Design and Development of Hybrid Power Generation System

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ABSTRACT— There is an increase in the demand of renewable energy resources to fulfill the demand of agriculture for water pumping purposes. In the most of rural area hardly four to six hours of supply electricity could be supplied. Alternately, in day or night, diesel based water pump are very expensive and maintaining them is costly. Diesel based pump caused environmental pollution. The Energy production from a combination of energy source knows as a hybrid system represented by an important objective is design & manufacture system consisting combination of solar wind and hydro to generate power and calculate performance and power generation from system. The present work aim to develop of hybrid power generation involved the process of selecting the best component and size, cheap, efficient, reliable and cost effective renewable energy. Design and development of hybrid system consist of three main systems, solar, wind and hydro out of which the main source of power to the energy system is photovoltaic where as wind and the hydro supported rest of the source. In this system is consist of 180 watt photovoltaic solar panels (PNX-180 polycrystalline silicon 180 W) ,wind turbine of 20 watts and hydraulic turbine of 10 watts. The photovoltaic, wind and hydro coupled with the battery of 12 V – 26 Ampere hours and battery charging and discharging controller.

Keywords— Hybrid energy system, photovoltaic energy, wind energy, hydro energy, Battery energy storage.

I. INTRODUCTION

Renewable energy is essential for social and economic development, however consumption of nonrenewable energy resources. Cause of air pollution and climate change. renewable energy is energy from that is non depleting or potentially renewable. Non depleting from of energy include energy from the sun, energy from wind and energy from flowing water actually three from of energy. Solar because differential heating from sun and partially responsible from wind. Evaporating water from the sun have water in the atmosphere which lead to precipitation, which drive the hydro electric cycle. Which give flowing actually few hundred years ago energy supply while renewable solar animal dung wood. After discovery, fossil fuel fraction of renewable energy supply were decreasing and fraction of fossil fuel is increasing. As it know that high quality of the fossil fuel release. Carbon dioxide, which cause environmental effect such as greenhouse gas emission, air pollution increase in economical cost of potential for depletion of fossil fuel supply with great increase uses of renewable energy resources. Renewable energy used it important recognize most of economical cost occurs in the beginning during installation once renewable energy installed up and running. In contrast energy come from Non renewable energy constant fuel cost and fluctuation in energy price many renewable energy sources used to generate electricity.

1.1 Solar energy

The function of solar energy photovoltaic system is to convert sunlight into electricity. The electricity generated can be used directly or stored different size of photovoltaic module produce different amounts of power. If overheating of solar panel then efficient of solar panel reduce. The Cooling system can be implemented to reduce the heat from the photovoltaic panel (Shenyi, et al, 2014) have carried out experiments on passive cooling toward the PV cell. In passive cooling method utilize rainwater as a cooling media rainwater is successfully increasing the electrical efficiency of the photovoltaic panel by 8.3 % .
(Khadidja, et al, 2010) has carried out the experiment on After experiment, it is found that gain in amount of energy when mounting the PV system on the trackers. Also, he found that 20-35 of efficiency increase has been achieved with two axis solar tracking system. The average solar power generation capacity of India is 0.25 KWH per $m^{2\ of}$ land area. The Indian Government is planning to targeting 100 GW of solar capacity by 2022 MNRE plan to add 12 GW of solar power capacity between 2016-17. This is massive target when compared to a target of 2015-16 of just 1.4 GW.

1.2 Wind energy

Wind turbine is converts mechanical energy into electrical energy. For design of high efficiency wind turbine consist of different aspect and performance shape and dimension of wind turbine determine the aerodynamic performance (Magdi,et al, 2011)Bet's

law calculate maximum power that can extracted from the wind turbine. (Wenehenubuna et al, 2015) carried out an experimental study on the performance wind turbine related with the number of blades. After the experiment, it found that Wind turbine rotor with four blades has high torque compared with two or three blade rotor In the fourth edition of Global wind energy outlook released in 2014 states the wind power currently share about 4 % of global electricity and It is expected to reach up to 17 % to 19 % by 2020 it is also producing 2 million jobs and reduce CO_2 emission. The word wide total wind capacity was 336GW, showing growth about 18.7% (44 GW) over the preceding year. Wind energy could provide 25-30 Global energy requirement by 2050. Wind energy is currently utilized by more than 84 countries to supply their electricity MNRE indicate that India is planning to achieve a target of 60000 MW is a total wind installation by 2022 this set the industry an ambitious annual target approximately 5000 MW/ year up to 2022.

