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# ANALYSIS OF PV-WIND HYBRID ENERGY SYSTEM PERFORMANCE USING MATLAB/SIMULINK

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**Abstract:** Applications of solar wind hybrid energy systems and their efficient usage (SWHES). Solar energy, the most plentiful natural source of energy, is essential for the creation of energy in the future. Due to the lack of coal, conventional power generation will become increasingly challenging in the future. The thermal power plant's increasing cost per unit of generation. Another factor is the loss of transmission power. Environmental damage will result from traditional power generation's emission of pollutants.

To overcome these difficulties in future we have to depend on solar power generation. It is clean source of energy and it can transform to any source of energy with no effect on the environment. To get continuous power supply we should operate wind and solar power plants together as a single unit. By this combined mode of operation, the overall efficiency of the system increases. The combined power generation will give the continuity power supply for household applications with battery as a storage element. SWHES are more reliable to small power application. This configuration also reduces the load on the conventional power generating system with no effect on the environment. It is a stand-alone hybrid Solar PV Wind energy system for applications in isolated area. The wind and solar PV system are connected to the common load through DC/DC Boost converter. The performance of the hybrid system is evaluated under different wind speeds and different irradiation levels

In the last few years the photovoltaic and wind power generation have been increased significantly. A hybrid energy system which combines both solar panel and wind turbine generator it is an alternative for conventional source of electrical energy like thermal and hydro power generation. A simple control technique which is also cost effective has been proposed to track the operating point at which maximum power can be coerced from the PV system and wind turbine generator system under continuously changing environmental conditions. The entire hybrid system is described given along with comprehensive simulation results that discover the feasibility of the system. The modeling and simulation of hybrid system is done using MATLAB/SIMULINK.

**Keywords:** Solar Wind Hybrid Energy Systems (SWHES), DC/DC Boost converter, MATLAB/SIMULINK

## I. INTRODUCTION

According to many renewable energy experts, a small "hybrid" electric system that combines home wind electric and home solar electric (photovoltaic or PV) technologies offers several advantages over either single system.

In much of the United States, wind speeds are low in the summer when the sun shines brightest and longest. The wind is strong in the winter when less sunlight is available. Because the peak operating times for wind and solar systems occur at different times of the day and year, hybrid systems are more likely to produce power when you need it.

Many hybrid systems are stand-alone systems, which operate "off-grid" -- that is, not connected to an electricity distribution system. For the times when neither the wind nor the solar system are producing, most hybrid systems provide power through batteries and/or an engine generator powered by conventional fuels, such as diesel. If the batteries run low, the engine generator can provide power and recharge the batteries.

Adding an engine generator makes the system more complex, but modern electronic controllers can operate these systems automatically. An engine generator can also reduce the size of the other components needed for the system. Keep in mind that the storage capacity must be large enough to supply electrical needs during non-charging periods. Battery banks are typically sized to supply the electric load for one to three days.

Due to the critical condition of industrial fuels which include oil, gas and others, the development of renewable energy sources is continuously improving. This is the reason why renewable energy sources have become more important these days. Few other reasons include advantages like
abundant availability in nature, eco-friendly and recyclable. Many renewable energy sources like solar, wind, hydro and tidal are there. Among these renewable sources solar and wind are the world's fastest growing energy sources.

FIG 1: Hybrid renewable energy

## II. LITERATURE SURVEY

Paper Name : PV-wind hybrid system: Author Name: Yashwanth Swale Year : 2016

In order to analyze the MLI's dependability in defective situations, this study designs 5-level modified T-type and modified Packed-U-Cell (PUC) multilevel inverter (MLI) topologies with a decreased device count. Incorporating the defect, whether caused by the loss of a single switch or a single h-bridge leg, is the goal of this effort. A built-in self-voltage balancing feature further simplifies and improves the circuit's dependability in the suggested T-type and PUC inverter. The suggested topologies are first modelled in a Matlab/Simulink setting, and the outcomes are contrasted with the standard MLI. The analytical advancements are then validated by experimental testing of both MLIs on a laboratory prototype.

