Hartej Singh Saini, Harinder Singh Sandhu / International Journal of Engineering Research and Applications (IJERA) ISSN: 2248-9622 www.ijera.com
Vol. 3, Issue 3, May-Jun 2013, pp.327-330

Performance Analysis of Hybrid Model of Wind Mill, Photovoltaic Cell and Fuel Cell

Harinder Singh Sandhu,Hartej Singh Saini

Abstract

In society to ensure the quality of life the energy is an essential requirement. According to increase demand of energy in world the science is developing the different energy generation systems, which can supply energy to the world under economic and environmental friendly conditions. . Sources have increased interest in renewable energy sources. Many societies across the world in which we live have developed a large appetite for electrical energy. In this research paper the three conventional energy forms i.e. wind energy, photovoltaic cell and fuel cell are combined together for the economic operation of energy generation.

Keywords:-Hybrid system, wind energy, photovoltaic cell, fuel cell.

I. INTRODUCTION

Hybrid power systems combine two or more energy conversion devices, or two or more fuel for the same device, that when integrate overcome limitation inherent in either. A hybrids programme can create market opportunities for emerging technologies before they are mature, achieving higher reliability can be accomplished with redundant technologies and /or energy storage. Some hybrid systems typically include both, which can simultaneously improve the quality and availability of power. Although the energy of sun and wind has been used by mankind for millennia modern applications of renewable energy technologies have been under serious development for only about 20 years. Hybrid systems are more economic, reliable and fuel efficient systems.

II. HYBRID POWER SYSTEM

Solar /Wind hybrid power system

The escalation in electrical energy costs associated with fossil and nuclear fuels, and enhanced public awareness of potential environmental impacts of conventional energy systems has created an increased interest in the development and utilization of alternate sources [1]. Photo voltaic and wind energy are being increasable recognized as cost effective generation sources in small isolated power systems. A realistic cost benefit analysis requires evaluation models that recognize the highly erratic nature of these energy sources while maintaining the chronology and inter dependence of the random Variables inherent in them. The renewable energy sources are environmentally friendly and use primary energy carriers like solar, wind and water flow, biogas, biomass etc. The sources mentioned above can be split into two groups: controlled sources and uncontrolled sources [2]. As controlled sources authors mean primary energy sources giving possibility to control electrical power production, for example coal. It is obvious that power production of uncontrolled sources is unpredictable and human independent. Solar and wind power plants are uncontrolled sources. Wind, Solar PV and Biomass power generations are viable options for future power generation. Besides being pollution free, they are free of recurring costs. They also offer power supply solutions for remote areas, not accessible by the grid supply. Today, around 30,000 wind turbines and more than 1, 00,000 off-grid Solar PV systems are installed all over the world.

The Solar/Wind hybrid system block diagram is shown in the figure below:

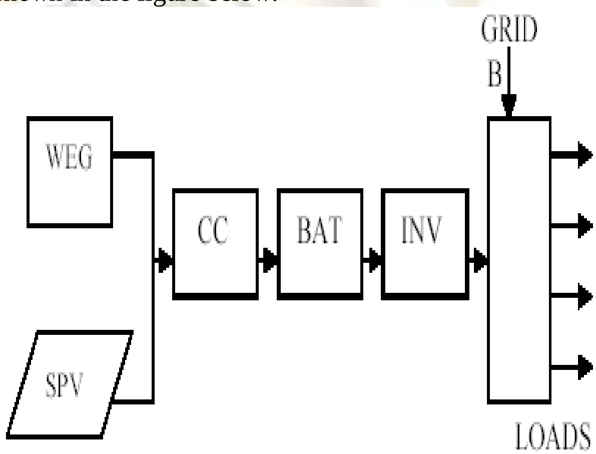

Figure 1: Block diagram of Wind / SPV Hybrid energy system

Where,
WEG = wind energy generator
SPV = solar photovoltaic panels
CC = power conditioning units
BAT = battery banks
INV = inverter

In this system solar power(PV) unit and wind power unit output is connected to a common output bus .the combined output of te both power units are send to power conditioning unit ,the conditioning unit regulatyes the power .mow the power is stored im battery umits for future work and for supplying to the load the battery stored dc power is converted into the ac power by using inverter[3].

