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Hybrid Solar-Wind Power Generation

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Abstract:-- **The Conventional energy sources are vanishing day by day and also the electricity demand also increasing at alarming rate. This has led for the generation of electricity from non-conventional energy sources which will help out for fulfilling the demand of electricity with advantages like no-pollution, free of cost etc. So, wind- solar hybrid system using PMAC will be a step towards this future. By using hybrid system we can increase the efficiency of system. In this paper we mostly concentrate on wind power generation. The aim of this project is to provide electricity in rural areas where people are still not supplied with electricity and can't afford to pay high electricity bills where it has reached. Our project will help them to illuminate their lives.**

I. INTRODUCTION

In several years there is progress in the production of electrical energy from the non-conventional energy sources but already there were different systems for solar, wind and other sources. But, there is less electricity generation from these sources (wind-about 55% & solar-about 15-18%). And also their operation is mostly dependent on environmental conditions.

As technology improved, there is electricity generation which uses more than one system in combination and this is known as Hybrid system. Wind-solar power generation is one of them. In rainy season wind system can operate while in summer season solar system work in better way. Due to this, system works effectively and also supplies the continuous electricity.

II. OBJECTIVES:

1) To provide rural area with electricity.
2) To move towards non-conventional energy sources.
3) Design and calculation of wind and solar system with efficiency.
4) Compare and contrast this and traditional energy generation system.

III. PROPOSED WIND-SOLAR PMAC SYSTEM

The system consists of following units:

A. Solar System
B. Wind System
C. Charge controller
D. Battery
E. Rectifier
F. Inverter

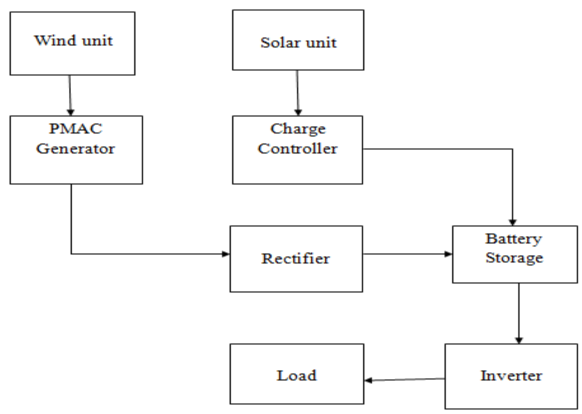

Fig 1. General View of Wind-Solar Hybrid System

IV. SOLAR SYSTEM :

Fig 2: Solar Panel

Solar power is the biggest renewable energy source. Using photoelectric effect solar panels convert the sun rays into electricity. And this electricity is used in your home etc.

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Solar irradiation :

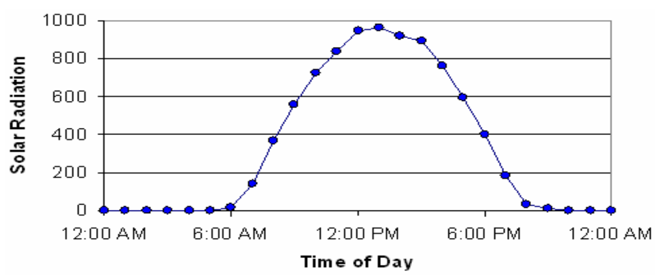

Fig 3: Solar Irradiation Curve

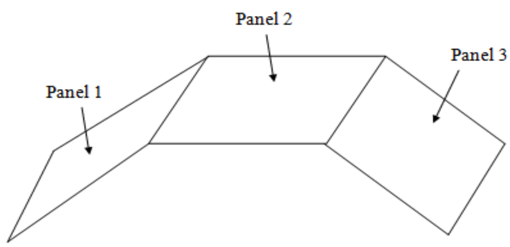

Fig 4: Solar Plate Assembly

The efficiency of solar is between 15-20%. We are going to place the solar panels like above manner, so that panels can generate the electricity during morning, afternoon and evening respectively.[1]

- No. of solar plates used: 3No.
- Output per plate : 60Watts
- Total output : 60W * 3=180 Watts

There are two types of connections are possible for the solar panels: 1.Series connection

2.Parallel connection

Series connection :

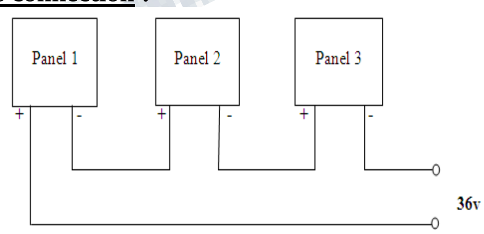

Fig 4(a)