Paper Name: Design and Simulation Studies of Hybrid Power Systems Based on Photovoltaic, Wind, Electrolyzer, and PEM Fuel Cells

Authors :Hussein A.Z. AL-bonsrulah Mohammed, J. AlshukriLama, M. Mikhaeel

Reducing environmental consequences and increasing energy sector flexibility have recently prompted a move from concentrated to decentralized production and a greater penetration of renewable energy sources. One device that may generate power via chemical reactions is a fuel cell. The use of fuel cells to convert and generate energy is an exciting new development in the field. Since not every day is bright, windy, or nighttime, this integrated system's improved dependability in providing continuous production is evident. The wind and photovoltaic energy systems compliment one other. Photovoltaic and electrolysis systems provide surplus electricity during off-peak hours. Gaseous hydrogen is kept in storage tanks after compression. The study's overarching goal is to create a completely autonomous electricity network in the Bahr AL-Najaf Area by cutting it off from the main grid. After studying and designing PEM fuel cells, it was discovered that at 0.61 volts and 1.04 A/Cm2, one layer is equivalent to 570.96 Watts. A single stack has a total power of 7422.48 Watts due to the fact that it is constructed with 13 levels. So, in order to get the necessary energy out of the fuel cells, 203 stk is the number of stacks that must be used.

Paper Name : Design and Optimization of Hybrid PV-Wind Renewable Energy System. Author Name : Jyoti B. Fulzele , M.B. Daigavane

In short, a hybrid renewable energy system combines two or more types of energy sources to meet the demand. Installing a well-designed hybrid energy system in outlying places where grid expansion is both difficult and expensive is a crucial use case for renewable energy systems. The coordination between various energy sources, energy storage, and the load is very complex, making the correct design of such a system a tough undertaking. In order to provide society with efficient, dependable, and cost-effective alternative energy, it is necessary to optimize hybrid renewable energy systems by choosing appropriate components, determining their size, and developing a control plan. Optimal design of a hybrid renewable energy system including photovoltaics, wind generators with batteries, and converters is shown in this work.

## III. METHODOLOGY

When two or more types of energy are used to power a load, the result is a hybrid energy system. Just said, a hybrid energy system is one that combines the best features of two or more energy sources to produce more usable electricity. A hybrid energy system is more cost-effective, efficient, and reliable than a traditional power source. Power generation in this system is accomplished by the use of solar and wind energy. When compared to other non-conventional energy sources, solar and wind power provide many benefits. Both of these energy sources are more widely available. The price has to go down. You won't have to track out any unusual spots to set up this system. The need for energy is on the rise globally. An ever-expanding middle class in developing nations is fueling this ravenous need by demanding access to luxuries that developed nations often take for granted.

There is a growing need for energy from conventional grid or utility sources due to the exponential growth of technology across all sectors, including personal gadgets, mobile devices, and (lifestyle) comforts. To lessen our reliance on fossil fuels, cut down on our emissions of greenhouse gases, and provide power to outlying areas that aren't connected to the national grid, hybrid systems that harness renewable energy sources like wind and solar power could be a viable alternative. Both solar and wind power have certain limitations when it comes to effective use. The idea of a hybrid power plant is proposed as a solution to these issues. This makes extensive use of wind and solar power plants, mitigating their respective drawbacks. We know that solar power is only accessible during the day, so it can't generate electricity at night. On the other hand, wind power remains constant and even rises in capacity throughout the night. Wind power kicks in here when the sun doesn't shine, and solar power goes out when the sun doesn't. As a result, hybrid power plants are more popular due to their superiority over standalone ones.


Fig.2 Hybrid solar and vertical axis wind turbine

Most of us picture horizontal axis wind turbines, or HAWTs for short, when we think about wind turbines. In appearance, a HAWT is quite similar to a wind turbine; its horizontal axis of rotation is occupied by blades that resemble propellers. Towers atop horizontal axis wind turbines house the electrical generator and primary rotor shaft, which must face the direction of the wind in order to function. To direct smaller turbines, all you need is a square wind vane aligned with the rotor (blades). On the other hand, larger turbines often use a wind sensor in conjunction with a servo motor to pivot the turbine towards the wind. An electrical generator is driven more efficiently by the gearbox, which is included in the majority of big wind turbines. This gearbox converts the rotor's sluggish revolution into a rapid rotation. Turbulence is created behind a tower, hence it is common practice to position the turbine upwind of the structure. The blades of wind turbines are designed to be sturdy so that strong gusts do not force them into the tower. On top of that, the blades are angled slightly upwards and positioned well forward of the tower. Since downwind machines don't need any extra mechanism to maintain their alignment with the wind, they have been constructed despite the turbulence issue. Another option is to bend the blades in strong winds; this decreases the swept area and, by extension, the wind resistance. Because fatigue problems are caused by turbulence and dependability is paramount, the majority of HAWTs are upwind devices.

