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Energy Management using Li-Ion Battery for Solar and Savonius Rotor Hybrid Energy System

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Article Info
Volume 83
Page Number: 6191 - 6196
Publication Issue:
May-June 2020

Article History
Article Received: *19 November 2019*
Revised: *27 January 2020*
Accepted: *24 February 2020*
Publication: *18 May 2020*

Abstract:
The demand for oil concentrated the supply of stable fuels which was uncovered by a petroleum crisis. Improvement of healthier sources of elective energy is renewable and has negligible ecological impact. The alternate fuels, the hybrid system's electrical energy is generally considered a more valuable renewable energy source because it is clean, plentiful and dispersed across the globe. Given the individualities of atmospheric reflection and absorption of photons, it is estimated that the event of solar radiation on the Earth's atmosphere is ten thousand times higher than the world's energy consumption. Reducing carbon dioxide emissions is a major benefit of the hybrid system. These approaches are accurate, fast and effective. Because of its benefits, such as the absence of fuel costs, low maintenance requirements and environmental friendliness, the hybrid system has become increasingly important as a renewable source. Such methods differ in complexity, mandatory sensors, combining speed, cost and performance rate. Hybrid Systems has the most capacity to meet our demands for electricity. Solar energy occurs during the day, but periods of solar irradiation differ due to the strength of the sun and the irregular shades produced by clouds, birds, plants, etc. Similarly, wind energy is capable of providing substantial electricity. Yet, its appearance is somewhat unpredictable, because one moment it may be here and in another it has gone in. The common inherent drawback of the hybrid system is the erratic natures which render it unreliable. This system requires the suppliers to supply the charge individually or automatically, depending on the efficiency of the sources of electricity. The integrated device energy analyzes are made for Li-ion batteries.

Keywords: *Induction Generator, Inverter, Microcontroller, Rectifier ,Relay, Solar Panel, Wind Turbine*

1. INTRODUCTION

Conventional sources of electricity are flawed and they pollute the atmosphere. Therefore, the use of alternative energy sources such as solar energy, tidal energy, wind energy, fuel cell, etc. has been given further attention. Wind Energy is among them the most growing and most auspicious form of renewable energy, as economically feasible. In this paper a hybrid system[1] of solar panel and rotor wind turbine model savonius [6] is proposed.Li-on battery is employed for storage purpose to examine the performance of overall system. The simplified block diagram shown in figure 1, consists of PIC Microcontroller, Relay driver, Converter and Inverter section to supply for both DC and AC loads. MATLAB Simulink is used to analyze the simulation results.

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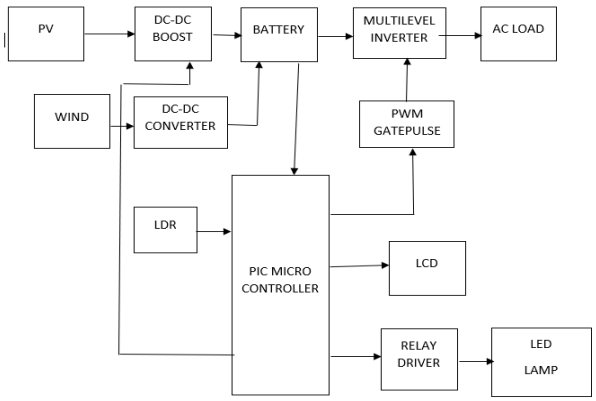

Figure 1: Block Diagram of Proposed Work

I. HARDWARE DESCRIPTION

A. Solar Panel

A 50W 12V monocrystalline solar panel is installed for the hardware unit. Positive output tolerance level is around 0-3%. The panel can withstand high winds and snow loads which may be approximately of 2400Pa and5400Pa. The panel is compatible with both on-grid and off-grid system. Table I indicates the specifications of the panel

Table: I Panel Specifications

Description	Ratings
Wattage Wp	50W
Voltage at max power	20.0 V
Current at max power	2.25 A
O.C Voltage	25.36V
S.C Current	2.40A
No of Cells	36

