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Solar-Wind Hybrid Generation System Integration with Grid

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ABSTRACT

Wind and solar energy are becoming popular owing to the abundance, availability and ease of harnessing the energy for electrical power generation. This paper focuses on an integrated hybrid renewable energy system consisting of wind and solar energies. Grid-tied power generation systems make use of solar PV or wind turbines to produce electricity and supply the load by connecting to the grid. In this study, the HOMER (Hybrid Optimization Model for Electric Renewable) MATLAB modeling has been used to model the power system, its physical behavior and its life cycle cost. Through the use of simulations, the installation of ten 2-MW wind turbines and 2.5-MW solar PV was evaluated.

KEYWORDS: *Wind energy, MPPT, PMSG, Boost converter*

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INTRODUCTION

To meet the day to day increasing load demand, conventional energy sources are no longer a viable solution as they are depleting rapidly[1]. Solar, due to its dependence on sunlight, can produce power only during the day mainly between 8 am and 5 pm. Wind, on the other hand, usually is more during late evenings and reaches its peak at night. Due to this complementary intermittent nature of wind and solar, power production can be leveled out throughout the day with a Solar-Wind Hybrid. With a hybrid, reliability of the grid is improved by ensuring peak power requirements are met[9]. The entire hybrid system comprises of PV and the wind systems. The PV system is powered by the solar energy which is abundantly available in nature. PV modules, maximum power point tracing systems make the PV energy system. The light incident on the PV cells is converted into electrical energy by solar energy harvesting means[3]. The maximum power point tracking system with Perturb &absorb algorithm is used, which extracts the maximum possible power from the PV modules. The ac-dc converter is used to converter ac voltage to dc[4].

Wind turbine, gear box, generator and an AC – DC converter are included in the wind energy system. The wind turbine is used to convert wind energy to rotational mechanical energy and this mechanical energy available at the turbine shaft is converted to electrical energy using a generator. To coerce the maximum power from wind system we used a maximum power point tracing system. Both the energy systems are used to charge a battery using bi-directional converter. Bidirectional converter and the battery form the common additional load to the wind and PV energy systems Hybrid generation systems that use more than a single power source can greatly enhance the certainty of load demands all the time. Even higher generating capacities can be achieved by hybrid system[5]. In stand-alone system we can able to provide fluctuation free output to the load irrespective of weathers condition. To get the energy output of the PV system converted to storage energy, and constant power delivered by the wind turbine, an efficient energy storage mechanism is required, which can be realized by the battery bank[6].

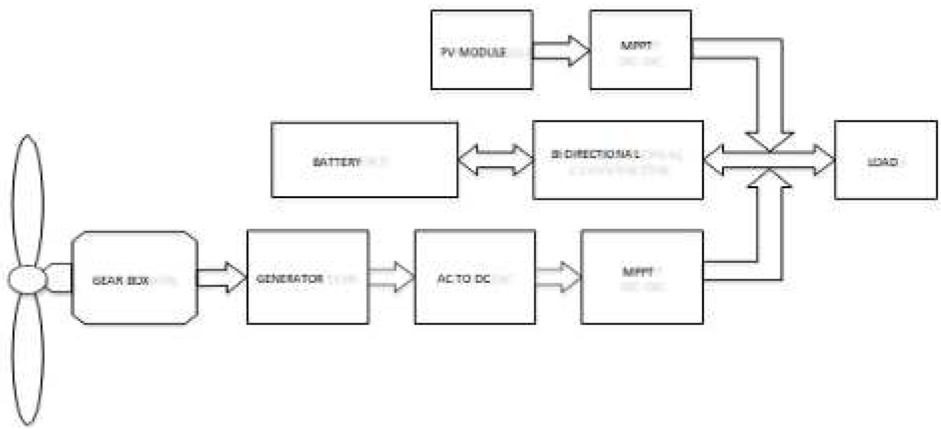

Figure 1 Block diagram of hybrid system

GRID-CONNECTEDPOWER SYSTEM

The integration of combined solar and wind power systems into the grid can help in reducing the overall cost and improving reliability of renewable power generation to supply its load. The grid takes excess renewable power from renewable energy site and supplies power to the site' loads when required[7].

