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Renewable Hybrid Power Generation System

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Abstract— *In parallel to developing technology, demand for more energy makes us seek new energy sources. Wind and solar energy are the most popular ones owing to their abundance, ease of availability and convertibility to electric energy. This work covers realization of a hybrid renewable energy system. The scheme involves conversion of solar power and wind power into usable electrical energy using solar panel and by designing a wind turbine with appropriate calculations and specifications. Battery in this system is charged by both solar and wind power, the DC output is then converted to AC using an inverter and fed to the load. The idea of water conservation through rain water collection and storage with the use of solar panel is also implemented. The main aim of the design is to create a system suitable to provide continuous power by utilization of non-conventional energy resources and making use of the additional advantage of the solar panel in the conservation of water. Power resources and load in the system are monitored and controlled in real time.*

Keywords— Hybrid, Reliable, Renewable, Solar Energy, Turbine, Water Conservation, Wind Energy**.**

1. INTRODUCTION

Electricity the driving force of modern civilization, is indispensable in our day to day life. There are two basic types of electricity generation. One of which is through conventional energy resources which will get extinct in near future, hence demanding an alternative arrangement. Therefore, it is of great urgency to go for non-conventional energy resources. The non-conventional energy resources like solar and wind can be a potential replacement. Solar power generation has some drawback, i.e., it cannot generate power in cloudy or rainy days. Moreover, it has very much limited capacity and we cannot take all available solar energy as its efficiency is much less. Wind energy, on the other hand, converts the mechanical energy of wind into electrical energy and it can be available even on cloudy or rainy days. So, hybrid power generation incorporates both the power generation system into one unit and the reliability of power generation system is thus improved. This system can be implemented in domestic, industrial or as a rural development model. So, the hybrid energy structure serves as a highly efficient and clean energy producing system.

2. HYBRID ENERGY SYSTEM

2.1 Solar Energy

Solar radiations represent the earth's most abundant energy source. The photovoltaic (PV) modules convert solar radiation from the sun into electrical energy in the form of direct (DC). The electrical energy generated using solar panels can be stored in batteries or can be used for supplying DC loads or can be converted using inverter to feed AC loads. Converting solar energy into electricity is the answer to the mounting problem in rural areas. Its sustainability for decentralized applications and its environment friendly nature make it an attractive option to supplement the energy supply from other sources. 1 KW of SPV generates 3.4 to 3.5 units (KWH) of energy per day.

2.2 Wind Energy

Wind energy is also one of the non-conventional energy resources that can be used for generating electrical energy with the help of wind turbines coupled with generators. There are various advantages of wind energy, such as wind turbine power generation, for mechanical power with windmills, for pumping water using wind pumps. Wind turbines convert mechanical power into electrical power. The wind power generated depends on the tip speed ratio, radius of the blades and the velocity and the density of the wind. Practically, it is observed that the flexible three blades propeller about 40m diameter, in a 62 Km/hr wind pressure with a rotation speed of 48 rpm produce maximum power of 14 MW.

2.3 Need for Hybridization

A hybrid non-conventional energy system utilizes two or more energy production methods, usually solar and wind power. The major advantage of solar and wind hybrid system is that when solar and wind power production is used together, the reliability of the system is enhanced. Additionally the size of battery storage can be reduced slightly as there is less reliance on one method of power production. The hybrid solution is the best option whenever there is significant improvement in terms of output and performance – which happens when the sun and the wind resources have the opposite cycles and intensities during the same day or in the same season. Thus to sum it up solar wind hybrid power has the following advantages –

- Ideal alternative to compensate for the lack of solar or wind energy in any geographical region.
- Clean and non-polluting power generation.
- Complement to each other.
- Stable power supply.

2.4 Water conservation using solar panels

Floating solar panels are a great new technology that's promising to change the way we look at renewable energy. The main aim of this concept is water conservation. It has been proven that Solar panels actually work better when they are cooled. That's why when we have two identical systems, one on land and one on water, the one on water is going to work better. Another advantage of floating solar panel is that they can shade the water they float on and reduce evaporation, collection of water and hence conservation.

3. LAYOUT OF THE MODEL

The idea of combining two intermittent renewable energy resources for a hybrid non-conventional power generation is due to unreliability of the renewable energy resources when used as a separate sources. Here, we have combined the power generated from the solar panel and the wind turbine which can be directly used to supply the load or charge the battery. The battery can be used to supply power during the non-availability of either of the resources. Fig.1 shows the block diagram of the hybrid power generation system using wind and solar power.

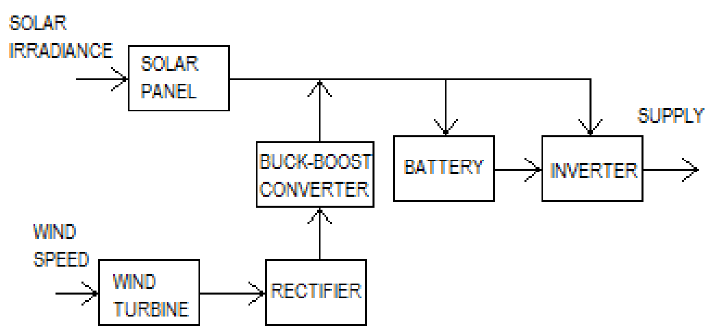

Fig 1: Block Diagram

3.1 ABBREVIATIONS AND ACRONYMS

Solar Panel absorbs the sunlight as a source of energy to generate electricity or heat. The photovoltaic cell is very similar to a PN junction diode. The energy of the absorbed photons is transferred to the electron proton system of the semiconductor material when sunlight falls on the junction. This causes charge carriers to flow across the junction due to a potential gradient and generate the flow of electricity. A photovoltaic (PV) module is a package, connected assembly of photovoltaic solar cells. The photovoltaic modules constitute the photovoltaic array of a photovoltaic system that generates and supplies solar electricity in commercial and residential applications.