For Series Connection:-

1. Total output power = 60W * 3=180W
2. Total output voltage = 12V+12V+12V=36V
3. Total output current = 5 amp

Parallel connection:

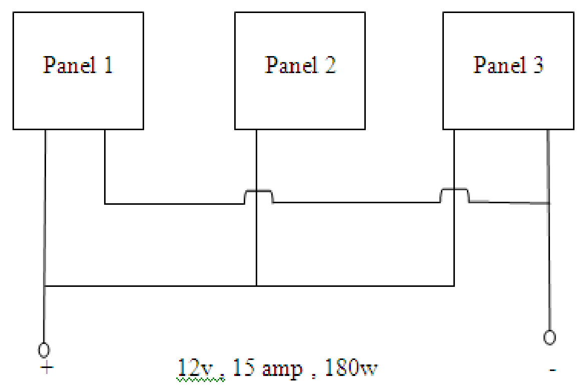

Fig 4(b)

For parallel connection:

1. Total output power = 60W * 3=180W
2. Total output voltage = 12V
3. Total output current = 5A*3=15 amp

We are going to use the parallel connection.

***Battery input** (when only solar system is operated):*

Total solar output = 180 W

Here we consider average output = 100W

Output voltage = 12V

Then, input to the battery = W/V = 100/12 = 8.33A

Observations of solar system:

Series connection –

Sr. No.	Current (I)	Voltage (V)	Resistance (R)Ω	VI (W)	I^2R (W)
1.	2.15	15	10	32.25	46.225
2.	2.04	33	20	67.32	83.235
3.	1.55	40	30	62	72.075
4.	1.51	56	40	84.56	127.68
5.	1.28	58	50	74.24	95.02

Table No. 1

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Parallel connection –

Sr. No.	Current (I)	Voltage (V)	Resistance (R)Ω	VI (W)	I^2R (W)
1.	0.48	18.5	50	8.18	11.52
2.	0.55	18.5	40	10.175	12.01
3.	0.80	18.5	30	14.8	19.2
4.	1.18	18.5	20	21.83	27.84
5.	2.34	18.5	10	43.29	54.75
6.	3.61	17	5	61.2	65.16

Table No. 2

Finalized diagram of solar system:

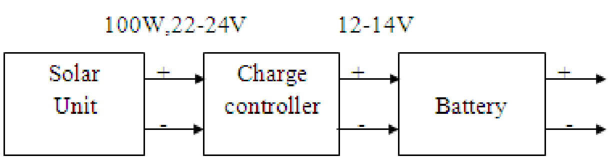

Fig. 5:Solar Unit

V. WIND SYSTEM:

Fig 6:Wind Mill

The first main source of our system is wind unit. There are two types of wind turbines: VAWT (Vertical Axis Wind Turbine) & HAWT (Horizontal Axis Wind Turbine). Here we are going to use HAWT as it gives the no. of advantages over VAWT.

The PMAC generator is used in the system. It is having no. of advantages over DC generator. In earlier days the cost of electricity is going to increase, so people are looking for an alternate energy source. And PMAC generator is suitable for it. [2]

The design considerations for wind system are as follows:

Blade and tail design:

Wind turbine is needed to capture the wind's energy and then there is the conversion of mechanical rotation into electric power. Some type of over-speed protection is provided to all wind turbines in order to protect them from high winds.

For example:

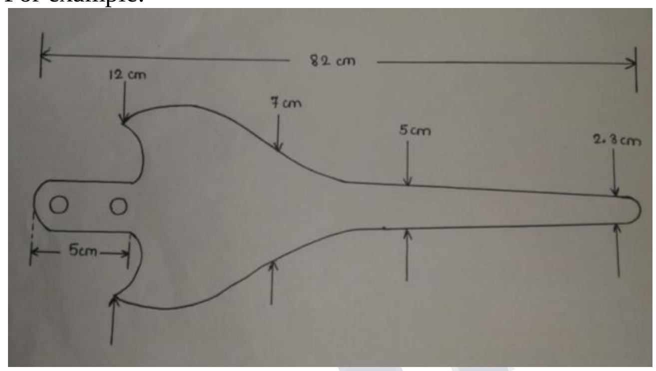

Fig 7(a)