## IV. CIRCUIT DESIGN AND WORKING

### A)DESIGN AND SIMULATE PV SOLAR POWER SYSTEM:

The model of the 12kW grid connected PV system is given as,

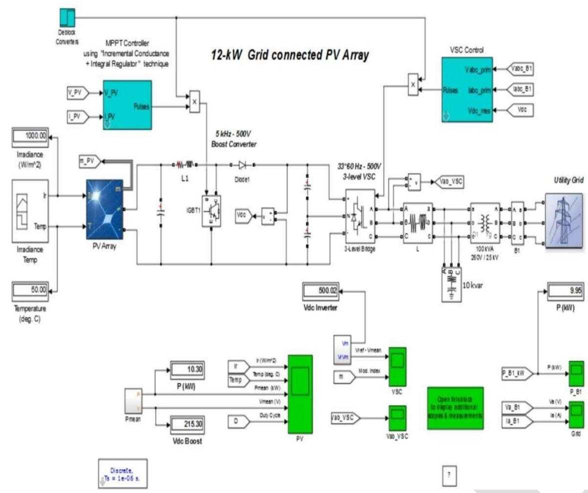



FIG 3: Simulation model of PV solar system

### 3.1.1 EXPLANATION OF MODEL:

First of all, a PV array block is needed to produce 12kW power so that we can then fed it to the grid. Also there are some inputs to the PV array i.e. Irradiance and Temperature. These two parameters can change the output power considerably, for example, if the temperature rises, the output power decreases.

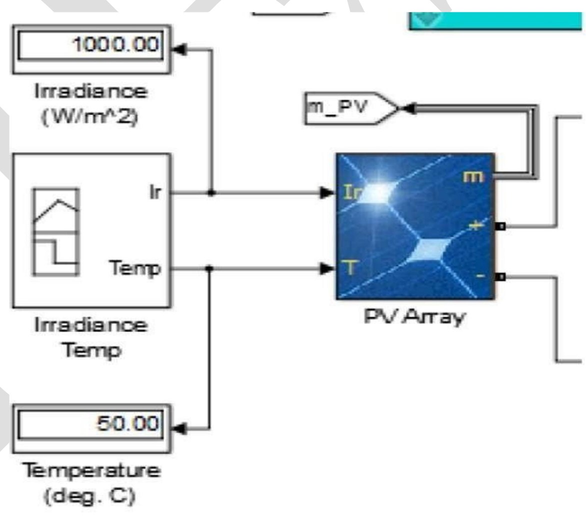



FIG 4: Simulation model of PV array

Then, there is a Boost converter which is used to maintain DC voltages at 500V to track maximum power point. Also, there is inverter which gets DC input and converts it into AC so that it could be fed into grid. Notice that the

VSC Control gives pulse to the inverter but there is another block Deblock which is used here to off the controllers for 0.05s.

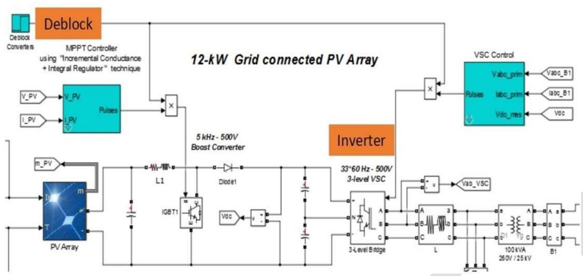



FIG 5: Simulation model of boost converter

After inverter, there is a filter or capacitor bank which is making the output
(V, I) sinusoids smooth. Then it further fed to transformer which is delivering power to grid.