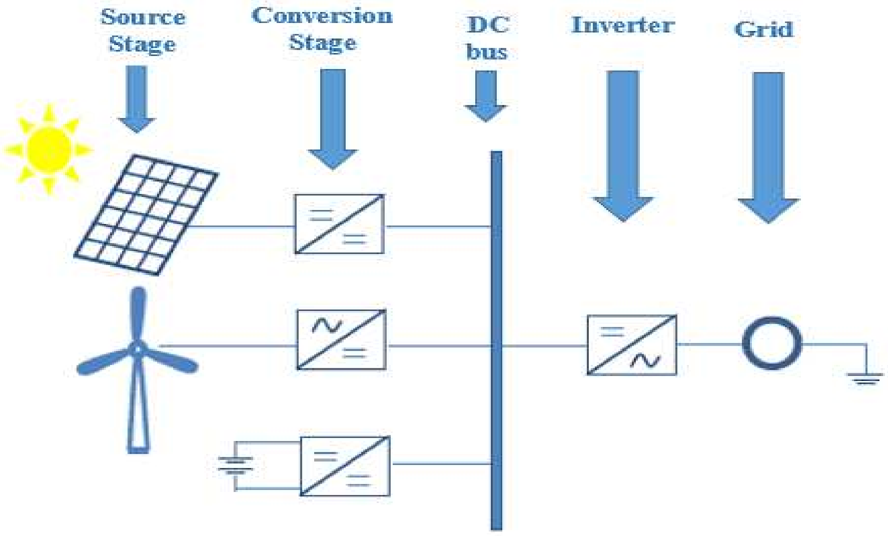

Figure 2 Grid-connected hybrid systems at common DC bus

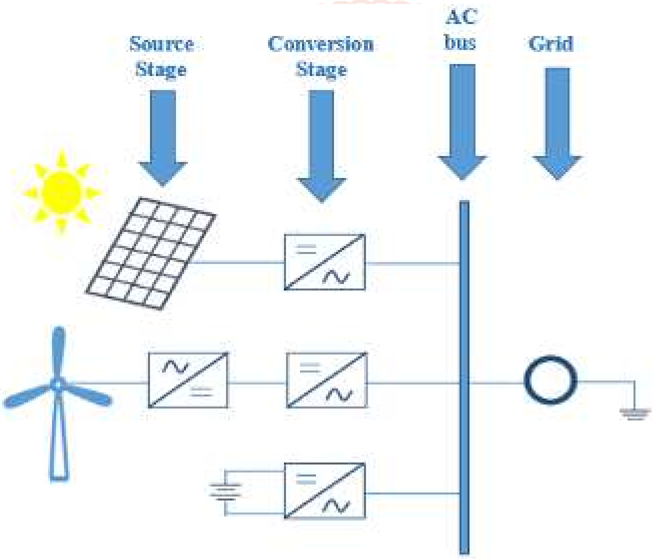

Figure 3 Grid-connected hybrid system at common AC bus

MODELING OF PV SYSTEM

PV array are formed by combine no of solar cell in series and in parallel. A simple solar cell equivalent circuit model is shown in figure. To enhance the performance or rating no of cell are combine. Solar cells are connected in series to provide greater output voltage and combined in parallel to increase the current[8]. Hence a particular PV array is the combination of several PV module connected in series and parallel. A module is the combination of no of solar cells connected in series and parallel.