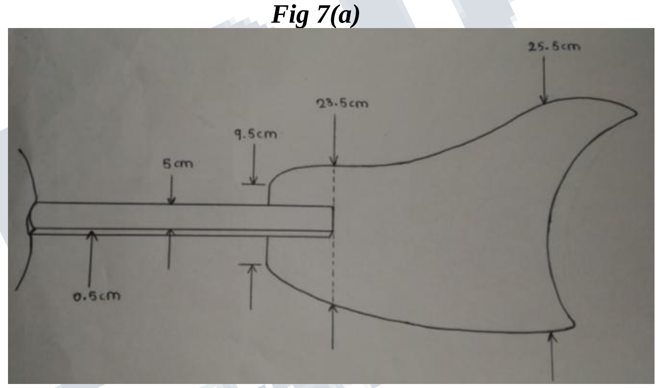

Fig 7(b)

1. ***Blade materials:***

Normally, ideal materials should be as follows:

- For reducing cost and maintenance, materials should have wide availability & easy processing.
- For reducing gravitational forces they should have low weight.
- High strength.
- High stiffness.
- It should be withstand in all types of environmental conditions.

The **fabric material** is the best suited material regarding these qualities. According to IEC61400 standards, wind turbines can be designed & validated.

CALCULATIONS

For Example-

1. $P=0.5\,\rho AV^3$

Where: P= output power in watts
ρ= air density in kg/m^3
A= Swept rotor area (m^2)
V= wind speed (m/s)

2. $P = 0.6*C_P*N*A*V^3$
   Where: 0.6 = Bets limit
   C_P = Rotor efficiency (0.4 generally)
   N = Efficiency of driven machinery
   A = Swept rotor area (m^2)
   V = Wind speed (m/s)

3. Revolutions (rpm) = $\frac{V*TSR*60}{6.28*R}$
   Where: TSR = Trip speed ratio
   R = Radius of rotor

4. Tip speed ratio –
   TSR = $\frac{\text{Blade tip speed}}{\text{wind speed}}$

Blade tip speed = $\frac{\text{Rotational speed (rpm)}*\pi*D}{60}$

Where: D = Diameter of rotor

- *Assuming;*

1. Radius of blade = 0.82m (2.69ft)
2. Diameter of blade = 1.64m
3. Average wind speed = 5m/s
4. No. of blades = 3
5. Air density = 1.27kg/m^3

- Width of blade is also called blade chord.

Blade chord (m) = $\frac{5.6*R^2}{(i*CI*r*TSR^2)}$

Where; R= Radius of tip
r = Radius of the point of computation
® = No. of blades
CI= Lift coefficient
TSR= Tip speed ratio

- Tip speed ratio is defined as :

TSR = $\frac{\text{Blade tip speed}}{\text{wind speed}}$

Blade tip speed

= $\frac{\text{Rotational speed (rpm)}*\pi*D}{60}$

Where: D = Diameter of rotor

= $\frac{407*\pi*1.64}{60}$

= 34.95

Taking average wind speed = 5m/s

TSR = $\frac{35}{5}$ = 7

TSR = 7

- Rotor blade swept area = Pi * $\left(\frac{Diameter}{2}\right)^2$

= Pi * $\left(\frac{1.64}{2}\right)^2$

Area = 2.112 m^2

- Revolutions ® = $\frac{V*TSR*60}{6.28*R}$

= $\frac{5*7*60}{6.28*0.82}$

R = 407.8 rpm

Calculations assuring various wind speed :

Sr. No.	Wind speed (m/s)	Power output (watts)	With Betz limit (P*0.6)
1	4.5	122.21	73.53
2	5	167.64	100.49
3	5.5	223.13	133.75
4	6	289.61	173.65
5	6.5	368.3	220.78
6	7	460	275.74
7	7.5	565.78	339.15
8	8	686.5	411.6

Table No. 3

2. Factors affecting on turbine design:

- Site-specific factors affecting design
- Climatic factors affecting design
- Low temperature
- Environmental factors affecting design

Hub design:

The generator is driven by the hub which is fixed to the rotor shaft. Hub drives the generator through a gearbox or directly.

The blades are directly bolted to the hub in the simple designs.

