Imperial Journal of Interdisciplinary Research (IJIR)
Vol-2, Issue-5, 2016
ISSN: 2454-1362, http://www.onlinejournal.in

Design & Development of Hybrid (Solar/Wind) Power Generation System

Ajay Shrinet[1] & Devesh Kumar[2]
[1]M.Tech Student, [2]Assistant Professor [1,2]Department of Mechanical Engineering
Madan Mohan Malaviya University of Technology, Gorakhpur, Uttar Pradesh, India

Abstract: *The project is a combination of mechanical & electronics engineering for the upcoming future due to declination of fossil fuels. The goal has been to construct a wind turbine driven water pumping system which lift the water from low head to high head along with the utilization of solar energy for the upcoming future. The purpose of constructing this project is to spread the idea for power generation with the help of Hybrid system.*
In 2009, two students from University of California was conducted a field study regarding lack of water i.e used for drinking & irrigation purpose and they have found that it was a serious issue. When they came back to Sweden they have constructed a model of a windmill driven water pump that employs wind energy for water pumping and other applications which are useful for farmers. The main aim of developing this type of windmill driven water pump is that farmers didn't depend upon other persons for the irrigation & other purposes.
Keywords: *Hybrid System, Solar Energy, Wind Energy, Water Pumping etc.*

1. Introduction:

As I came across so many technologies regarding irrigation purpose & water pumping. For the activities like crop growing, vegetable production farmers were spending large amount of water. For taking water they have undergone the adaptation of bore well and pumping the water through the fossil fuel pump etc for their daily life. Sometimes they have to pay amount for this therefore it becomes burden to get profit in irrigation when the expenses were deducted in large amount.

To get over this we are implementing wind turbine driven water pumping system to drag the water from bore well (i.e low head) to the irrigation field (i.e high head) along with solar panel. I am making the hybrid system (by using Solar & Wind energy), in the case of wind absence we can use the solar power for pumping the water & vice versa. The power is also generated by this system i.e very useful.

By studying over different cases the main aim of my project that came into picturize is that, the use of wind and solar energy for pumping the water from low head to high head & battery charging also by making it hybrid.

The large/extent use of non renewable fuels like coal/petroleum based products/oil etc is the main reason of negative impact on our environment. In fact the fossil fuels are important source for the power generation and take care of the whole world power generation in a proper way. Knowing the concern about global warming & our dependency on fossil fuels we are moving towards renewable sources of energy. Here I am discussing about two renewable resources of energy i.e solar energy & wind energy. Both these sources of energy are easily available in worldwide & are environmental friendly also. By all these reasons I am implementing this technology.

2. Literature Summary:

Deepak Kumar Lal in 2010 concluded that: A large proportion of the world's population lives in urban & rural areas that are geographically separated and less populated. In this paper he proposed a hybrid power generation system i.e suitable for isolated area application. The concept behind hybrid renewable energy sources is that, the base load viability is to be covered by the largest and firmly available renewable energy sources and other intermittent sources that should cover the peak load of an isolated mini grid electric system. The study is based on modeling, simulation and different methodology of renewable energy system in rural areas mainly in India. Various renewable and alternative energy resources, energy storage and their usefulness in terms of the cost and their performance we have to discuss.

GM Shafiullah in 2010 concluded that: Current power systems create many environmental impacts due to utilization of fossil fuels mainly coal which produces carbon dioxide i.e emitted into the atmosphere. In respect to fossil fuels, renewable energy sources offer another sources of energy which are in general: easily available, technically effective and environmentally friendly also. Due to all these excellent properties of renewable energy

sources like solar and wind energy they are having more demand or their demand increases in the upcoming future, which produces power without giving out of carbon dioxide emissions. This paper represents technical & economical analysis of a hybrid power generation system for subtropical climate and they also enquired the impact of renewable energy sources to the existing and smart power system i.e going to be used in future.

