DESIGN OF HYBRID POWER GENERATION USING SOLAR TRACKING PV MODULE AND WIND TURBINE

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1. ABSTRACT

This paper describes the design a new and evolving Electrical power generation system by integrating solar and wind energy for the Green computer laboratory. The design implementation consists of adding reflectors to the photo-voltaic solar-cell array panels along with a dedicated sun tracking system, a mast mounted wind generator, lead acid storage batteries, an inverter unit to convert DC power to AC power. A wind sensor detects the maximum wind flow direction to Guide the windmill with plastic finished edges to improve the overall efficiency. All the natural wastage energies are used for production of electricity. Electricity is available with a minimum cost and pollution free to anywhere in the world at all times. This process production of electricity is possible without hampering the ecological balance and it Yields the least production cost for electricity generation. Electrical lighting loads and electrical heating loads, several fuse and junction boxes and Associated wiring, and test instruments for measuring voltages currents power factors and harmonic contamination data throughout the system. This hybrid solar-wind power generating system is extensively use in the Industries and also External use like to run the Green computer laboratory.

KEY WORDS: photo-voltaic, solar cell, wind energy, renewable energy, integrating power generation system, wind power generation system, solar pv tracking system, wind sensor, non conventional energy sources, solar power generation system, plastic finished edges.
2. INTRODUCTION

The concept of solar and wind energies dates back to nearly 7,000 years ago [1]. Solar power generation system has some drawbacks that is it cannot generate power in cloudy or rainy days. Electricity cannot be seen, felt, tasted, smelled, heard or (safely) touched. This paper designs a hybrid energy system combining solar photovoltaic and wind turbine as a small-scale alternative source of electrical energy where conventional generation is not practical. Nowadays, it is very necessary to find out the renewable energy. For domestic and small commercial purposes, at present in the world, more than 60% of people and INDIA 70% of people are not getting electricity in their daily life for lighting, cooking, moderate machine operating etc. In 1767, Horace de Saussure of Switzerland builds first solar collector which is later used as a solar cooker. In 1887, Electricity is produced for the first time with a windmill in Glasgow, Scotland and in Ohio, USA, and in 1920 the world’s first wind turbine on a vertical axis is invented. One of the primary needs for socio-economic development in any nation in the world is the provision of reliable electricity supply system. This work is a design and development of an indigenous technology hybrid Solar-wind power system that harnesses the renewable energies in sun and wind to generate electricity. Stable energy supply is essential for strong economic growth and poverty reduction. In recent years, photo voltage power generation has been receiving considerable attention as one of the more promising energy alternatives. The reason is direct conversion of sunlight into electricity. Its advantages are

1. Absence of moving part
2. Ability to function unattended for long periods
3. Modular nature in which desired current voltage and power level can be obtained by mere integration.
4. Long effective life and high reliability.

Out of all the renewable energy sources, wind energy and solar energy are reliable energy source. The renewable energy generation has a drawback that the change of output characteristic becomes intense because the output gently depends upon climatic conditions including solar irradiance, wind speed and temperature.

3. WIND POWER GENERATION SYSTEM

Energy available in the wind depends on the density and air velocity. The energy of a mass of air which is displaced is determined by the kinetic energy (K.E) flux. The basic equation for electric power generated by a wind turbine [2] is

\[
P_r = \frac{1}{2} \rho s v^3
\]

Where

- \( P_r \) = electric power output from a specific wind generator
- \( v \) = wind velocity (meters/seconds)
- \( \rho \) = density of air at turbine blades
- \( s \) = surface swept of wind turbine.