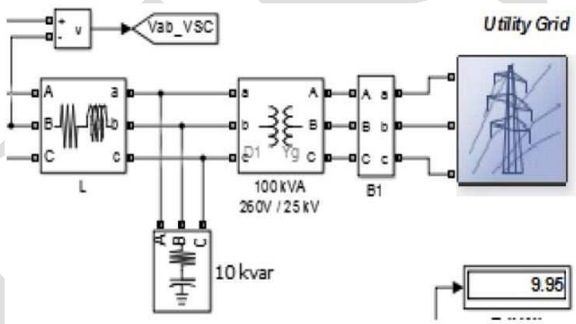



FIG 6: Simulation model of capacitor and inverter

**CALCULATIONS:**

Here the selected parallel strings to 10 and series strings to 4.

As we know voltage adds up in series and current adds up in parallel. The voltages at maximum power point of selected panel are 54.7V and current at that point is 5.58A.

$V_m$=54.7$m$ $I_m$=5.58$m$

Total voltage of PV array = 54.7V×4 = 218.8V

Total current of PV array = 5.58A×10 = 55.8A

Total power of PV array = 218.8V×55.8A = 12209.04W

Hence, $m^{mmmmm}$=12.2Kw

Irradiance value = 1000W/$m^2$ → 250W/$m^2$ → 1000W/$m^2$

Temperature value = 25°C → 50°C

**B) DESIGN AND SIMULATE WIND POWER SYSTEM:**

**The Simulink model of 12kW Wind power system connected with grid is given as,**

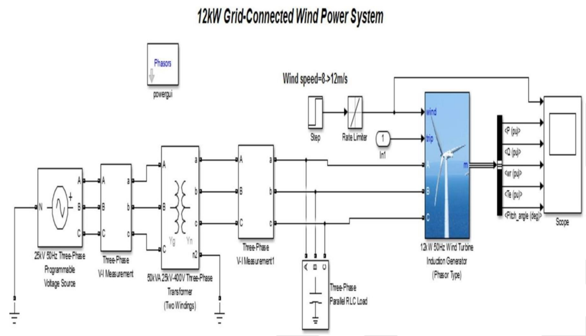



FIG 7: Simulation model of wind power system

**EXPLANATION OF MODEL:**

On to the extreme left, there is a three phase voltage supply which is grid supply at 25kV generating at 50Hz frequency.

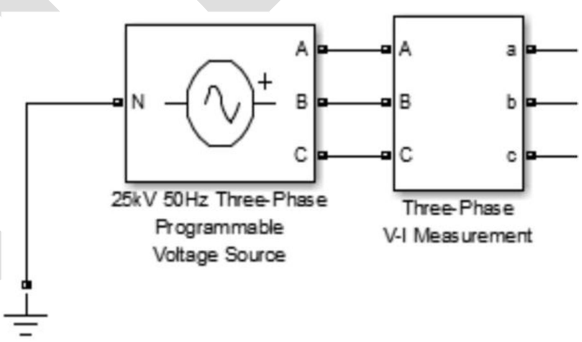



FIG 8: Simulation model of three phase supply

As we move to the right, there is a three phase two winding transformer with alignment. It has rating of 50kVA with primary side at 25kV and secondary side at 400V.

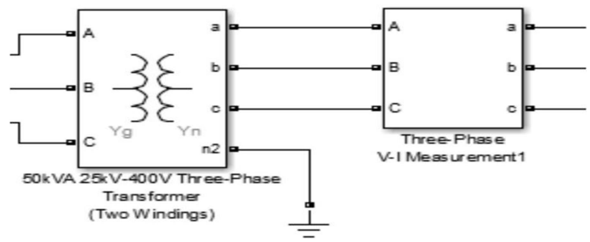



FIG 9: Simulation model of three phase two winding transformer

Then there is a capacitor bank injecting 4kVA to the induction generator of Wind turbine.

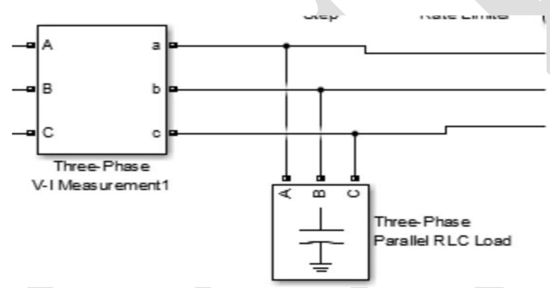



FIG 10: Simulation model of three phase RLC load

Wind turbine model gets input of three phases from grid and wind speed using step block.
The output of wind turbine is viewed using scope block.