Prabodh Bajpai in 2010 Concluded that: In this paper we are discussing about decentralized distribution/generation technologies that are based on renewable energy sources, such as solar photovoltaic and wind generators that address the major issues which are concerned with conventional diesel generators to a large extent and are therefore it is considered as emerging alternating power solutions to stand alone applications. The stand alone Wind-Turbine-Generator power systems using different energy storage technologies, i.e. Wind Turbine Generator-Battery system, Wind Turbine Generator-Fuel Cell system and Wind Turbine Generator-Fuel Cell-Battery system are optimized and compared in this paper. This paper is very much important in the field of Hybrid power generation.

3. Component of Hybrid (Solar/Wind) Power Generation System:

The various components of Hybrid (Solar/Wind) Power Generation system are as follows.

1. A 20 W Solar Panel.
2. Horizontal Axis Wind Turbine.
3. A 12 V 7 AH Battery.
4. Charge Controllers.
5. D.C Motor with Pump

3.1 Solar Panel:

It is a device which is used to convert solar radiation into the electrical energy which consists of so many modules connected in series & parallel. The physical appearance of Photo-voltaic cell is very similar to that of the excellent P-N junction diode formed by semiconductor material. When the P-N junction absorbs light, the energy of absorbed photon is transferred to the nearby electron and proton of that material creating the charge carriers to separate at that junction point. The charge carriers at the junction region create a potential gradient and get accelerated under the electric field and circulate the current through an external circuit.

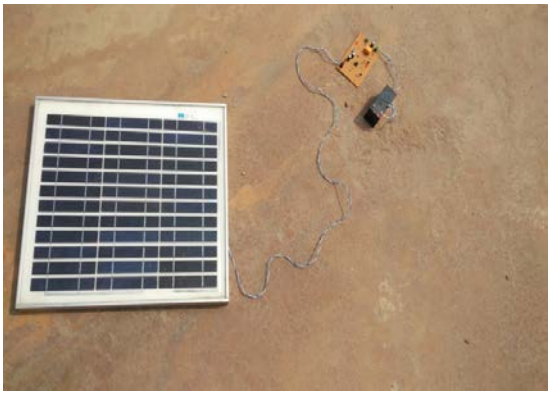

Figure-1: A 20 W Solar Panel

Table-1: Specifications of Solar Panel

Maximum Power (Pmax)	20 W
Voltage at Maximum Power (Vmp)	14.4 V
Maximum System Voltage	1000 V DC
Material Type	Polycrystalline
Weight	Approximately 3 Kg
Open Circuit Voltage (Voc)	21.4 V
Short Circuit Current (Isc)	1.32 A
Length(in mm)	465 mm
Height(in mm)	495mm

3.2 Wind Turbine:

It is the system which extracts energy from wind by rotation of the blades & by this way wind energy is converted into electrical energy. Basically wind turbines are classified into two groups: the one is vertical and another one is horizontal. The power generation in wind turbine mainly depends upon one thing i.e at what speed wind is blowing. As the wind speed increases power generation also increases. The power generated from wind is always not continuous its fluctuating from time to time & also depend upon the weather.

Figure-2: Horizontal Axis Wind Turbine

3.3 Battery Bank:

The battery used in my system is 12 V 7AH UPS battery. The battery I am using in my project is lead acid battery, which requires less maintenance & having high reliability. For calculating the size of battery bank we need the following information:

1. Total daily use of battery in watt-hour.
2. The total back up time of the battery.

Table- 2: Specifications of 12 V 7 AH Battery

Overall Height	100 mm
Height up to lid	93 mm
Length	153 mm
Width	65 mm
Weight	Approximately 2.5 Kg
Battery Type	Lead Acid Battery

Figure-3: UPS Battery

3.4 Charge Controller:

The basic function of charge controller is that it controls the source which is to be active or inactive. Simultaneously it charges the battery and also provides power to the load. It is having overcharge & short circuit protection which helps the battery to run long last.

The most popular & safe charge controllers that are used now days are MPPT. The full form of this is Maximum Power Point Tracking. Maximum Power Point Tracking system is consuming maximum performance from our solar panel in any conditions.

Maximum Power Point Tracking system can yield an energy gain of up to 30% from our photovoltaic panel.

