**Performance Analysis of a Hybrid Solar-Wind Power Generation System**

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*Abstract*

**Renewable energy resources are currently being deployed on a large scale to meet the requirements of increased energy demand, mitigate environmental pollutants, and achieve socio-economic benefits for sustainable development. Integration of renewable energy sources provides energy security, substantial cost savings, and a reduction in greenhouse gas emissions, enabling the nation to meet emission targets. A hybrid renewable energy system generates more reliable electrical energy, as the single source of intermittent nature can't supply continuous generation. This paper focuses on the use of solar photovoltaic generation in conjunction with wind turbines to generate electrical energy. For the maximization of the output power, the MPPT technique is utilized and the performance assessment of the hybrid power system based on the output nature is done.**

***Keywords***: Hybrid system, Maximum power point tracking, controller, De-risk, markets.

INTRODUCTION

The usage of renewable energy for electricity generation is a priority research topic nowadays in recent years. Renewable energy source captures the attraction for environmental consideration pollution free easy availability and continuous. Out of the other renewable energy sources available in the market, photovoltaic cell energy generation is the most promising resource because of its affordable cost simple implementation, and portability. To have continuous power supply and efficiency improvement it is coordinated with other renewable energy sources like wind fuel cell and axillary unit (AU)to form hybrid renewable energy sources this is generally combined with a battery storage system thus the implementation of a hybrid renewable energy system was formed where more than two renewable energy sources were implemented. An auxiliary unit was used as a backup generator that can generate power when all the RES fails to generate may be of a diesel generator set or a supercapacitor [1]. India’s annual solar energy is equivalent to more than 5000 trillion. The decision variables were the number of PV panels, wind turbines, and batteries, the capacity of transferred power by inverter, the angle of PV panels, and wind tower height time between 2300 and 3200 hours. The low energy density and discontinuous availability of this energy can be used very dependently for many purposes. Wind power is abundant renewable generally distributed and clean. Used to replace fossil fuels it can reduce greenhouse gas emissions. when using wind energy at low to medium permeability levels intermittent winds will not cause problems. Different types of faults and treatment of a large-scale motor generator of a pumped storage power station were good references for similar fault prevention and diagnosis [2]. The improved crow search algorithm (ICSA) was implemented for designing a different combination of the stans-alone hybrid system such as PV /wind /battery for improving the low supply reliability over the horizon considering minimizing the net present cost. The number of PV panels, wind turbines, and batteries, the capacity of transferred power by inverter, the angle of PV panels, and wind tower height were taken as the decision variables. [3]. The PV system is suitable for combining with other renewable (e.g wind) or non-renewable (e.g diesel) sources to obtain consistent energy for consumption. In addition to significant advantages, solar energy protection has its drawbacks such as the cost of maintenance of the entire system and the impact of maintenance on the ecosystem as well as the development of consumer awareness. We must be aware that overcoming these problems leads the world to the necessary protection of the environment [4]. The technical challenges required to ensure that power grids are dominated by inverter-based generation or purely powered by inverter-based generation such as power system security assessment, voltage, and frequency management, power system stability resource forecasting techniques for unit commitment, behind the meter generators and loads integration to the grid, frequency and voltage support, power system flexibility assessment, methods protection schemes enhancement power quality mitigation techniques, and modeling requirements to support real-time power system operation needed further research to ensure the reliable and stable operation for all operating scenario [5]. From the comparative analysis of two different types of distributed power flow controller (DPFC) models of a hybrid solar wind generation system integrated with a grid the in-rush current for three-phase mode, DPFC was more (I.e.20A) compared to DPFC with batteries (I.e.15A) in hybrid systems [6]. A reliable and continuous power supply for various load conditions was ensured from the hybrid power generation unit with MPPT controllers [7]. [8] The collaborative actions of the hybrid system with a fuzzy logic (FLC) based energy management strategy during fluctuations of renewable-based power protection were investigated. Analysis of different energy management techniques on the hybrid structure with comparison to FLC and developing an efficient and reliable methodology for Techno-economically sizing of such hybrid systems with experimentally verified models of the hybrid system components which may be valuable for evaluating the feasibility of the stand-alone hybrid renewable system. In Article [9] 7 MPPT techniques have been used by considering the parameter's steady state settling time, MPP tracking speed, algorithm complexity, PV array dependency, handling of partial shading, and efficiency. The hybrid MPPT technique is extracting the maximum PV power with a less steady state. The hybrid(P&O-PSO) MPPT technique was extracting the maximum PV power with less steady state oscillations with high accuracy and high efficiency. Research and development(R&D) funds should focus more on technical and optimization challenges regarding the operation development and scaling of hybrid power systems [10]. With high penetration of distributor-generating resources, the grid-connected photovoltaic system [GCPVS]caused accidental stress on the electrical grid. maximum PowerPoint tracking [MPPT], inverters that supported services like reactive power management, frequency regulation, and energy storage are units important for mitigating the challenges caused by the growing adoption of GCPVS [12]. In the article [11] topology gathered maximum power using multi-input KY boost converters for hybrid energy. The simulation and optimization of the operation of the hybrid system have been done by Homer (hybrid optimization model for electric renewable) software using the real-time field data of solar radiation and wind speed of that area. The net present cost (NPC) and CO2 emission could be reduced by about 29.65 % and 16 tons per year respectively compared to the conventional power plants [12]. Experimental results from the operation of a testbench constituted of a PV wind hybrid system were tested and they have concluded that the primary energy supplier PV array is (84 %) and the secondary energy supplier wind turbine 16(%) [13]. obtained by adding the contribution from each source. The objective of this paper is to present the energy production data from the hybrid power system used for lighting purposes.