1.3 Hydro energy

Hydro energy is energy generated by the force of water this is a powerful way to generate the electricity. Hydro energy is converted into electrical energy by hydroelectric power plant. This energy is called hydro electricity. India first hydroelectric power plant in 1887 at Darjeeling in west bangal. hydro power depends on water level from the ground, the volume of water flowing per unit time and efficiency of the turbine hydro power required water reservoir due to the force of water turbine start rotating due to which mechanical energy is produce shaft from the turbine is converted to generator therefore generator produce electricity. (Zhang et al, 2007) it investigates the flow interaction between the jet and rotating bucket and relative flow in the bucket of pelton turbine. The present installed capacity is 42,783 MW, which is 14.35 % of total utility electricity generation capacity in India. In addition to 4274 MW small hydro power unit are installed in 2016.

1.4 hybrid system

The hybrid system is a combination of two or more components connected to each other. A hybrid solar wind and hydro system that converts sunlight, wind and water energy into electricity.[6](Vadirajacharya et al.2012) investigated that individual system, power generation is costlier. So solution for that to used solar and wind energy. The system is design capture energy an compliment and combine way at the time of no wind. Energy is available through solar photovoltaic panel during day time and windmill generated energy ever suitable wind speed available. The generated energy can be stored in a battery bank. Hybrid energy system has extended used where grid connection is unavailable.

2. The hybrid photovoltaic wind hydro system description

The propose system composed of at 180W photovoltaic solar panel (PNX 180 polycrystalline silicon 180), one wind turbine of 20 W and hydraulic turbine of 10 W connected to battery. The PV wind and hydro hybrid system is coupled to battery of 12V-26Ah lead acid types and battery charge controller. photovoltaic panel connect solar radiation into direct current and wind turbine and hydraulic turbine generated the direct current by the controller. The DC voltage obtain from PV and wind system is connected to input of controller system.

The schematic diagram for the hybrid system solar wind hydro system shown in fig 1 with photo of actual installation. The experimental set up has realized in the research unit in renewable energy in Pune region. The photovoltaic panel consist of primary energy supply while wind and hydro are secondary energy supply.

In the schematic diagram show that energy obtain solar wind is supply to battery through charge controller. After that energy stored in battery is used for the water pumping purpose that pump water is impinge on water turbine to generate power and supply to battery. Basically aim to the research work to increase power generation with minimum cost.

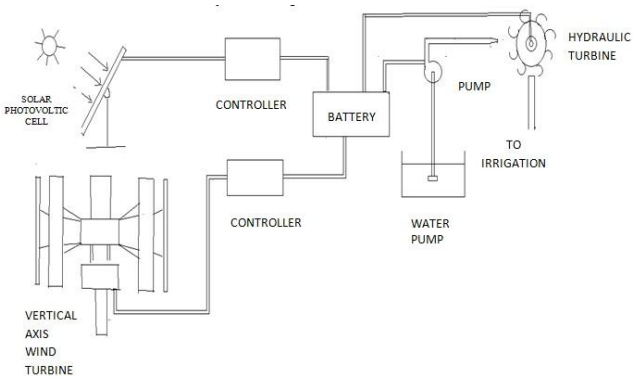

Fig.1 Schematic diagram of the hybrid system

Fig. 2 Photos of the PV Panel and wind Turbine

Fig. 3 Photos of the Water turbine and DC motor pump

3. Analytical design

A. Analytical Calculations of Wind turbine

Wind turbine is the device used to extract energy from wind. To fulfill need of water pumping, power required considered is 20 W.