The relationship with power recovered and available power is known as power reactivity coefficient \( C_p \). Here Wind-mill output power [2] is

\[
P_c = \frac{1}{2} C_p \rho \pi R^5 \frac{v_{m}^{3}}{\lambda^3}
\]

\[\text{(2)}\]
Where

\[ \lambda = \frac{\Omega R}{V} \]  \hspace{1cm} (3)

\( \lambda \) = ratio between linear speed and the wind speed

R = Radius of the shaft

V = Linear Speed of the Blade

When wind move across the wind turbine, the static pressure drops to a lower pressure than the atmospheric pressure. As the air follows its trajectory, it takes its atmospheric value again, inducing an extra wind deceleration, by this way, in a distance between upstream of the turbine and downstream behind the turbine, there is no change in static pressure, but there is a reduction in kinetics energy [6]. This phenomenon is represented by the betz law. The wind turbines transform energy in moving air to rotary mechanical energy the use of electrical devices to convert wind energy to electricity. Wind turbine for electricity generation is productive wind speed, productive wind speeds will range between 4m/see to 35m/see, optimal range is 6m/s, and wind forms required 12ha/mw wind power potential assuming 1% and 200w/sq.m at 50 m hub- height [3]. The principle of operation wind is a stream of air moving from a higher pressure location to air moving from a higher pressure location to a lower pressure location. Wind is moving a substantial mass of air that blows at a substantial speed therefore it can be useful work. It can push end lift or if it hits the turbine’s blades .it can cause the turbine to rotate fast.

The disadvantage is the total cost can be cheaper than solar systems. Electricity production depends on wind speed, location season and air temperature hence various monitoring systems are needed. The energy in the wind turns two or three propeller-like blades around a rotor. The rotor is connected to the main shaft which spins a generator to create electricity. Wind turbines are mounted on a tower to capture the most energy at 100 feet 30 meters or more above the ground. The wind energy is a renewable source of energy, energy is used to run wind mill wind turbine consists of flexible five blades propeller about 35 m in diameter is a 60km/hr wind pressure with a rotation speed of 47rpm produce max power 12mw, kestrer type 5 number curved blades is highly suitable [5]. The main drawback of this system is that as wind speed or velocity is not constant with respect to time. The wind energy is to the battery or any power storage device. In wind power system the power generation increases in proportion to the cube of the wind speed, thus it is highly affected in rainy and stormy period. When the wind speed is formidable to produce electricity, small size wind mill with generator either horizontal or vertical or inclined at a certain angled blades can be placed on the wall, the sun sets etc of a building for utilizing the max power of wind in all directions. A simple relationship [5] exists relating the power generated by a wind- turbine and the wind parameters.

\[ P = 0.5 \rho A C_p V^3 \eta_g \eta_b \]  \hspace{1cm} (4)

where

\( \rho \) = air density (1.225kg/m\(^3\) at sea level, less at higher elevation).

A = rotor speed area, exposed to the wind (m\(^2\))

C\(_p\) = Coefficient of performance (.59 to .35 depending on turbine).

V = wind speed in meters

\( \eta_g \) = generator efficiency

\( \eta_b \) = gear box/ bearings efficiency.
Table 1: Main characteristics of the wind turbine

<table>
<thead>
<tr>
<th>Type</th>
<th>Five Blade Upwind</th>
</tr>
</thead>
<tbody>
<tr>
<td>Rotor Diameter</td>
<td>6.7 m</td>
</tr>
<tr>
<td>Blade Pitch Control</td>
<td>KESTRER</td>
</tr>
<tr>
<td>Over speed Protection</td>
<td>AUTOFURL</td>
</tr>
<tr>
<td>Gearbox</td>
<td>None, Direct Drive</td>
</tr>
<tr>
<td>Temperature Range</td>
<td>-40° C to +60° C</td>
</tr>
<tr>
<td>Generator</td>
<td>Permanent Magnet Generator</td>
</tr>
<tr>
<td>Output Form</td>
<td>3 Phase A.C, Variable Frequency</td>
</tr>
<tr>
<td>Start-up Wind Speed</td>
<td>3.4 m/s</td>
</tr>
<tr>
<td>Cut-in Wind Speed</td>
<td>3.1 m/s</td>
</tr>
<tr>
<td>Rated Wind Speed</td>
<td>13.8 m/s</td>
</tr>
<tr>
<td>Rated Power</td>
<td>7.5 kW for Battery Charging</td>
</tr>
<tr>
<td>Cut-out Wind Speed</td>
<td>None</td>
</tr>
<tr>
<td>Furling Wind Speed</td>
<td>15.6 m/s</td>
</tr>
<tr>
<td>Max. Design Wind Speed</td>
<td>54 m/s</td>
</tr>
<tr>
<td>Rotational Speed</td>
<td>0-350 rpm</td>
</tr>
<tr>
<td>Tower</td>
<td>18.3 m</td>
</tr>
</tbody>
</table>