B. Savonius rotor

Savonius is a types of air turbine with vertical axis. With this type whatever the direction the wind is blowing, it will push the rotor around. The prerequisite is to have a ring divided vertically into two parts. Such two parts are attached to a vertical shaft's two opposing directions as the wind blows into the unit, two separate convex and concave surfaces cross, and different forces are exerted on them, giving the rotor a torque. Even though the efficiency of this type of turbine is less when compared to other types, it may be applicable for small projects which are less than 100W. Coupled with the utility system, the induction machine seeks errand for fixed-pitch, almost constant speed wind turbines to provide damping for the wind turbine drive train as it encounters volatility in the power input due to wind speed variations. An induction generator has no problem with synchronization.

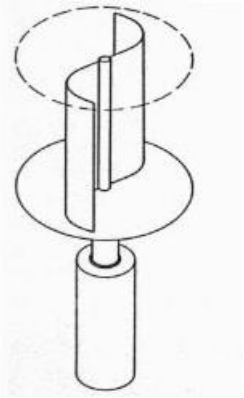

Figure:2 Savonius Rotor

C. Li-ion battery

In perfect condition a 12V solar panel needs the output of 17V or more in order to charge efficiently the 12V battery. In this proposed system 16 Li-ion batteries are connected in parallel. The nominal capacity is 2600Ah and the minimum level is 2500mAh.Discharge current and voltage level is .52A and 2.75V. Because of high power density and energy density Li-ion batteries are preferred. It also has increased number of charging cycle with the conventional batteries [4]. The appearances of Li-ion energy storage unit are shown in table II

Table: II Battery Characteristics

$V_{nominal}$	3.6V
$Z_{internal}$	≤70mΩ
$V_{cut\text{-}off(discharge)}$	3.0V
$V_{max\ charge}$	4.20±0.05V
I_{SC}	0.51A
I_{RC}	1.2A
I_{SD}	0.51
I_{RD}	1.3A
Operating temperature	Charge 0-45^{0}C Discharge : -20^{0}C-60^{0}C
Cycles	300 cycles of residual capacity

The storage capacity of the energy storage unit

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with respect to the temperature and moisture level for a certain duration of a month. According to the enhanced coulomb counting algorithm Li-ion battery, the following parameters can be calculated.

$$\boldsymbol{SOC} = \frac{\boldsymbol{Creleasable}}{\boldsymbol{Crated}} \times \mathbf{100\%} \quad (1)$$

$$\boldsymbol{SOH} = \frac{\boldsymbol{Cmax}}{\boldsymbol{Crated}} \times \mathbf{100\%} \quad (2)$$

$$\boldsymbol{DOD} = \frac{\boldsymbol{Creleased}}{\boldsymbol{Crated}} \times \mathbf{100\%} \quad (3)$$

Where,

$C_{releasable}$ =releasable capacity of an operating battery

C_{rated} =rated capacity of battery

C_{max}=Maximum releasable capacity of fully charged battery

$C_{released}$=Capacity discharged by any amount of current.

D. Converter Charge Control Unit

MPPT charge controller tests the PV module output, compares it to the battery voltage, then adjusts the best power the PV panel can generate to charge the battery and converts it to the best voltage to get the full battery current [9],[10]. It can also provide the power to connect DC charging directly to the pump. This paper suggests a cumulative conductance algorithm, based on the benefit. All the regulator functions of the system are performed by PIC 16F877A microcontroller which includes the action of the relay driver circuit, LDR unit, and the pulse generation required for the multilevel inverter section.

II. Proposed Hardware / Software Unit

The proposed hardware model is shown in figure 3, with the solar panel and savonius rotor, the controlling unit is shown in figure 4.