1) Diameter and Radius of rotor

Power generated by a wind turbine is given by formula

$Pa = ½ \times \rho \times A \times v^3 \times C_p$

$A = 0.426\ m^2$

A= D x H

D= diameter of the blade

Taking diameter as 1 meter, height of turbine can be calculated as

H=0.426 m

2) Theoretical torque generated

After market survey, generator purchased for 20 Watt capacity with following specifications

Voltage =24 V

Power = 20 Watt

Rpm, N = 300

$P = \frac{2 \times \pi \times N \times T}{60}$

T= 0.6333 N m

This is theoretical torque produced, in actual torque required is more

3) Tip speed ratio (TSR)

Tip speed ratio is calculated by formula

$TSR = \frac{\omega r}{V}$

TSR= tip speed ratio

r = Blade length

V = rated velocity

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

ω = 31.41 rad/sec

TSR = 2.10

4) Number of blades (n)

Number of blades given by formula

$n = \frac{4\pi}{TSR}$

$= \frac{4\pi}{2.10}$

= 5.98

Now minimum number of blades require is more than 5, so for balancing purpose, number of blades selected are 6

5) Final Blade dimensions
Final dimensions of rotor according to above calculations are

Table 1 Specification of wind turbine

Sr. No	Parameter	Dimensions
1	Rotor total swept area	0.426 m^2
2	Number of blades	6
3	Angular speed	2.10 rad/ sec
4	RPM	300
5	Standard Coefficient of performance	0.3

B. Calculation of Solar panel
Total load =240 watts
Period of operation = 6 hr
Total watt hour = 240 x 6 = 1440 W-hr
Period of solar panel expose to sun = 8 hours
Therefore solar panel wattage = 1440/8 =180Watt
No of panel = 180/180=1

Table 2 Specification of Solar turbine

Sr. No	Parameter	Dimensions
1	Power (Pm) in watt	180
2	NOs	1
3	Voltage at Maximum Power (Vmp) in Volts	26.5
4	Current at Maximum Power (Imp) in Amps	6.79
5	Solar Cells per Module (Units)	54
6	Length x Width x Thickness (L x W x T) mm	1260 x 986 x 35
7	Weight – Kg	14
8	Area – Sq. M	1.24

C Calculation of Impulse Turbine
1) Velocity of jet
$V_1 = C_v \sqrt{2gH}$
Assuming Head = 3m, $C_v = 0.985$
$V_1 = 7.5569$ m/s
2) Velocity of Wheel :
$u = € \sqrt{2gH}$
€ = Speed ratio = 0.455
u= 3.490 m/s
3) Mean diameter of Runner (D)
$u = \frac{\pi DN}{60}$
D= 0.1025m
4) Number of bucket :
Z= 360/2y
Z= 9
Water power
$= ½ (\rho A V) V^2$
=7.06 Watts.

Table 3 Specification of Solar turbine

Sr no	Parameter	Specification
1	Types	Impulse
2	Rated power	10 watts.
3	No of blade	9
4	Diameter of Runner	0.1025 m
5	RPM	500

4. Load analysis

Statistical data are collected for the energy consumption of direct current (DC) motor pump for the pumping purpose from the inverter for the alternating current (AC) supply is given to the inverter and display the direct current (DC) supply in term of current and voltage in the display screen and by taking the product of current and voltage by using the relation P= VI power consumption is calculated.

As show in the Fig. 4 below show that minimum power required to run the (DC) motor is 60 watts. So it is necessary to store the power in the battery which needs to be greater than 60 watts to run the water pump. As the voltage goes on increasing discharge of the motor is also increase, but the power required will be more.