Fig 1. Actual picture of wind power station

Fig 2. Basic diagram of wind-mill power system
4. DESIGN AND IMPLEMENTATION (Integration of Wind and Solar Energy Systems)

To eliminate the above drawback of individual renewable power generation system like solar and wind. By integrating the wind energy, so that power supply remains continuous without any sort of interruption or load shedding. The aim of this work is design and implementation of Hybrid power generation system using wind-energy photovoltaic solar energy for continuous (24x7) power generation. The Solar-Wind with Power Generation System is designed as shown in Fig.3. It has some special equipment to change the battery or the power storage (accumulator) circuit. Control circuit ad-join with electric power generating system provides necessary control functions such as adding or summing up electric power derived from more than one sources at a time i.e. solar and wind power simultaneously, over voltage protection, amount of electric power directed to the load and battery etc.

Thus by implementing Solar with Wind, Integrated Power Generating System in a compact package, we have an uninterrupted power supply at the minimum cost at all places at all times. Moreover, we can avoid the accidental risk and causes by lightning to human and nature both. This method ensures a highly practical oriented pollution free and accident free inventory for electric power generating system. The electric power afforded by this system is completely pure and secured form without any sort of environmental pollution. Also it does not produce any greenhouse effect or acid rain or emit any kind of poisonous gases or radiation etc.

Fig 3. Integrated Electricity Generating System
5. SOLAR POWER GENERATION SYSTEM

The Sun is continuous fusion reactor in which Hydrogen combines to form Helium and evolving huge amount of heat energy as per the reaction[5]

\[
4 \text{H}^1 \rightarrow 2 \text{He}^4 + 26.7 \text{MeV} \quad (5)
\]

The Heat Energy from the Sun is emitted in the universe and the Earth by transmission of tiny bundles of Energy particles called photons which moves with finite speed (almost speed of light) and Energy. When Photons strike an atom they interact with electrons by transferring their Energy and hence they are observed. The sun rays are composing of different wave-length spectrum from the low to the very high ranges but UV (Ultra Violet) radiation, other low and very high range wave length radiations are observed by ozone, oxygen, nitrogen, water vapour etc lying above the Earth’s atmosphere. Thus the sun rays consist of Wavelength (\(\lambda\)) radiation between 0.29 \(\mu\)m to 2.3 \(\mu\)m approximately.

A typical solar tracking PV system must be equipped with two essential features:
a) Azimuth tracking for adjusting the tilt angle of the surface of the PV array during changing seasons, and
b) Daily solar tracking for maximum solar radiation incidence to the PV array.

The tilt angle $\theta$ of a PV system required at any given time in the year can be expressed as a function of the seasonal Sun’s Altitude $\phi$ as follows:

$$\text{Tilt Angle } \theta=90-\phi$$

![Solar Tracking System](image)

Fig 6. Tilt Angle $\theta$ of PV array

Before the advent of solar tracking, fixed solar panels have been positioned within a reasonable tilt range based on the latitude of the location. A rule of thumb is to select a tilt angle of within $15^\circ$ of the latitude depending on whether a slight winter or summer bias is preferred in the system. Solar tracking is best achieved when the tilt angle of the tracking PV array system is synchronized with the seasonal changes of the sun’s altitude and with the geographical insolation level for optimized solar tracking during the day.

