Journal of Science and Technology
ISSN: 2456-5660 Volume 4, Issue 3, May-June 2019, PP 14-20
www.jst.org.in

Design and Simulation of PV-Wind Hybrid Energy System

K.Naresh[1], Y.Srinivasa Rao[2]
[1](EEE Department, Usha Rama College of Engineering, Vijayawada. India)
[2](EEE Department, KLEF, Vaddeswaram, Guntur District, India)

Abstract : *PV-Wind hybrid energy system is the most upcoming alternative for power generation in place of fossil fuels generators. This paper will give the mat lab simulation modelling of PV-wind hybrid energy system. The given model will give the key details of each parts of PV-wind hybrid system. In this model there will be parts they are: a photo voltaic energy subsystem wind energy subsystem, a inverter and a battery backup. The photovoltaic energy is converted to AC using inverter and wind energy by turbine, the energy produced is stored in the battery and when necessary it discharges. This hybrid is useful for both industrial and household purposes. This will reduce the dependence on one source because it has multiple sources.*
Keywords: *PV-Wind energy hybrid system, system controller, continuous distribution*

I. Introduction

Now-a-days the availability of fossil fuels getting reduced so some areas are facing the lack of electricity. so to make a change in this areas we are developing the renewable energy source systems which are eco friendly, low maintenance and satisfies the demand [1-2]. In many of the renewable energy source systems very useful one is PV-Wind energy hybrid system. The PV-Wind energy hybrid system is the combination of solar energy and wind energy. solar energy is produced from the sun rays via solar panels but they are less efficient. but we can also increase the efficiency of the solar panels by some methods as increasing volume, using better material in manufacturing of solar panels. wind energy is commonly a large-scale generation unit [3-5]. But we can use it as small-scale unit by some changes. In wind subsystem wind energy is converted into electrical energy using turbine. For meeting some demands this system is containing some extra parts as battery storage, inverter. Battery is for charging and discharging purpose when generation system produces excess energy then the excess energy is stored in the battery. When the generation is not enough for load demand then battery gives the stored energy it is called discharging [6-8]. This operation is done with help of system controller which helps in the prevention of battery over charging and deep discharging. Inverter is used for DC to AC conversion. We use inverter to convert from DC bus load to AC bus load as shown in the fig.1. Many countries with average wind speed in the range of 5-10m/s and average solar insolation level in the range of 3-6kwh/m^2 are pursuing the option of pv and wind system to minimize their dependence on fossil-based non-renewable fuels. The use of hybrid energy system also reduces combustion of fossil fuels and consequent CO2 emission which is the principle cause of greenhouse effect/global warming [9-11]. Other advantages of PV-Wind hybrid system can be achieved only when the system is designed and operated appropriately. The block diagram of PV-Wind hybrid system is shown in fig.1

We can observe three cases in this system depending upon the power generated and load demand in the DC grid. When the power generation and load demand are equal [12-14]. When the load demand exceeds power generation which leads the bus voltage to drop, when power generation exceeds load demand which leads in the rise in bus voltage. The DC bus voltage must be maintained at permissible limits at all the operating conditions as this is considered as the stability index of the grid. The battery plays an important role in this hybrid system in maintaining DC bus voltage and continuous power distribution. Hence a control system is implemented for the current control in the bidirectional buck-boost DC-DC converter of the battery [15].

The main objective of a control system implemented here ensures that load is sharing equally so that the circulating currents between the source can be avoided. The state of charge of batteries must be maintained between certain limits. Such that batteries should not be over charged and should not be deep discharged so that the life time of the battery bank can be increased. Hence the constant monitoring of the state of charge of battery is necessary [16-18].

