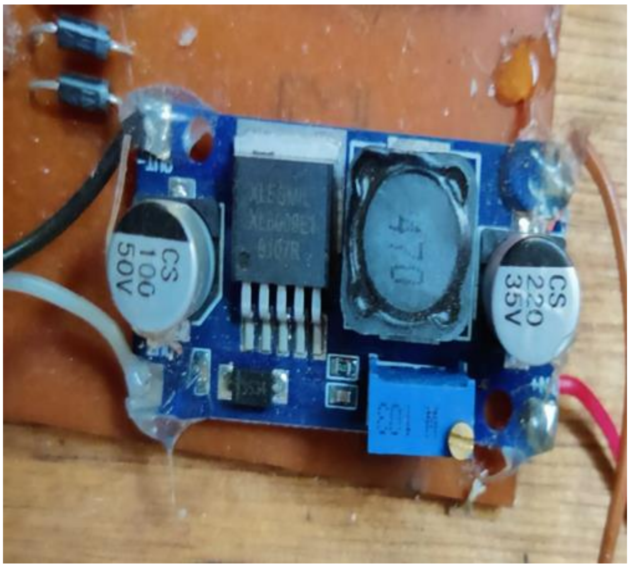


Fig 5: Booster Circuit

The specifications are

Table 2: Specifications of Booster circuit

Input (Volts)	Output	
	Volts	Amp
0-3	12	0.2
3-4	12	0.4
4-5	12	0.8
5-6	12	0.9
6-7	12	1

Battery: A battery is an electric device of one or more electrochemical cells. When it is supplying electric power, its positive terminal is the cathode and its negative terminal is the anode. The negative terminal is the source of electrons that will flow through an external electric circuit to the positive terminal. When a battery is connected to an external electric load, a red ox reaction converts high-energy reactants to lower-energy products, and the free energy difference is delivered to the external circuit as electrical energy. The

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specifications of the battery are Battery Type : Lead acid Battery , Battery Capacity : 8Ah , Output Voltage 12 V. The complete system diagram is shown in fig 7

Fig 6: Battery

Fig 7 Complete system diagram

4. Experimental Results

While testing the system we have calculated both theoretical values and experimental values and then the comparison is done.

Theoretical calculations: The total power generated by this system may be given as the addition of the power generated by the solar PV panel and power generated by the wind turbine. Mathematically it can be represented as

PT= NW * Pw + NS *Ps ---------------- (1) where

PT = Total Power generated, NW= No. of wind turbine, Pw= Power generated by wind turbine, NS = No. of solar panels, Ps= Power generated by solar panel.

Calculation of wind energy: One of the eco-friendliest methods of conversion of energy is to convert the air into energy. But most of the energy of air remains uncaptured by the turbine. Conversion of the energy follows the Betz law. The Betz law provides a power coefficient, which is called the Betz limit. It shows how much energy a turbine can absorb from air. Theoretically the maximum value of Betz limit is 0.593. And practically the value range is 0.35 to 0.45. The available wind power of a turbine is equated by

K.E. = ½. Mv^2……………………………………………… (2)

Where,

K.E. = kinetic energy of wind

M = mass of wind draft

V = velocity of wind draft

M = ρ. AV

So,

K.E. = ½. P. AV x V^2…………………………………………….... (3)

Pw = ½. ρAV^3watt.--(4)

Where,

ρ = density of air

=1.225 kg/m^3

Area for wind turbine

A = d*h $meter^2$

Where, d = diameter h = height.

Table 2: Vehicle Speed and Energy relationship

Sr.No	Vehicle Speed	Energy KWh
1	40km/hr	0.0622
2	70km/hr	0.5162
3	100km/hr	0.940

Calculations for solar energy:

To determine the size of PV modules, the required energy consumption must be estimated. Therefore, the power is calculated as

PS = Ins(t) * AS*Eff(pv)

Where,

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Ins (t) = isolation at time t (kw/ m^2)

AS = area of single PV panel (m^2)

Eff (pv) = overall efficiency of the PV panels and dc/dc converters.

Overall efficiency is given by,

Eff(pv)= H*PR

Where,

H = Annual average solar radiation on tilted panels.

PR = Performance ratio, coefficient for losses

Experimental calculations: We took 4 readings on hourly basis from 10.30 am to 1.30 pm as follows

Table 3: Solar Readings

Sr.No	Time	Voltage (V)
1	10.30 am	14.55
2	11.30 am	13.06
3	12.30 pm	14
4	1.30 pm	14.40

The battery took 2 hrs to charge from 12.2 V (Fully Discharge) to 13 V (Fully Charged) without load. We took 5 readings each hour at the interval of around 12minutes for 5 hours.

Hourly Avg.Generator Output = 3.68 Volts

Battery took around 15-20 Hours to charge from 0 to 100% with wind as active source. Average Booster Output = 12V. 0.4 Amp

Table 4: Wind Readings

Sr. No.	Time Interval	Avg. Wind Speed (Meter/Sec)	Generator Output (Volts)	Booster Output	
				Volts	Amp
1	11-12	2.12	1.82	12	0.2
		4.17	4	12	0.4
		4.20	4.5	12	0.8
		6.11	5.6	12	0.9
		3.611	3.5	12	0.4
2	12-1	8.33	6.2	12	0.1
		6.0	5.4	12	0.9
		3.51	3.3	12	0.4
		8.40	6.24	12	1
		2.69	2.20	12	0.2

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3	1-2	3.81	3.75	12	0.4
		6.24	5.72	12	0.9
		2.00	1.2	12	0.2
		3.24	3.3	12	0.4
		4.10	4.2	12	0.8
5	2-3	6.52	5.98	12	0.9
		8.40	6.24	12	1
		3.00	2.8	12	0.2
		4.35	4.34	12	0.8
		8.45	6.09	12	1

Table 5: Hybrid Output

Sr. No	**Time Interval**	**Avg. Wind Speed (Meter/Sec)**	**Avg. Generator Output (Volts)**	**Booster Output**		**Solar Output**		**Combine Output**	
				Volts	**Amp**	**Volts**	**Amp**	**Volts**	**Amp**
1	11-12	4.166	3.84	12	0.4	10	1	12	1
2	12-1	4.722	4.66	12	0.8	12	0.8	12	1.6
3	1-2	3.889	3.63	12	0.4	16	0.6	12	1
4	2-3	5.566	5.09	12	0.9	14.6	0.7	12	1.6

It is observed that while keeping load continuous battery percentage was neither increasing nor decreasing, it remained constant to 12.3Volts for 4 hours.

5. Conclusion

The system is developed using solar energy and wind energy. The experimental values are taken from the roof top of five storied building and the results are given in the table. It is observed that the wind is variable due to this the charging time with only wind as active source is more than combined active source wind and solar. In future the energy generated by this system can be stored and use for nearby villages or home town. It can also reduce the load of existing power plant.

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