3.2 Wind Turbine

Wind turbine can be defined as a unit consisting of a fan that rotates due to blowing wind. A gear box is used for converting energy from one device to another device using mechanical method. An electrical generator is coupled with wind turbine, hence, it is named as wind turbine generator. There are different types of wind turbine generators and these wind turbine generators can be directly connected to the power grid or loads or batteries based on different criteria.

3.3 Buck-Boost Converter

A buck-boost converter is a DC-DC converter. It is used to step down or step up the DC voltage to a desired level to meet the requirements of the load or to charge the battery.

3.4 Battery

A battery is used to store the generated electricity to meet the load requirements. Choosing a battery of proper Ampere-hour ratings is very essential based on its load requirements. The ratings of a battery depend on the total hours of backup and the load that it has to supply in times of need.

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3.5 Inverter

We need to convert the DC power generated into an equivalent AC power and then step up the AC power to meet the actual demands of the load. The inverter is used to convert DC output of the battery into a utility frequency AC current that can be fed into a commercial electric grid or used by local, off-grid electrical network. The input voltage, output voltage, frequency and output power handling depends on the design of the inverter circuit.

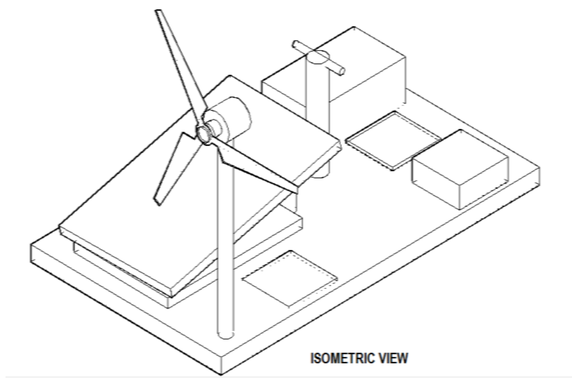

Fig 2: Isometric View

4. Experimental setup

The hardware model is implemented and the output is fed to the load. The solar panel is placed at an angle of 30° and the DC output is fed directly to the battery. The wind turbine generates DC output power which is stepped up or steeped down using a buck-boost converter to a sufficient voltage to charge the battery. The battery DC output is fed to the inverter which converts it to 230V AC to supply to the load. The solar panel is being placed over a water reservoir to implement the water conservation and rain water harvesting technique. The measured values of the components used in the prototype model of the solar wind hybrid power generation are given in Table 1.

Components	Input voltage	Output voltage	Output current	Output power
Solar panel	-	18 V	0.46 A	8.28 W
Wind Generator	-	3.4 V	0.6 A	2.04 W
Buck-Boost converter	3.3 V	18 V	-	-
Inverter	12 V	230 V	-	-
Total Power (Theoretical)				10.32 W
Total Power at Load (Practical)				6.2 W
Total Output Voltage				230 V

Fig 3: Experimental Setup

5 Equations

5.1 Wind Power Calculations

If V =Wind Speed (m/s), C_P = Power Co-efficient, ρ= Density (kg/m3), r = Radius (m)

Wind Power, $P_w = 0.5 * \rho * \pi * r^2 * V^3 * C_p$ Watt (1)

Wind Power is converted to rotational power using wind turbine. The rotational speed of the wind depends on the Tip-Speed Ratio (TSR).

$$TSR = \frac{2 * \pi * r * N}{60 * V} \quad (2)$$

Hence, the Speed of wind turbine, $N = \frac{60 * V * TSR}{2 * \pi * r * N}$ (3)

Now, the Gearbox changes this rotational speed.

Speed of the shaft, $N_{sf} = N*G$ where G = Gear Ratio

Frequency of Induction Generator, $f = \frac{P * N_{sf}}{120}$ (4)

k_f = form factor, k_c = pitch factor, k_d =distribution factor, φ = useful flux per pole (Weber), T=turns per phase.

Induced Emf, $V = 4.44 * k_f * _{kc} * k_d * f * \varphi * T$ (5)

5.2 Solar Power Calculations

If q=Charge of electron, k=Boltzmann constant, T=temperature (Kelvin)

Open Circuit Voltage of the solar panel, $V_s = \frac{n*k*T}{q} * \ln\left(1 + \frac{I_a}{I_s}\right)$ (6)

Short Circuit Current, $I_s = I_l - I_0 \{\exp [\frac{q*(V+IR)}{nkT}] -1\} - \frac{V+IR}{R_{sh}}$ (7)

A_s=Area of the solar panel, Ins(t) =Isolated time, ŋ=Efficiency

Solar Power Output, Ps=Ins(t)*A_s*ŋ

5. CONCLUSION

The objective of this project was to design a power system that combines both a wind turbine and a solar panel in one single unit. The main idea of combining the two types of systems together was to try to achieve a constant power production, which would be available most of the time. This project would serve the electricity needs of the rural areas that are not fitted with an electricity distribution system. Prevention of water evaporation and collection of rain water for use in arid areas can be implemented using this model. The constructed system is of low operating cost and has efficient energy saving capability. This is a clean, green, reliable, pollution free, low emission distributed technology power system which can serve as a prototype for rural electricity development model, industrial and domestic power usage.

6. FUTURE SCOPE

There are many scopes for future modification, expansion and up gradation.

- Protection devices like Relay, Circuit Breakers and Lightning arresters can be incorporated.
- Solar Power tracker can be used to get more solar energy.
- SCADA can be used for better energy management.

If installed in coastal area, tidal power plant can be added with the scheme for more efficiency.

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