Tower:

Types of towers: 1.Floating towers
2. Land-based towers

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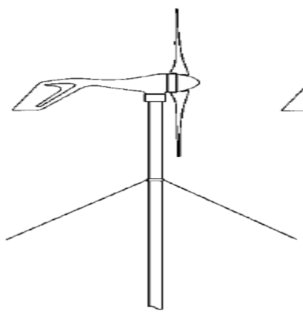

Fig 8: Types of Towers

1. *Tower height:*

The output power from wind increases as the altitude of tower increases. So, tower having higher altitude are mostly preferred.

For HAWT, tower height is approximately 2 to 3 times the blade length.

Ex. For blade length 2 feet, tower height 6 to 7 feet.

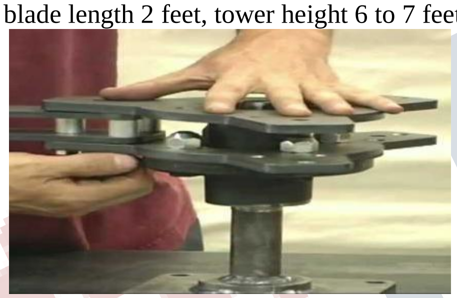

Fig. 9: Supporting Assembly

2. *Tower materials:*

By using lighter material in the tower there is reduction in overall transport and construction cost of wind turbines. Here we are going to use GI material for tower.

Generator design:

Disadvantages of synchronous generator –

- Complicated design.
- High cost.
- The wind energy is wasted after a certain wind speed.

So there is use of PMAC generator.

As we are going to use AC generator for wind system, the output will be AC. Our estimated output from wind system is 200-300w by considering the efficiency of a generator to be 90%.

Battery input (when only wind system is operated):

Total wind output = 400 W

Here we consider average output = 250W

Output voltage = 230V, 50Hz

Output current = W/V = 250/230 = 1.08A

Rectifier input is 1.08A, so output of rectifier circuit is approximately 8-10A. Here we are going to design 10A rectifier circuit.

Therefore, battery input = 10A.

Finalized diagram of wind system:

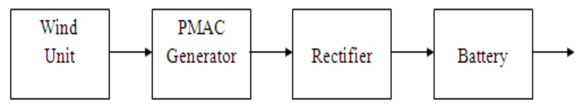

Fig 10: Wind Unit

6. CONTROLLING SYSTEMS:

Rectifier:

We are using AC generator for wind system, the output will be AC. It can't be fed to load directly as output is variable and so the output frequency. So, to avoid this problem, we will design a rectifier whose output will be 12V DC used to charge the battery (i.e. the output of wind will be stored in battery) so that we can use it as per requirement.

Charge controller:

A charge controller limits the rate at which electric current is drawn from electric batteries. It prevents overcharging and overvoltage, which can reduce battery performance or lifespan.[3]

In our project the charge controller controls the power output from solar.

Battery:

We know the output of Solar is DC which is stored in Battery. The output of wind system will be AC which will be converted to DC through the Rectifier and stored in battery.

We have decided to use battery of capacity 12V, 75AH.

Inverter:

The DC stored in 12V, 75AH battery will be used for residential load by inverter. Inverter will be designed by using IGBTs using PWM technique full bridge scheme. Inverter is a device used to convert DC into AC supply.[4mate rating of our inverter will be 500VA.The output will be 230V, 2.5A for residential use.

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6. OUR PROPOSED MODEL :

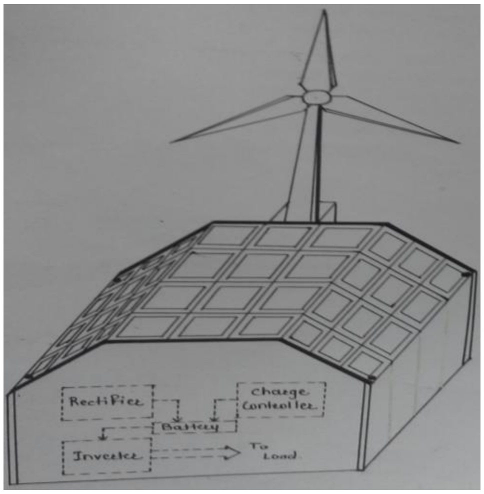

Fig 11: Final Model

Our proposed system is as shown above. Our aim is to make this system as flexible as possible so that can be easily dismental for transportation.

8. CONCLUSION:

1. Thus from hybrid combination of wind-solar, we can considerably increase the power output with increased efficiency for different environmental conditions.

Ultimately these renewable energy sources will be the only option for electricity generation in future, as the conventional energy sources are going to vanish.

2. The project will enhance our knowledge towards these non-conventional sources as an electrical engineers.

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