3.5 D.C Motor with Pump:

It is a device which is used to convert electrical energy into mechanical work. The DC pump is coupled with it which is used for lifting the water.

Table-3: Specifications of D.C Motor

Brand Name	TTT Motor
Continuous Current	0.14 Amp
Type	Permanent Magnet D.C Motor
Weight	350 gm
Size	42 * 67 mm
Torque	900 g.cm
Voltage	12 V

The Permanent Magnet DC motors which is the most important components that can be used in place of generators in my project. With the help of D.C Motor I lift the water from low head to high head in my project.

Figure-4: D.C Motor with Pump

4. Calculations:

Calculation for Overall Efficiency from Solar Panel:

The power i.e generated by solar panel is given by;
Solar Power (S.P) = Ins(t) * AS* Overall Eff(pv)
Where,
Ins(t) = Insolation at time t in (W/ m^2)
AS = area of single PV panel (m^2) = 0.465 * 0.495 = 0.230175 m^2
Overall Eff(pv) = overall efficiency of the PV panel
Power (P) = Voltage * Current = V * I in watt
The Solar Insolation is calculated by the following formula:

Ins(t) = S * Cos Z

Where, S= Solar Constant
Z = Zenith Angle

Calculation for Overall Efficiency of Solar Panel on 14th March 2016:
Time= 9:00 am
Solar Power (S.P) = Ins(t) * AS* Overall Eff(pv)
Ins(t) = S * Cos Z
$Z = Cos^{-1}(Sin\varphi * Sin\delta + Cos\varphi * Cos\delta * Cos H)$
Φ = 26.75° for Gorakhpur region
δ=23.45 sin{(360÷365) * (284+ n)
n= 31+29+14= 74 days
δ= -2.818
H = 15 * (Time in hours-12)
H = 15 * (9-12) = -45°
$Z = Cos^{-1}(Sin\varphi * Sin\delta + Cos\varphi * Cos\delta * Cos H)$
$= Cos^{-1}$[sin 26.75 * sin (-2.818) + cos 26.75 * cos (-2.818) * cos (-45)]
Z = 52.5°
Ins(t) = S * Cos Z
Ins(t) = 1000 * Cos 52.5 = 608.76 W/m^2
Voltage at 9:00 am = 15.32 Volt
Current at 9:00 am = 0.34 Amp
Power (P) = V * I = 15.32 * 0.34 = 5.208 Watt
Overall Efficiency = Power/ Area of solar panel * Ins(t)
Overall efficiency = 5.208/(0.465* 0.495 * 608.53) * 100 = 3.72 %

Calculation for Overall efficiency of Solar Panel on 14th March at 10:00 am:
Φ = 26.75°
δ = -2.818°
H = 15 * (10-12) = -30°
From the above formula of zenith angle I calcúlate below:
$Z = Cos^{-1}$[sin 26.75 * sin(-2.818) + cos 26.75 * cos(-2.818) * cos(-30)]
Z = 41.38°
Ins(t) = S * Cos Z
Ins(t) = 1000 * cos 41.38 = 750.28 W/m^2
Voltage at 10:00 am = 16.15 Volt
Current at 10:00 am = 0.43 Amp
Power (P) = V * I = 16.15 * 0.43 = 6.945 Watt
Overall Efficiency = Power/ Area of solar panel * Ins(t)
Overall efficiency = 6.945/(0.465 * 0.495 * 750.28) * 100 = 4.02 %

Calculation for Overall efficiency of Solar Panel on 14th March at 11:00 am:
Φ = 26.75°
δ = -2.818°
H = 15 * (11-12) = -15°
From the above formula of zenith angle i calcúlate below:
$Z = Cos^{-1}$[sin 26.75 * sin(-2.818) + cos 26.75 * cos(-2.818) * cos(-15)]
Z = 32.93°
Ins(t) = S * Cos Z
Ins(t) = 1000 * cos 32.93 = 839.38 W/m^2
Voltage at 11:00 am = 17.05 Volt
Current at 11:00 am = 0.61 Amp
Power (P) = V * I = 17.05 * 0.61 = 10.401 Watt
Overall Efficiency = Power/ Area of solar panel * Ins(t)
Overall efficiency = 10.401/(0.465 * 0.495 * 839.38) * 100 = 5.38 %