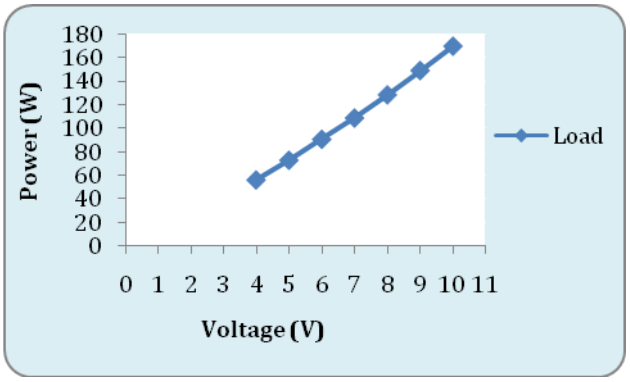

Fig.4 Energy consumption value of DC water pump

5. Result and discussion

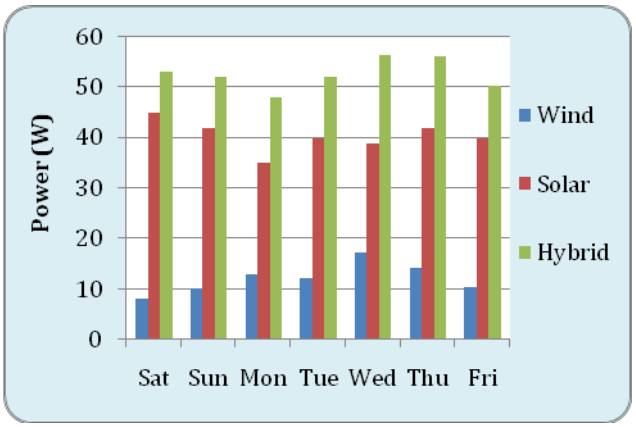

Fig.5 Comparison between power generated by wind turbine, photovoltaic and hybrid system

The above Fig. 5 show the part load shared by individual system for the span of one week. The power output of individual system measured with the help of multimeter which measure the voltage and current of solar and wind system and by taking the product of current and voltage by using the relation P=VI power produce by individual system is calculated.

The power output of the solar system on an average is about 35-40 watts because energy conversion of polycrystalline silicon solar sell is 15 – 18 % this is because of lower silicon purity.

Power output of wind on an average is about 7-10 watts. The wind turbine is manufactured in such a way that they can generate maximum output with minimum speed also it can be rotated any direction of wind. It can be seen from the contribution of the PV array is much greater than that of wind power system

II. CONCLUSIONS

Hybrid system has much advantage including operation and maintenance cost reduces the cost of energy and environmental friendly as compared to non renewable energy system:

The paper studied the feasibility of integrating renewable energy in pumping of water for irrigation purpose. The power that any individual system depend on the weather condition of particular location. Power supplied by photovoltaic array is more important than wind and hydro system.

III. REFERENCES

R. Magdi and M. Adam (2011) Wind Turbines Theory - The Betz Equation and Optimal Rotor Tip Speed Ratio, Fundamental and Advanced Topics in Wind Power.

F. Wenehenubun, A. Saputraa, H. Sutanto, (2015) An experimental study on the performance of Savonius wind turbines related with the number of blades, Energy Procedia 68297 – 304

S. Wu and C. Xiong, (2014) Passive cooling technology for photovoltaic panels for domestic houses.

B. Khadidja, K. Dris, A.Boubeker and S. Noureddine (2014). Optimisation of a Solar Tracker System for Photovoltaic Power Plants in Saharian region, Example of Ouargla. Energy Procedia.

Zhang et al (2007) Flow interaction in a pelton turbine and the hydraulic efficiency of the turbine system, Journal of power and energy, Vol 221, part A, pp.343-357

Dr.Vadirajacharya, P.K. Katti,(2012) Rural Electrification Through Solar and Wind Hybrid System: A Self Sustained Grid Free Electric Power Source, Energy Procedia 14 (2012) 2081 – 2087

Y. Shivrath et. at, (2012) Design & Integration of Wind-Solar Hybrid Energy System for Drip Irrigation Pumping Application, Vol.2, Issue.4, July-Aug 2012 pp-2947-2950

R. Kishore and S. Priya, (2013)Design and experimental verification of a high efficiency small wind energy portable turbine (SWEPT), Journal of Wind Engg. Industrial Aerodynamics 118, 2013, pp 12–19.

OnderOzgener, (2006) A small wind turbine system (SWTS) application and its performance analysis, Energy Conversion and Management 47, 2006, pp. 1326–1337.