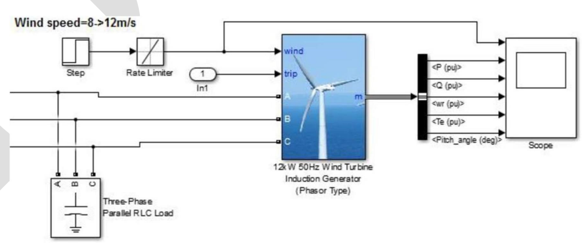
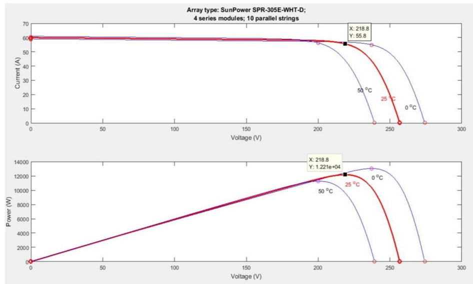



FIG 11: Simulation model of wind turbine

**V. RESULT ANALYSIS**

**A) VI & PV CURVE:**




GRAPH 1: VI & PV CURVES

As mentioned in calculations, the maximum power is 12.21kW at temperature of 25.

Also, notice that as temperature varies from 0 to 50, the power decreases as voltage decreases.

**IRRADIANCE & TEMPERATURE**

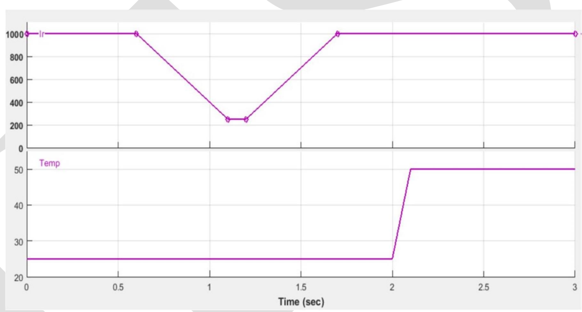



FIG 12: Irradiance & Temperature curve

The irradiance value is changing from 1000 to 250 and back to 250.

The value of temperature rises from 25 to 50.

**$V_{dc}$ IN BOOST CONVERTER**

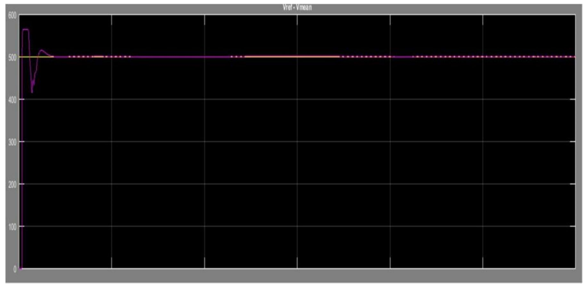


FIG 13: Resultant graph of boost converter

The DC voltage remains 500V after some time of settlement.

**Vab_sc:**

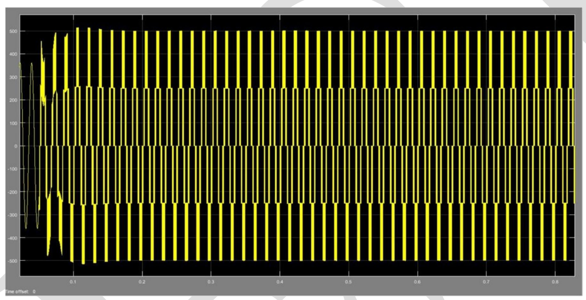


FIG.14: Resultant graph of voltage at inverter

**GRID:**

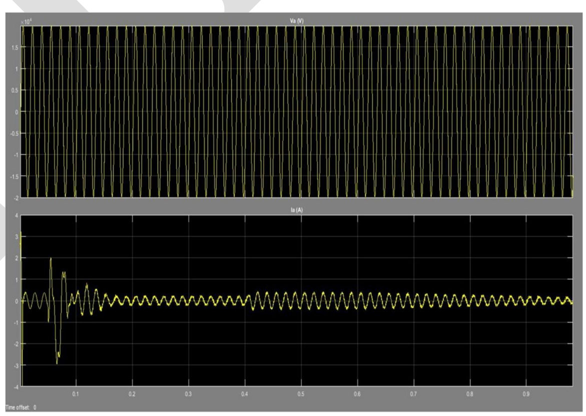


FIG 15: Resultant graph of voltage and current at filter of capacitor bank

Clearly, after passing through filter of capacitor bank, the sinusoid of voltage and current becomes very smooth as compare to the curves after inverter.