Figure: 3 Proposed system model

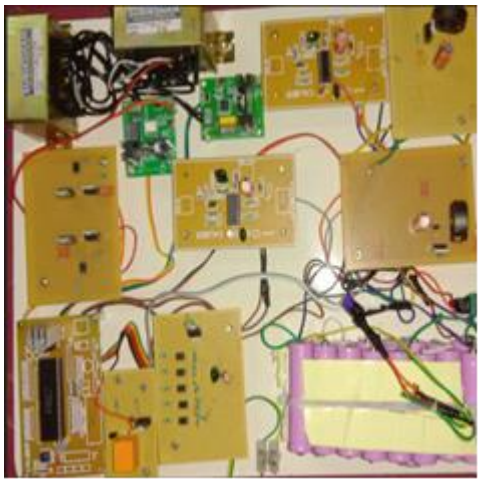

Figure: 4 Hardware Circuit

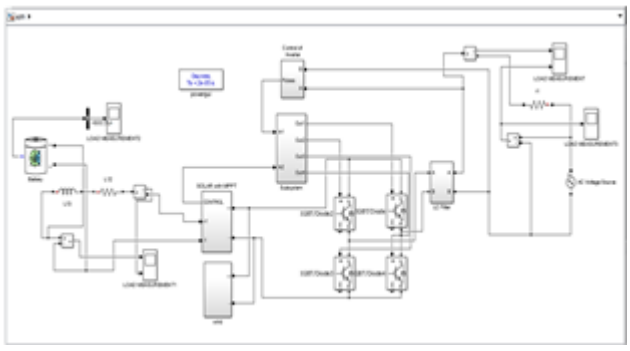

Figure: 5 Simulation Circuit

MATLAB software used to obtain the simulation results of the hybrid system.

III. Software Compilers

The PIC 16F877A is a family of redesigned microcontrollers made by microchip technology from Harvard Architecture. PIC was referred

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specifically to as the remote interface controllers. The PIC 16F877A MCU features two built-in Contrast Catch and PWM control modules. The CCP module consists of 16bit registers for each of the three modes that change its operating function as catch, compare and PWM duty cycle register based on the user requirement.

IV. Result and Discussion

The proposed hybrid system [5],[7],[8] is planned to install in National Highways where the adequate solar and wind generation is possible. By passing vehicles the savonius rotor can able to rotate and generate power depending on wind velocity and the average value of wind velocity is calculated with the vehicle speed of 60km/hr approximately. Also, the solar panel placed, and its generation is noted according to the intensity level of solar irradiance. Table III shows the hardware output of the hybrid system.

Table:III Solar Intensity Measurement

Time in (hr)	Intensity level (W/m^2)	V	I	W
9.00-10.30a.m	10	3	3	9
10.30a.m-12.00pm	20	7	3	20
12.00-4.00p.m	31	8	3	25

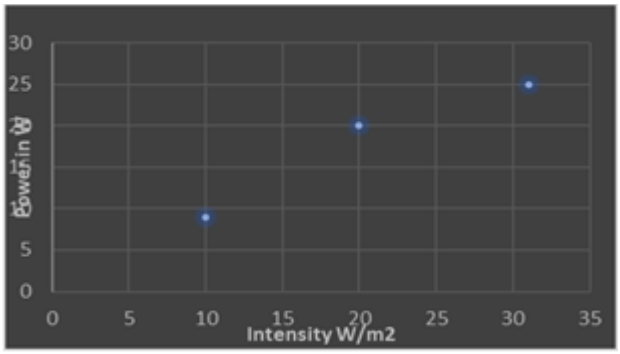

Figure:6 Solar power related to intensity

Day basis of solar output is dispatched in table IV. With respect to the output of the battery, the converter boosts up output voltage for efficient charging of the battery.

Table: IV Wind velocity by moving vehicles

Vehicles	Wind Speed(m/s)	Power Generation W
Car	6	8
Van	12	15
Truck	20	23
Bus	25	28

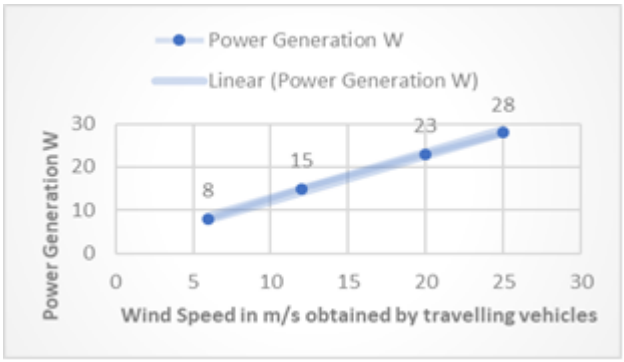

Figure:7 Wind Power Generation chart

By continuously obtaining the approximated power the proposed battery needs the required time as mentioned in the table to charge to its nominal value.