SOLAR PHOTOVOLTAIC-WIND HYBRID SYSTEM

An important type of solar hybrid system is the solar photovoltaic hybrid system, in which the complementary power source is the wind. This is a genuinely nice combination of both solar and wind. Another agreeable point about coupling wind and solar systems with each other is that normally the peaks of solar energy occur when the wind is not that strong and wind peak operating times occur when the solar energy is nonexistent or at least peak. This means that the systems are inherently listed, fluctuating in terms of power generation. wind power systems and solar power systems are not individually as effective as their combination because, wind or solar energy is not as much available as needed, therefore the solar wind hybrid systems can be better choices for consistency by generation. They can also be integrated with another complementary power source such as decent to fold a guarantee we are consistent by the generation that uses batteries for the must. [3] Maximum voltage control is commonly used to increase power output in all situations of wind turbines and solar cell (PV) systems. MPPT units are often integrated into power conversion systems and send various loads to provide automatic conversion, filtering, and control.

*Benefits of Hybrid System*

De-risk the overall generation profile of a renewable plant and this has a further effect of maximizing the utility of the interconnection. It Provides more consistent and dependable power production, supplies continuous loads, and Unlocks new markets for renewable. Longer battery life- Charging via simultaneous sharing of power between solar and wind, sources keep the battery in peak charge condition, leading to a longer life.

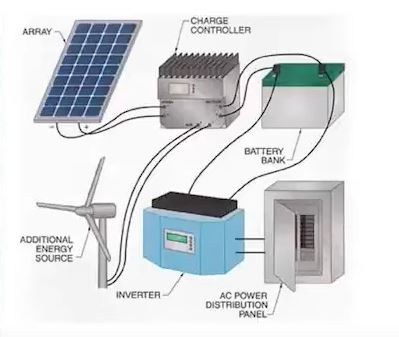


Fig1. Model of hybrid power system

BLOCK DIAGRAM

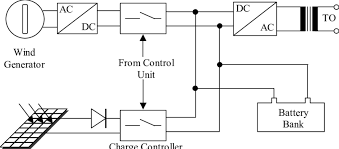


Fig2Block Diagram of Hybrid System.

DIAGRAM DESCRIPTION

*1. Solar Panels*

The solar panel converts solar radiation into electrical energy. They have similar physical properties to diodes, with PN junctions formed by semiconductors. The energy of an absorbed photon is transferred to the electron-proton system of the material, creating charge carriers at the junction. The charge carriers in the junction region create a potential gradient, get accelerated under the electric field, and circulate as the current through an external circuit. A solar array or panel is a group of several modules electrically connected in series-parallel combination to generate the required current and voltage. Solar panels are the medium to convert solar power into electrical power.

*2. Wind Turbine*

The wind turbine is a system that extracts energy from the wind by rotation of the blades of the wind turbine. The wind turbine has two types one is vertical and another is horizontal. in this system we are using a horizontal axis wind turbine. As the wind speed increases power generation increases. The power generated from wind is not continuous it fluctuates. To obtain the non-fluctuating power we have to store in a battery and then provide it to the load.

*3. Charge Controller*

The charge controller has a basic function is that it controls the source which is to be active or inactive. it simultaneously charges the battery and also gives power to the load. the controller has overcharge protection, short circuit protection, pole confusion protection, and an automatic dump load function. It should also vary the power as per the load demand .it add both powers so that the load demand can be fulfilled. And when power is not generating it should extract power from a battery and give it to the load .

*4. Battery Bank*

The battery bank size can be chosen as per the load requirement [14]

The PV panel, and wind turbine they both connected to a charge controller MPPT (maximum PowerPoint tracking), which does charge controlling of the battery. The battery drives to the inverter, inverter goes to the AC distribution panel. the charge controller receives variable input but it should control the charging of the battery in a well-defined manner. the controller needs to look at two inputs to optimize battery charging.

TABLE I

**HYBRID SYSTEM SPECIFICATIONS**

|  |  |
| --- | --- |
| **Solar PV Module Used (250/260/265/270/275)/24V SOLAR PV MODULE At STC 1000W/m2, Temp=25°C** | |
| **Component Description** | **Specifications** |
| Model | HST60F265P |
| Open circuit voltage Voc | 38.39V |
| Short circuit current Isc | 9.51A |
| Vpm | 30.88V |
| Ipm | 9.01A |
| Pmax | 278.49W |
| Temperature(°C) | 25.0 |
| Dimension | 1650\*987\*40 mm |
| Irradiation (W/ m2) | 1000 |
| **Wind parameters** | |
| Rotor diameter | 1.24 meter |
| Rotor swept area | 1.207-meter square |
| Number of blades | 3 |
| Nominal power | 177 watts |
| Output voltage | 10- 35 V AC |
| Axis type | HAWT |
| Wind direction adjustment mechanism | Tail |
| Highest design wind speed | 25 meters per second |
| Maximum power (20m/s) | 524W |

TENTATIVE OUTCOMES AND DISCUSSION

Fig 3. Characteristics of Hybrid System.

Fig 4. Battery charging concerning time.

This work deals with the performance analysis of a developed hybrid solar wind power generation system. Figure 3 shows that the voltage rises at constant current to peak voltage when full charge is reached current level was off and at last, voltage is lowered to float charge level. Figure 4 shows that the battery terminal voltage increases with time, because of the continuous energy sources battery voltage increases over time.

CONCLUSION

The hybrid power generation unit based on the wind solar system was developed to overcome intermittency and uncertainty and make the power system more reliable, rechargeable and remarkable. This paper presents the performance assessment of the hybrid (solar-wind) power system at various load conditions. The output power of the hybrid system increases when compared to the individual subsystems. Also found that the MPPT charger switching the battery charging from the maximum power from either source automatically was studied.

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