**PV:**

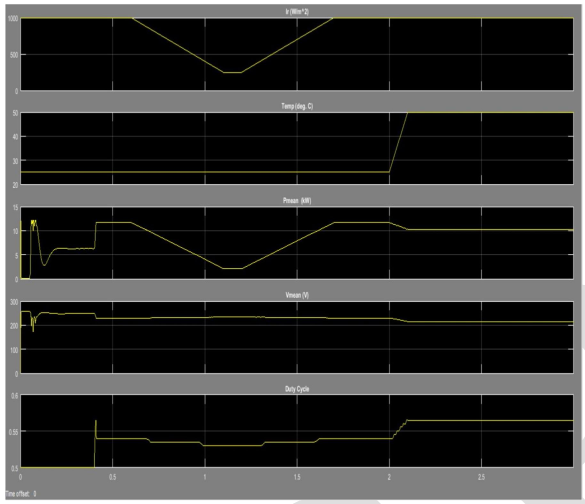



FIG 16: Resultant graphs of irradiance, temperature, Pmean, Vmean, duty cycle.

First graph is of irradiance and it is changing as expected from 1000->250->1000.
Second graph is of temperature and it is changing from 25->50.
Third graph is of Pmean in which till t=0.05s, there is no controller in working due to deblocking. But after that the power goes up towards 12kW. Then it went down and as duty cycle changes the power mean also drops and when $I_r$ rises to 1000W/m2, Pmean again rises.
Fourth graph is of Vmean which changes according to the change in duty cycle graph (fifth graph)

**B) WIND POWER CHARACTERISTICS:**

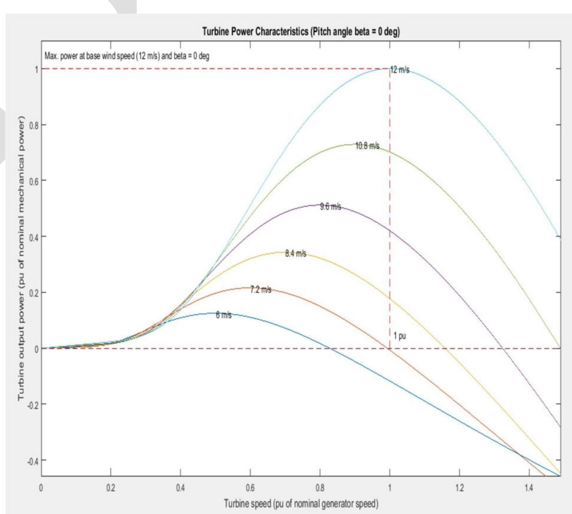


FIG.17: Resultant graph of power output of wind turbine at different speeds of wind

This graph is showing the power output at different speeds of wind. As we have selected wind of 12m/s as nominal, then it shows the maximum power of 1pu (12kW) on a wind speed of 1pu (12m/s).
Power output on other wind speeds is also shown on the graph.

**P, Q, wr, Te, PITCH ANGLE, WIND SPEED:**

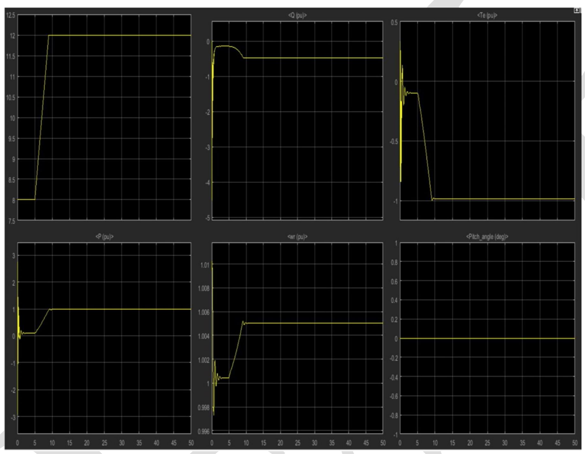


FIG.18: Resultant graphs of wind speed, output power, reactive power, rotor speed, torque and pitch angle

First graph is showing wind speed increasing from 8m/s to 12m/s.
Second graph is of P, which is showing that when wind approach to 12m/s, it gives output power of 1pu or 12kW.
Third graph is giving value of reactive power when wind speed changes.
In fourth graph, the speed of rotor is more than 1pu because it is connected to induction generator and has more speed than 1pu.
Similarly, the fifth graph is giving info about torque.
In sixth graph, the pitch angle remains same.