Table 2: Solar Module Specifications

| Maximum Power $W_p$ | 210$W_p$ | 840 $W_p$
<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Maximum Power Voltage, V</td>
<td>42</td>
<td>-</td>
</tr>
<tr>
<td>Maximum Power Current, A</td>
<td>5.24</td>
<td>-</td>
</tr>
<tr>
<td>Open Circuit Voltage, V</td>
<td>50</td>
<td>-</td>
</tr>
<tr>
<td>Short Circuit Current, A</td>
<td>5.7</td>
<td>-</td>
</tr>
<tr>
<td>No of cells Pcs</td>
<td>4</td>
<td>-</td>
</tr>
<tr>
<td>Size of the Module, mm</td>
<td>15688 m$^2$</td>
<td>62752 m$^2$</td>
</tr>
<tr>
<td>Weight per piece, Kg</td>
<td>19</td>
<td>-</td>
</tr>
</tbody>
</table>

5.1 Battery Storage Unit

The battery bank has a nominal voltage of 120V. It is formed by 12 elements of 12V connected in series. Each element is of the type lead acid deep cycle low maintenance single cell, being of model classic OPzS, manufactured by Exide. The better nominal capacity is $C_{20}$ at 135Ah. Its nominal life is of 15 years at 20°C.

The battery bank is mounted in the same container of the control units and the inverter, but in a separate room, in order to guarantee the safe operation of the electric/electronic equipments, as can be seen in the figure. The batteries are arranged in 3 series and each series contain 4 batteries. Table 3 present a synthesis of the technical specifications realed to the battery bank.
Table 3: Main characteristics of the battery bank

<table>
<thead>
<tr>
<th>Capacity ($C_{20}$)</th>
<th>135Ah</th>
</tr>
</thead>
<tbody>
<tr>
<td>Battery type</td>
<td>Lead Acid</td>
</tr>
<tr>
<td>Nominal Voltage</td>
<td>120 volts</td>
</tr>
<tr>
<td>Number of elements</td>
<td>12</td>
</tr>
<tr>
<td>Voltage/element</td>
<td>12 volts</td>
</tr>
</tbody>
</table>

Fig 7. The Battery Storage Unit

5.2 Power Controller

It is obvious that the power controller component is the most innovation one, and the one that makes this system different, as the other components are all of them commercially available in the market. The power controller has been designed, developed and manufactured by PRAPAN especially for this project, and the power converters involved in CICLOPS II will be even more advanced and specialized in these systems. It is not commercially available, because it’s in the prototype phase.

The controller controls the voltage from the battery and transfer the same amount of voltage to the system. Where W indicates wind mills indicate solar system B indicates battery storage these 3 indicators will be visible in LCD controller. It has three separate lines known L1, L2 and L3 visible on the surface of the controller.
6. RESULTS AND DISCUSSION

The current and voltage values from the Wind Turbine, Solar Panels, Battery group and load are measured and this power in consuming for computer green lab to run the sixty computer systems and six LED small tube lights and 1 fan for 12 hours.

7. CONCLUSIONS

This Integrating Solar-Wind Energy Power Generation System will be highly effective in all places, especially in rural areas where the commercial electricity has not reached or undelivered. It causes no effect on nature i.e. pollution free, at the same time not proneness any kind of accident due to lightning and highly suitable for domestic purposes. It is also useful to urban and city areas, simultaneously with the commercial power supply to minimize power supply load i.e. cut short power charge. By using this system, People can save electricity charge and very less maintenance charge to this equipment is required. The designing of this equipment is done in such a way that it is very compact and acts as user friendly. When it is manufactured in a large scale, cost of this integrated natural resources power generation system is affordable. Moreover there is no power failure or load shedding situation at any times. Therefore, it is the most reliable renewable power or electricity resources with the least expenditure in the globe.

REFERENCES