The paper is organised as follows: Section 2 explanation of different components present in this hybrid system with respective block diagrams. Section 3 Ratings and specification of different components and description of block diagram is given. Section 4 results are shown with respective to the waveform at different time periods are given. Section 5 the conclusion and future scope of this project is given

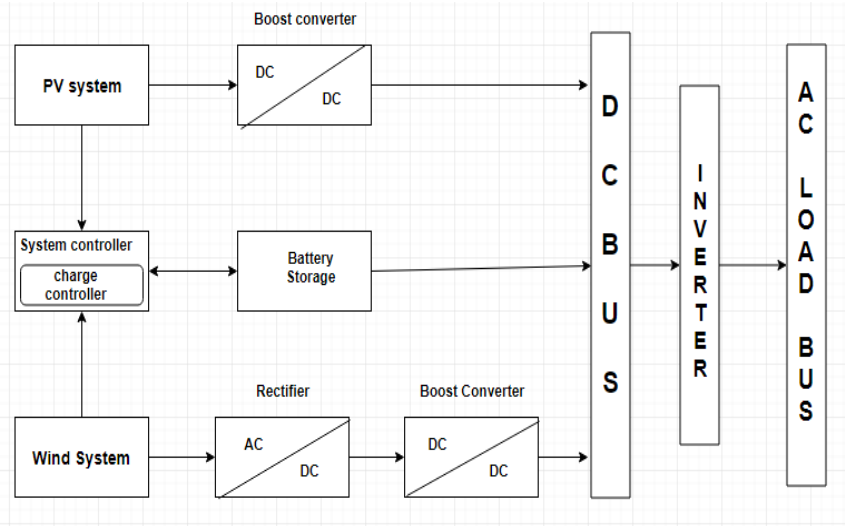

Fig.1. Block Diagram of PV-Wind Hybrid Energy System

II. Explanation of Subsystems

2.1. Photovoltaic subsystem

The photovoltaic subsystem consists of photovoltaic array. Photovoltaic array consists of photovoltaic modules connected in series and parallel according to the requirement of voltage and power ratings. As we know that solar cell less power production unit in this hybrid system to maximise the generation we use the maximum power point technique(MPPT). The output power of the solar cell can be calculated using following equation. The general formula.

$$I_{pv} = I_l - I_d - i_{sh}$$

(1)

The block diagram of photovoltaic subsystem as PV hybrid system with its power electronic components is shown in fig 2.1. It is a system before the combination of PV-Wind hybrid system. This system is used in areas where the power supply through the grid is difficult and transmission cost is very high. The solar cell is very well known power system used for the smale-scale sectors like homes, offices, motor vehicles and e.t.c. But we can also use this system for large-scale distribution by increasing its volume/size and applying suitable methods like Maximum power point technique(MPPT). In the above figure the transmission of power is as follows. Solar cell generates power by observing the UV rays from sun. It produces the DC so we use inverter to convert DC to AC because the load is AC load. Control system is used to maintain that load demand and supply power is always equal. When the generation is excess than demand then the excess power is stored in the storage system battery and when the demand is greater than generation the storage system provides the backup. Here the charge controller is used to avoid the battery form over charging and over discharging by doing this we can increase the life time of the battery.