## CONCLUSION

In this study, we detailed a hybrid energy system that can operate independently, using variable-speed wind production, a solar system, and a power electronic interface. The MATLAB/SIMULINK software package was used for the computer simulations. When operated independently, the system's performance is tested under a range of wind speeds and irradiation levels. Alterations in sun irradiance and wind speeds cause AC voltage to fluctuate. To keep the source and load in equilibrium, a battery system is used. The goal of this technology is to provide enough power to a rural region. We provide the results of evaluating the created system's performance on the MATLAB/SIMULINK platform.

## \FUTURE SCOPE

Energy demand is increasing day by day all over the world. Due to this demand, the reserves of fossil fuels like coal, oil and natural gas are depleting rapidly. To cope up with this unbalancing situation, we should keep more optimistic view about the renewable energy sources. The sources like solar, wind, hydro have the substantial capabilities to compensate for the increasing energy demands. As far as India is concerned about its geographical location, it has the abundant source of solar energy (about 5,000 trillion kWh/year) as well as wind energy (about 300 watt/$m^2$). But both of these energy sources have some disadvantages, to counteract with them, the efficient way to use the sources is by combining them. The technique is called solarwind hybrid energy source. It is an independent source which gives general idea about hybridization of these sources to increase the efficiency.

## REFERENCES

[1] CristianDragosDumitru, and Adrian Gligor, "Modelling and simulation of Renewable Hybrid Power system using MATLAB/SIMULINK Environment.", Scientific Bulletin of the, PetruMaior" vol. 7 (XXIV), No. 2, 2010, ISSN 1841 - 9267 pp.122-125

[2] K.RVenkateswarlu, and J.Krishna Kishore, " Modelling and Simulation of Micro grid System Based on Renewable Power Generation Units by using Multilevel Converter., " International Journal of Engineering Research and Technology, ISSN : 2278 - 0181, vol. 10, Issue 6, August - 2012.pp.1-5

[3] N.Sambasiva Rao, "Design and Simulation of Hybrid Solar - Wind Electric Power System Interface to Grid System, International Journal of Research in Engineering and Advanced Technology, vol.3, Issue 4, August 2013.pp.4107-4116

[4] U.Vinatha, Vittal K P, "Grid Integration of Wind and Photovoltaic Hybrid Energy System, "Journal of Electrical Engineering, National Institute of Technology, Karnataka, Surathkal, India. pp.1-6

[5] F.Valenciaga and P.F. Puleston, "Supervisor Control for a Stand-alone hybrid Generation System using Wind and Photovoltaic Energy" IEEE transactions on energy conversion, vol. 20, No.2, June 2005.pp.197- 207

[6] Chaitanya Marisarla, K.Ravi Kumar, "A Hybrid Wind and Solar Energy System with Battery Energy Storage for an Isolated System, "Journal of Engineering and Innovative Technology, vol.3, Issue 3, September 2013. Pp.99-104.

[7] Cultura A.B, Z.M. Salameh, (2011) "Modelling and simulation of a wind turbine- generator system", IEEE Power and Energy Society General Meeting, pp 1-7

[8] Hasnaoui O B K, J. Belhadj, M.Elleuch, (2006) "Low voltage ride through performances of direct drive permanent magnet synchronous generator wind turbine, "CERE-06, Hammamet, TUNISIA.pp.73-83

[9] Karrari M, Rosehart W, Malik OP. “Comprehensive control strategy for a variable speed cage machine wind generation unit. IEEE Trans Energy Convers 2005; 20(2):415-423

[10] Wai RJ, Lin CY, Chang YR. “Novel maximum power extraction algorithm for PMSG wind generation system. IET Electr Power Appl 2007; 1(2):275-283.

[11] R.Srinivasan, M.Yogaselvi, “Stand-alone Hybrid Wins Solar Power Generation System Applying Advanced Power Control Techniques, "IJAREEIE. Vol.3, Issue 2, April 2014 pp.627636s