Table:V Battery Charging Time

Power (W)	Time required for charging (hours)
6	14
10	8.4
20	4.2

With the proposed system, in order to charge the 24V ,4A lithium ion battery approximately 7 hours is needed to charge with the output of solar and wind power. A 20W LED lamp can be powered from the battery [7]. The battery can withstand to power the lamp from 7.00p.m to 5.00am efficiently. DOD of the battery is 80% of its full load capacity.

The simulation results of wind generator for typical wind velocity base speed of 12m/s is shown below figure 8,

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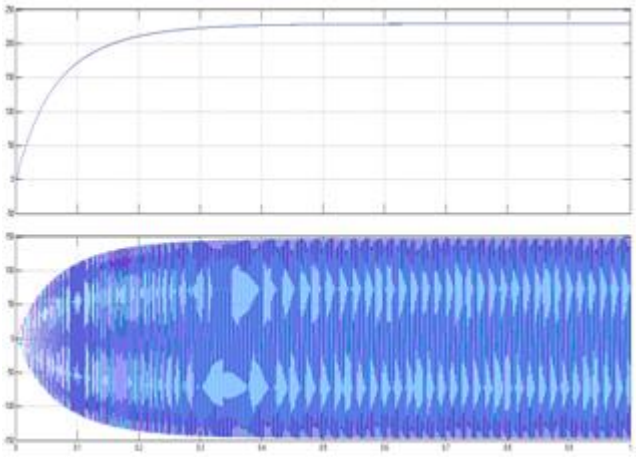

Figure:8 Wind Generator output

The output of the solar panel is clearly exposed in figure 9.

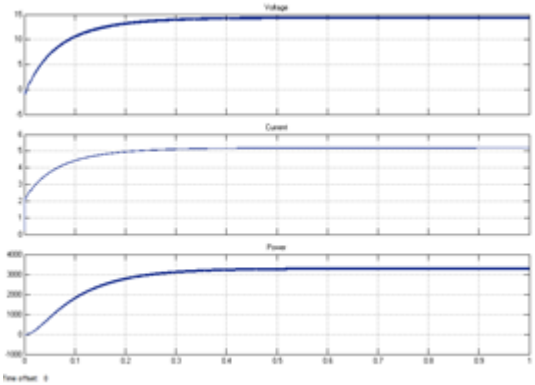

Figure: 9 Solar output

The battery charging characteristics of simulation result is shown in following figure 10.

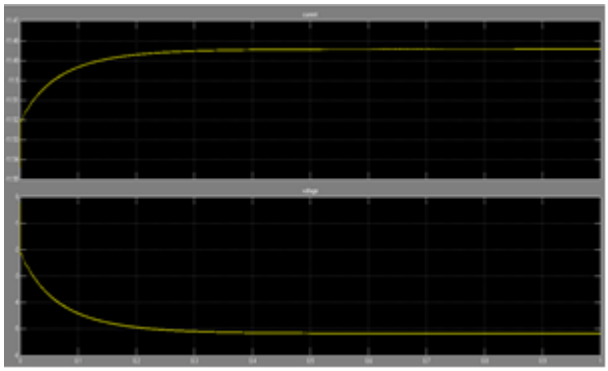

Figure:10 Battery Charge /Discharge Characteristics

Battery SOC is shown in simulation output. Based on the above result the proposed system might work successfully if placed on highways with proper storage devices.

V. CONCLUSION

The proposed hybrid power generation project is installed in national highways and the generated power is efficiently used for and powering stand-alone streetlight. The efficient output can be obtained from the wind turbine during the air flow periods and during the daytime the solar panels would produce their peak outputs. The generating power is stored in Li-ion battery can be utilised for 10 hours to light a 20W lamp during nighttime in highways. Further the load can be additionally attached with a 3way socket pin in order to charge mobile for emergency purpose while travelling.

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