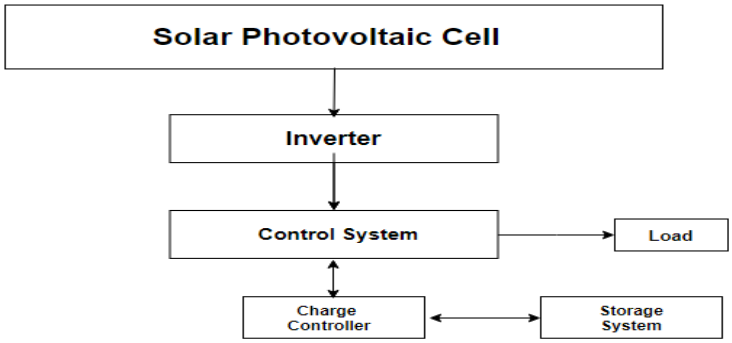

Fig 2.1. Architecture of photovoltaic hybrid system

2.2. Wind Energy Subsystem

To design a reliable and economical wind system a location with a better wind energy potential must be chosen. In addition analysis should be done for feasibility, economical, capacity meeting demands. Generally wind energy systems are used for the large-scale production. So, this system is used in the hybrid system. The architecture of wind hybrid system is shown in fig 2.2 . The power generation of wind system depends upon the speed of the wind. Wind flows through the wind turbines and rotate them then the mechanical energy is converted into electrical energy using turbines. Because of the unexpectable wind speed the generation of energy is unstable it produces the variable AC. So, we use rectifier to convert variable AC to fixed DC but we need a supply so we use converter to convert fixed DC to fixed AC. The control system in this system is having the same working principle as solar system. Charge controller is used to control the charging and discharging of battery to increase the life time of the battery. When the system generated power is surplus, then that excess power is used for loading the batteries. When the load requirement is not supplied by the system then the battery power is used as backup security. The output power of the wind energy system can be calculated using the following equation

$$P_W = \frac{(C_p \lambda A V^3)}{2} \quad (2)$$

Here P_W= output power; C_p= the power co-efficient; λ= the tip speed ratio; A= the frontal area of wind turbine; V= the wind speed.

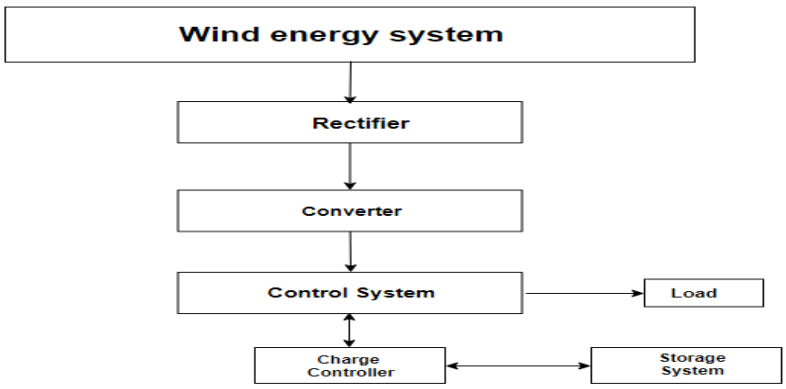

Fig 2.2. Architecture of wind energy hybrid System

2.3. Storage unit

The storage system we used here is battery. We already mentioned that battery is used to store excess power, regulate system voltage and used as backup in case of insufficient power generation from the hybrid system. Battery size depends upon the maximum depth of discharge, temperature, and battery life. A battery state of charge (S_b) is expressed as follows:

Charging process:

$$S_b(t+1) = S_b(t)[1-\sigma(t)] + [I_B(t)\Delta t.\eta_C(t)/C_B] \quad (3)$$

Discharging process:

$$S_b(t+1) = S_b(t)[1-\sigma(t)] - [I_B(t)\Delta t.\eta_D(t)/C_B] \quad (4)$$

In this storage unit we use lithium ion batteries. Depending upon the voltage and power requirements the batteries are connected in series and parallel combination. Li-ion batteries have greater life time than other type of batteries. There are two electrodes in the battery one is positive electrode which is made up of metal oxide and other is negative electrode which is made up of carbon. There will be an electrolyte in between positive and negative electrode which helps in free flowing of positive particles through it and it is made up of lithium salts in organic solvents. In below chemical reaction left side reaction indicates charging and right side reaction indicates discharging.

$$LiC_6 + CoO_2 \leftrightarrow C_6 + LiCoO_2 \quad (5)$$

In this system as shown in fig.1 the battery storage unit is connected to the DC bus pre-connected with system controller. System controller used to transfer power in both directions as per the conditions required. The battery is connected to DC bus with the help of control system this control system is a control strategy to control the charging and discharging of battery. It helps in preventing the battery from over charging and over discharging to increase the life time of the battery.