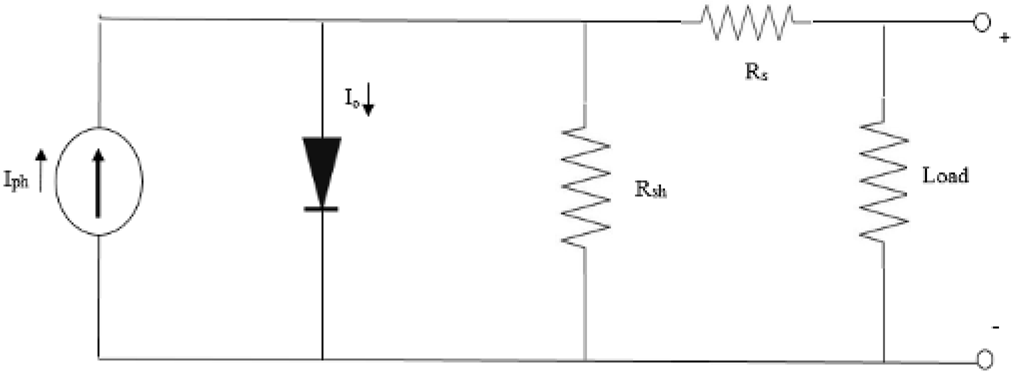

Figure 4 Circuit Diagram of Singe PV cell

Photo Current of the Module:

$I_{ph}=[I_{scr}+k_i\ (T-298)\ ]*\lambda/1000$ (1)

Reverses Saturation current of the module:

$I_{rs} = I_{sr}/[\exp(qV_{oc}/N_s kAT)-1]$ (2)

Saturation current of the Module I_o:

$I_o = I_{rs}[T/T_r]^3 \exp[qE_{go} / BK \{1/T_r - 1/T\}$ (3)

Current of the PV module:

$I_{pv} = N_p * I_{ph} - N_p * I_o [\exp \{(q * V_{pv} + I_{pv}R_s) / N_s AKT\} - 1]$ (4)

This equation is used to simulate in mat lab/Simulink and the result shows the nonlinear Characteristics of photovoltaic array at different irradiations and temperature.

MODELING WIND TURBINES

A wind turbine converts kinetic energy of air i.e. wind power into mechanical power i.e. rotating motion of the turbine that can be used directly to run the machine or generator. Power captured by wind turbine blade is a concomitant of the blade shape, the pitch angle, speed of rotation, radius of the rotor. The equation for the power generated is shown below.

$P_m = \frac{1}{2}\pi\rho Cp(\lambda.\beta)R^2V^3$ (5)

Where

P_M – Power capture by wind turbine

ρ – Air Density

β- Pitch angle (in degrees)

R – Blade Radius (in meters)

V – Wind Speed (in m/s)

The term λ is the tip- speed ratio given by the equation

$$\lambda = \frac{\Omega R}{V}$$

Where

Ω – Rotor speed of Rotation

C_p can be expressed as the function of the tip-speed ratio (λ)

$$C_p = \frac{1}{2}\left(\frac{116}{\lambda_1} - 0.4\beta - 5\right) exp^{\frac{-165}{\lambda_1}} \quad (6)$$

$$\lambda_1 = \frac{1}{\frac{1}{\lambda+0.089} - \frac{0.035}{\beta^3+1}}$$

Hybrid MATLAB Simulation Model: Figure 5 shows the complete final model of the Hybrid PV-Wind system, The subsystem HPW is the hybrid subsystem which is giving the accumulated DC as the output.