Calculation for Overall efficiency of Solar Panel on 14th March at 12:00 am:
Φ = 26.75°
δ = -2.818°
H = 15 * (12-12) = 0°
From the above formula of zenith angle I calcúlate below:
$Z = Cos^{-1}$[sin 26.75 * sin(-2.818) + cos 26.75 * cos(-2.818) * cos(0)]
Z = 29.57°
Ins(t) = S * Cos Z
Ins(t) = 1000 * cos 32.93 = 869.77 W/m^2
Voltage at 12:00 am = 17.81 Volt
Current at 12:00 am = 0.73
Power (P) = V * I = 17.81 * 0.73 = 13.001 Watt
Overall Efficiency = Power/ Area of solar panel * Ins(t)
Overall efficiency = 13.001/(0.465 * 0.495 * 869.77) * 100 = 6.49 %

Calculation for Wind Velocity Required:

The power i.e generated by wind turbine is given by;

Power = (density of air * swept area * velocity cubed)
{Wind Power (W.P) = ½. ρ* (A)* Cp * $(V)^3$ }
Where,
ρ is the density of air in (kg/m^3) = 1.2 kg/m^3
A is the swept area in (m^2) = ∏ * R^2 where,
A = ∏ * 0.7 * 0.7 = 1.54 m^2

R is Radius of rotor = Length of the blade + Radius of hub = 0.7m
V is the velocity of wind in (m/s)
Cp is called as coefficient of performance = 0.56

I calculate power with the help of voltage & current obtained during working condition with the help of one formula i.e

[P = V * I]

Where, P is power developed in watt
V is voltage obtained during operating condition
I is current obtained during operating condition.

Time	Wind Velocity	Voltage	Current	Power	Cp
11:00	0.562	0.71	0.13	0.0923	0.58
12:00	0.878	1.25	0.28	0.350	0.58
13:00	1.26	2.53	0.41	1.0373	0.58
14:00	1.73	4.37	0.61	2.6657	0.58

By this way both Solar Power & Wind Power Calculation part has been done & I fulfil the requirements from my system.

5. Conclusion & Results:

I have concluded that the overall efficiency of my system is 5.512 %. Some panels are available in the market for research work whose efficiency is up to 40%. So from my point of view there is requirement of some more research in this field.

For the hybrid system which runs on solar & wind, wind system is suitable in those areas where the availability of wind is more like coastal areas because the availability of wind is less where I performed my research work i.e in Gorakhpur region.

In terms of research and development so many new technologies are present in the above field. Moreover there are so many difficulties in terms of the efficiency of hybrid system and optimal use of different forms of energy. The different challenges that are faced by me in renewable energy technologies are:

1. The devices such as solar panel/ PV and fuel cells that store solar energy need improved & best technology to harness more amount of useful power from these resources. The poor efficiency of solar is the major obstruction for encouraging its use now days that we have to improve it.

2. It should be confirm that, there is minimum amount of power loss in the electronic equipments that are used in renewable energy technologies.

3. The storage system i.e battery banks are used should be of more storage capacity so that it helps in water pumping for irrigation purpose.

As we know that in the upcoming future the fossil fuels are depleted from the world so in the future we need to develop power with the help of renewable energies.

6. References:

[1]National Renewable Energy Laboratory, http://www.nrel.gov/gis/maps.html,accessed January 12, 2009.
[2]http://en.wikipedia.org/wiki/Solar_power_in_India.

[3]http://en.wikipedia.org/wiki/Wind_power_in_India.

[4]http://www.Hybrid Solar Wind Electricity.html.

[5]Jiangsu Top Pump Manufacture Co. Ltd. Semi Rotary Hand Pump. Available online: http://www.allproducts.com/manufacture100/tpg/product2.html[2010-05-24].

[6]Books on Hybrid (Solar & Wind) Power System.

[7] Non-Conventional Energy Resources by G.D.Rai.