III. Description and specifications

The ratings and specifications of PV-Wind hybrid system is given in the below table.1:

Table 1. Ratings and Specifications

Components	Specifications	Ratings
Photovoltaic array	Sun Power SPR-305E-WHT-D	40KW
Wind turbine	Permanent magnet synchronous generator-salient pole	10KW

Batteries	Lithium-ion	12KV,150Ah
Load	3-phase Y-connected unity Pf load	30KW

3.1. Description and control of system

In this paper we take hybrid system. Hybrid system means the combination of two or more power generating systems. In this paper we take Pv and wind hybrid system because these two systems work using renewable resources like solar power and wind power. We can get these two resources commonly together and these two are less expensive and less maintenance when compared to the other renewable resource systems like hydro power plants, bio-fuel power plants and other. But less efficient than them but we can use them for some areas where the supply of power from is grid is difficult and transmission cost is high due to fuel generators. In this system we use the combination of photovoltaic and wind hybrid energy system with the battery as storage or backup unit. If the two systems want to connect in parallel the output voltage of the two systems must be same. In case of PV system its output is variable DC and get fixed DC and in case of wind system it generates variable AC because the speed of wind is unpredictable so it generates variable AC here we use rectifier to convert variable AC to DC and boost converter is used to boost the variable DC to fixed DC. This two systems are connected to the DC bus. In this system we can observe two case one is when the source power generation is greater than load demand and other one is when load demand is greater than system generation. If this cases are occurred we face the problem of discontinuous distribution to avoid this problem we add extra unit called storage/backup unit. When the system generates the excess power than load requirement that excess power will store in the battery and when the load demand is greater than power generation then the battery will act as backup power supply by supplying stored energy. To make this operation happen properly we implement a control strategy called system controller. This system controller will detect the condition for charging and discharging and operate the function. The system controller consists of charge controller which helps in the prevention of battery from over charging and over discharging to increase the life time of the battery. In this system we use Li-ion battery as the storage unit. The battery also connects to the DC bus. But the main load is AC load so we convert this DC to AC using inverter. This inverter is connected in between DC bus and AC bus. In this paper we check the performance of the system by adding some temporary load using a switch. Where the switch will turn ON at certain time limit and turn OFF after the time period. When the extra load is added the current waveforms will vary.

IV. Results and Discussion

The performance of this system and capacity and techniques implemented in this is examined by adding the temporary load with switch giving a certain time period to trip and current will vary according to load increment and decrement. The figures shown below are the results of the system this paper proposed with a time periods and different parameters. All these results are taken from the simulation of matlab simulink model. Figures are represented in the two axis plot as x-axis and y-axis.

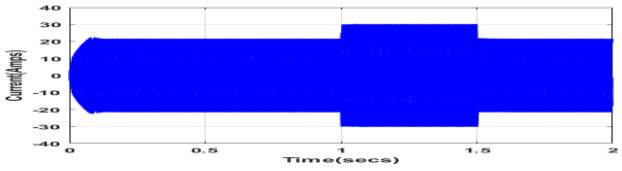

Fig.4.1. output of the current at load and also before and after addition of temporary load