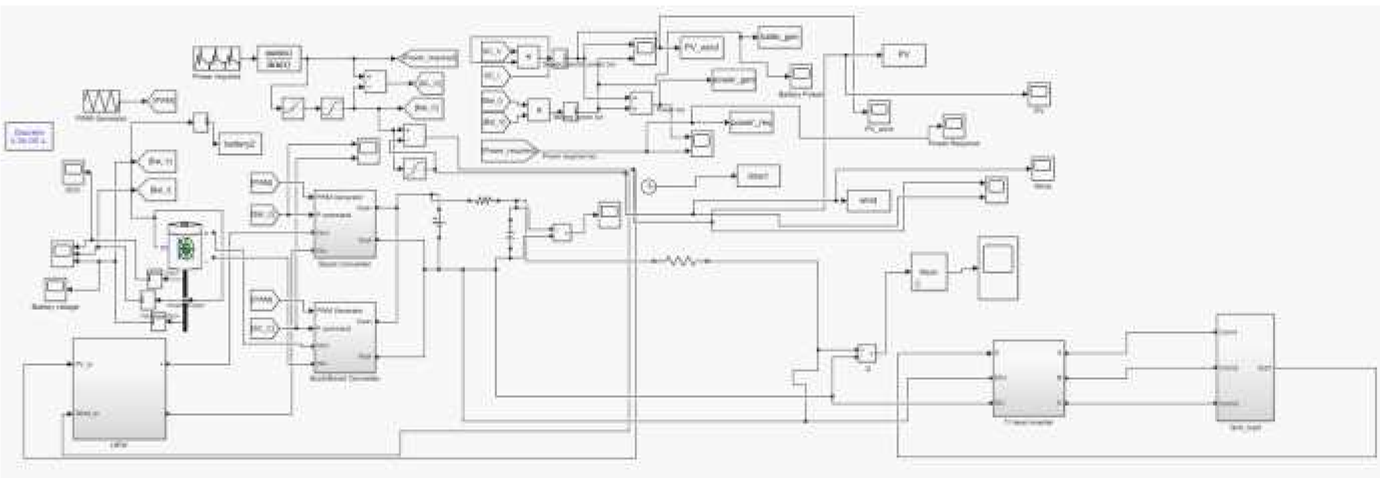

Figure-5 MATLAB/SIMULINK of Hybrid PV-Wind system

Results:

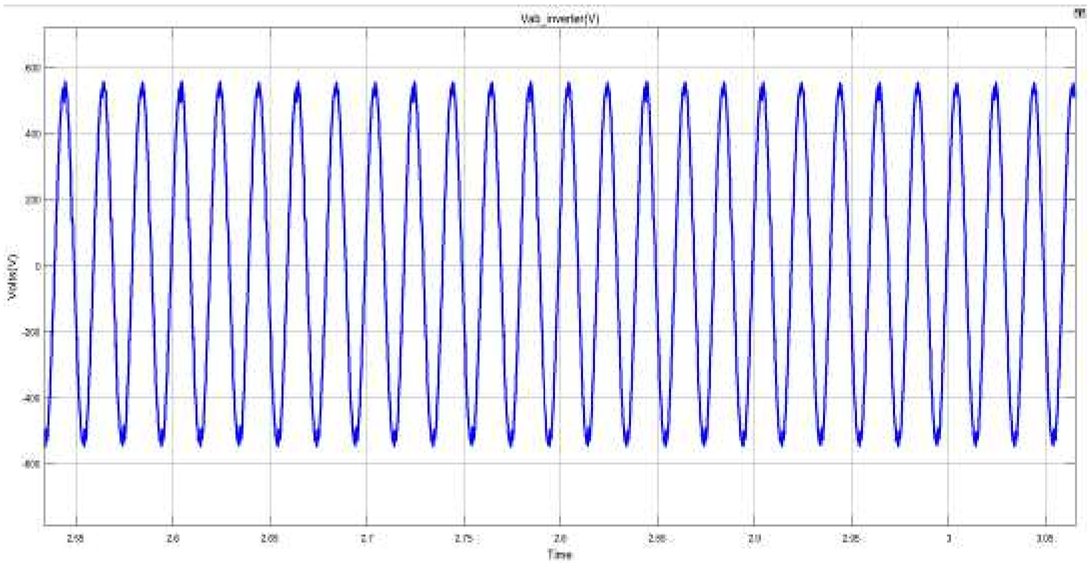

Figure 6 Inverter Voltage

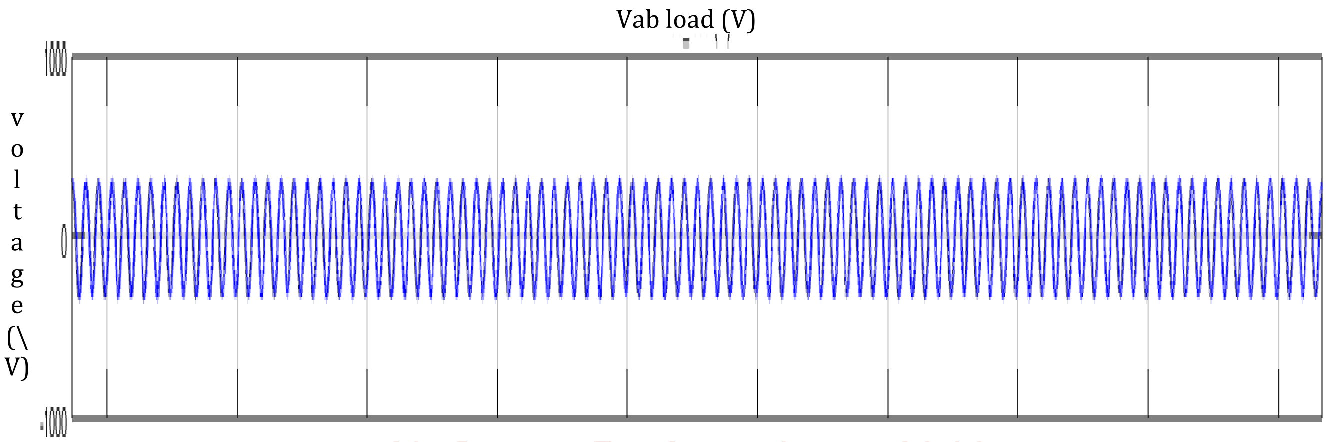

Figure 7 Load Voltage

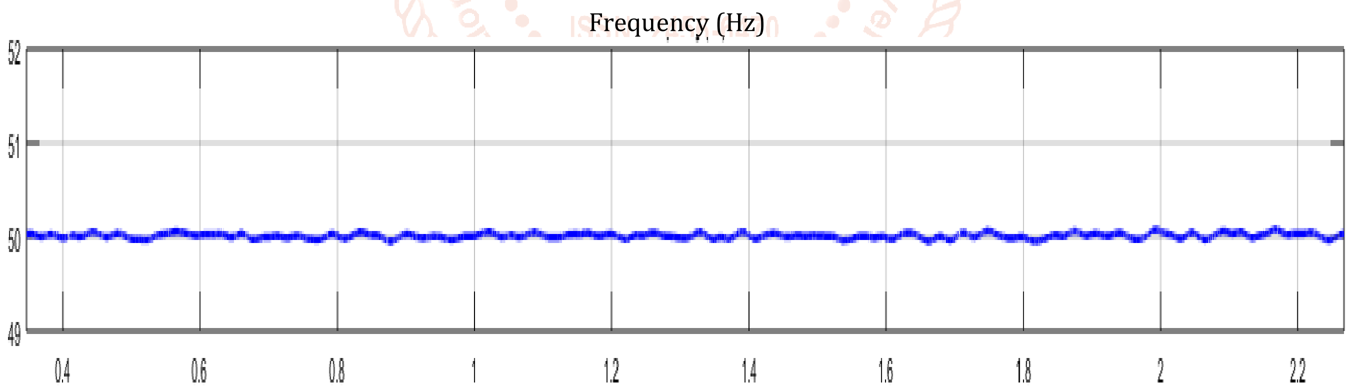

Figure 8 Frequency of the system

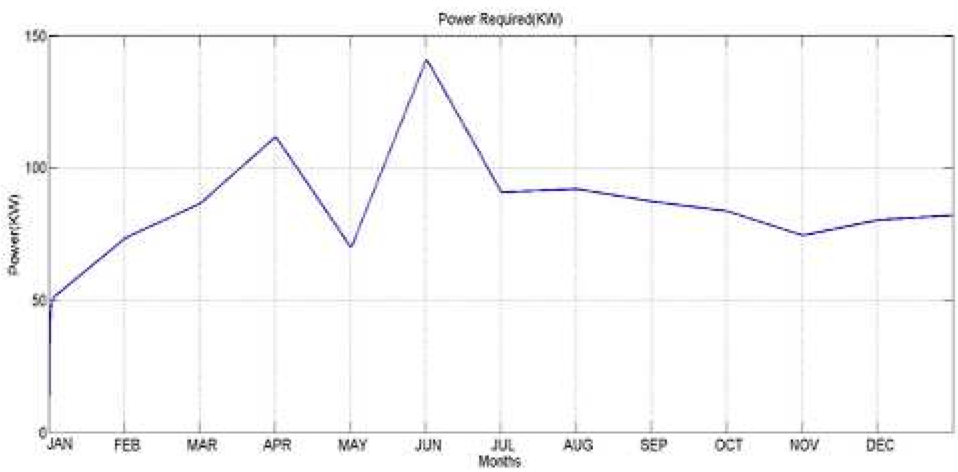

Figure 9 Power Demand

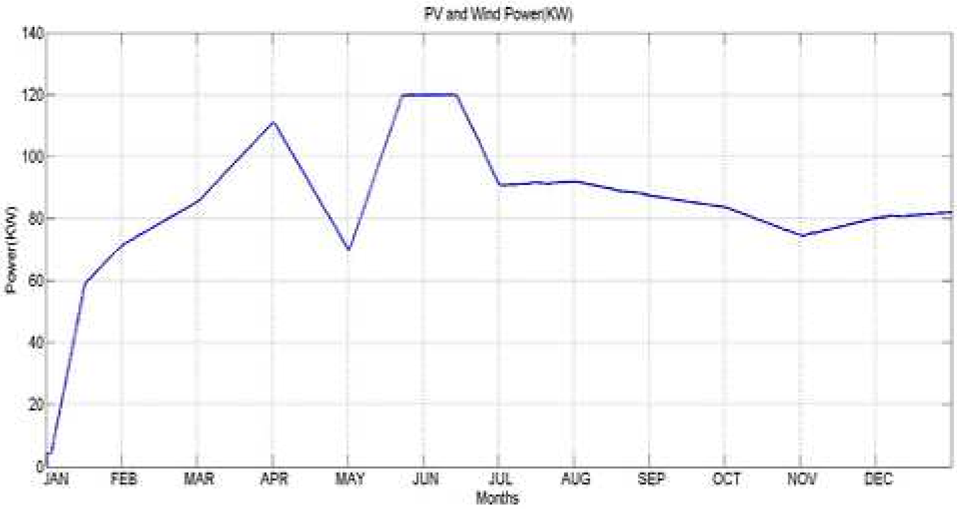

Figure 10 PV and Wind Combined Power Generation

Figure 11 PV Power Generation

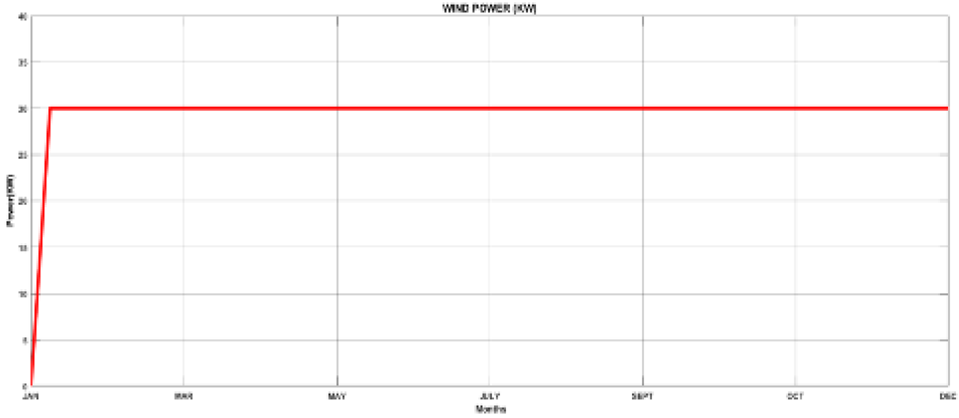

Figure 12 Wind Power Generation

Conclusion:

PV cell, module and array are simulated and effect of environmental conditions on their characteristics is studied. Several PV panels are connected in series to get the maximum output.Wind energy system has been studied and simulated. A wind turbine of 2.5MW nominal mechanical output power is used and the turbine is driving the synchronous generator of 70KVA. The A.C. generated by the synchronous generator is fed to the rectifier to convert it into the DC. A Hybrid System of wind and PV is simulated with the Load curve requirement . The hybrid system is connected to grid with stabilization. Both the systems are integrated and the hybrid System is used for battery charging and Discharging

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