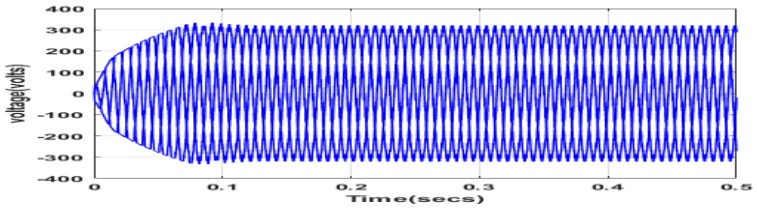

Fig 4.2. output voltage at load

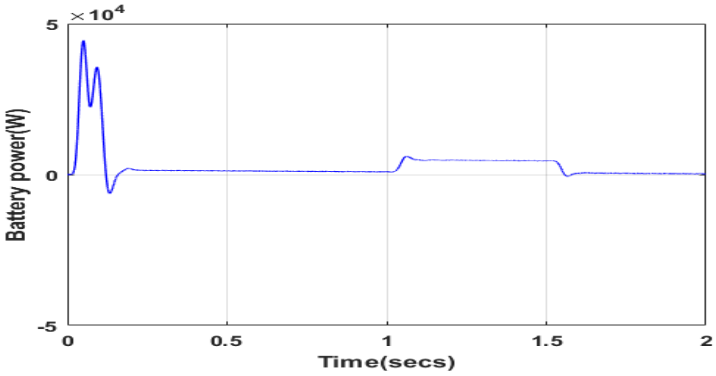

Fig 4.3. Output battery power

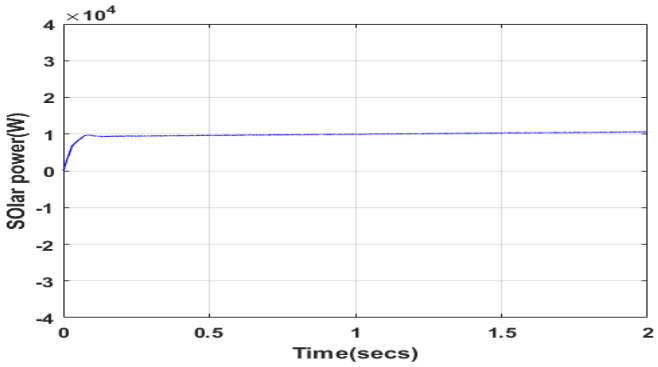

Fig 4.4. Output solar power

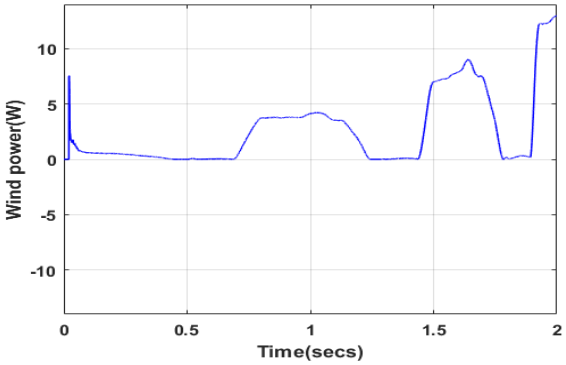

Fig 4.5.Output wind power

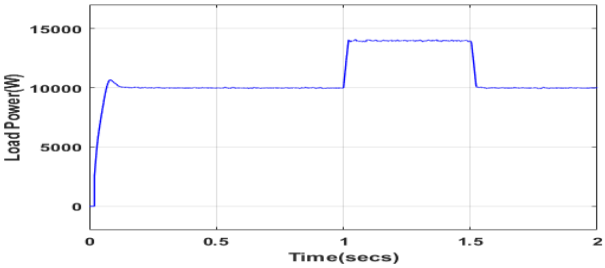

Fig 4.6. Output Load power

V. Conclusion

In this paper simulation, design and features of PV-Wind hybrid energy system is explained. This model gives the various parameter outputs. The integration of Solar PV,wind by an inverter with battery energy storage system make continuous distribution of power to meet the load demand. The system controller has charge controller which prevent the battery overcharging and overdischarging and thus increase the life time of the battery. The power management and control by using an inverter between Solar PV, Wind, Battery and load is shown in this paper which indicate the performance of PV-Wind Hybrid Energy System.

References

[1] "PV-Wind Hybrid System-A review with case study" Authors: Yashwanth sawle, S.C.Gupta and Ashish Kumar Bohre. Available at http://dx.dol.org/10.1080/23311916.2016.1189305. Cogent Engineering.

[2] E.M. Natsheh, member IEEE, Albarbar, member IEEE and J.Yazdani, member IEEE, "smart grid integration of solar/wind energy conversion system".

[3] Title:"performance of modelling of a small-scale wind and solar energy hybrid system". Zhengnan Cao, Fergal O'Rourke,William Lynos. Centre for renewable energy Dundalk institute of technology school of engineering, Ireland, D00142257@student,dkit.ie.

[4] E. Miller, "smart grids – smart idea", Renewable energy focus magazine, vol.10, pp 62-67, Sep – Oct.2009.

[5] Arjun A.K., Athul. S, Mohamed Ayub, Neethu Ramesh and Anith Krishnan, "micro hybrid power systems- Afeasibility study", journal of clean energy Technologies , vol.1, No.1, January 2013, pp 27-32.

[6] http://en.wikipedia.org/wiki/solar_hybrid_power_systems.

[7] B V Rajanna, SVNL Lalitha, Ganta Joga Rao, SK Shrivastava, "Solar Photovoltaic Generators with MPPT and Battery Storage in Microgrids", Vol. 7, pp. 701-712, Sep. 2016.

[8] P. G. Arul, V. K. Ramachandaramurthy, and R. K. Rajkumar, "Control strategies for a hybrid renewable energy system: A review" Renewable and Sustainable Energy Reviews, 42, 597- 608 (2015) DOI: 10.1016/j.rser.2014.10.062

[9] B. Bhandari, K. T. Lee, G. Y. Lee, Y. M. Cho, and S. H. Ahn, "Optimization of hybrid renewable energy power systems: A review" International Journal of Precison Engineering and Manufacturing - Green Technology, 2, 99-112 (2015) DOI: 10.1007/s40684-015-0013-z.

[10] A. A. Ahmed, L. Ran, and J. Bumby, "Simulation and control of a hybrid PV-wind system," Proc. 4th IET International Conference on Power Electronics, Machines and Drives (PEMD 08), pp. 421-425, April (2008) DOI: 10.1049/cp:20080556.

[11] M. F. Almi, M. Arrouf, H. Belmili, S. Boulouma, and B. Bendib, "Energy management of wind/PV and battery hybrid system" International Journal of New Computer Architectures and their Applications (IJNCAA), 4, 30-38 (2014) DOI: 10.17781/P003.

[12] S. Bae and A. Kwasinski, "Dynamic modeling and operation strategy for a microgrid with wind and photovoltaic resources," IEEE Transactions on Smart Grid, 3, 1867-1876 (2012) DOI: 10.1109/TSG.2012.2198498.

[13] N. A. Ahmed, A. K. Al-Othman, and M. R. AlRashidi, "Development of an efficient utility interactive combined wind/photovoltaic/fuel cell power system with MPPT and DC bus voltage regulation" Electric Power Systems Research, 81, 1096-1106 (2011) DOI: 10.1016/j.epsr.2010.12.015.

[14] Y. Huang, Y. Xu, and X. Zhou, "Study on wind-solar hybrid generating system control strategy," International Conference on Multimedia Technology (ICMT 11), IEEE Press, pp. 773- 776, July (2011) DOI: 10.1109/ICMT.2011.6002600.

[15] F. O. Resende and J. A. P. Lopes, "Management and control systems for large scale integration of renewable energy sources into the electrical networks," Proc. IEEE International Conference Smart Science Vol. 3, No. 3, pp. 127-138(2015) Smart Science 136 on Computer as a Tool (EUROCON 11), IEEE Press, pp. 1-6, April (2011) DOI: 10.1109/EUROCON.2011.5929423.

[16] M. Dali, J. Belhadj, and X. Roboam, "Hybrid solar-wind system with battery storage operating in grid-connected and standalone mode: Control and energy management - Experimental investigation" Energy, 35, 2587-2595 (2010) DOI: 10.1016/j.energy.2010.03.005.

[17] H. Ghoddami, M. B. Delghavi, and A. Yazdani, "An integrated wind-photovoltaic-battery system with reduced powerelectronic interface and fast control for grid-tied and off-grid applications" Renewable Energy, 45, 128-137 (2012) DOI: 10.1016/j.renene.2012.02.016.

[18] N. J. Mhusa, G. N. Nyakoe, and E. V. Mgaya, “Power management in photovoltaic-wind hybrid system based on artificial intelligence” Journal of Multidisciplinary Engineering Science and Technology, 2, 140-148 (2015).