Wind/PV/Fuel Cell hybrid power system

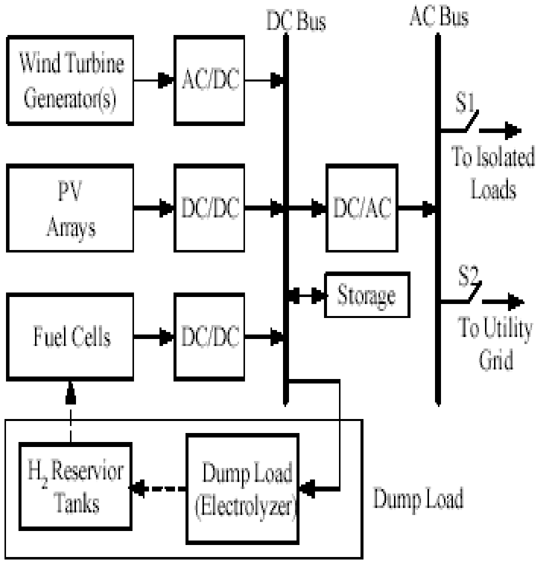

Figure 2: Functional View of Wind/ SPV/ Fuse cell system

The wind /PV/fuel cell hybrid power system is a improved model of the wind /PV hybrid power system .in this system one new energy conversion device fuel cell is added to the system .by adding the fuel cell in the hybrid model increase the efficiency of the hybrid power system ,now the output of the wind turbine ,PV solar cell and fuel cell is connected to an common dc bus ,the output of all the power units are converted into dc before connecting it dc bus .the supply to the dump load of fuel cell is also supplied from the dc bus .a storage unit of batteries is used with the dc bus for storing the power ,for supplying the dc power to load or grid ,dc to ac converter is used .the output of the dc to ac converter is send to the ac bus and from ac bus the supply is send to the load and grid[4].

III. POWER OUTPUT FROM HYBRID SYSTEM USING SIMULATION TOOL MATLAB

Solar photovoltaic cell

The solar cell is the basic building of the PV power system it produces about 1 W of power. To obtain high power, numerous such cell are connected in series and parallel circuits on a panel (module), the solar array or panel is a group of a several modules electrically connected in series parallel combination to generate the required current and voltage[4]. The electrical characteristics of the PV module are generally represented by the current vs. voltage (I-V) and the current vs. power (P-V) curves. Figs. and show the (IV) and (P-V) characteristics of the used photovoltaic module at different solar illumination intensities.

The I– V characteristic of the PV module are

$$I = IL - I0\ (e^{q(V + IRS)/nkT} - 1) \quad (1)$$

Where IL = photo current
I0 = diode saturation current
RS = series current
q = charge of electron
k = constant
T = temperature
N = number of PV module

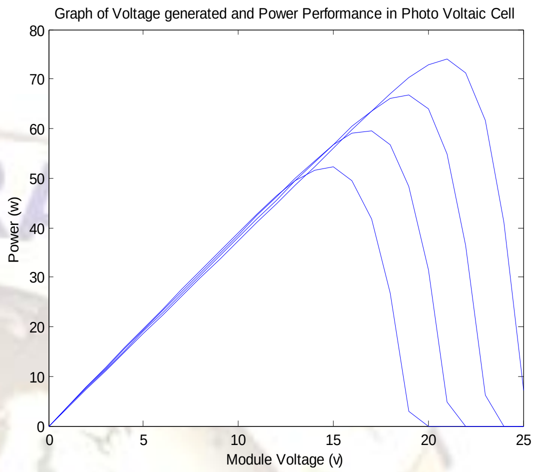

Figure 3: Output Power (W) vs Module Voltage (V) From Hybrid System Using Simulation

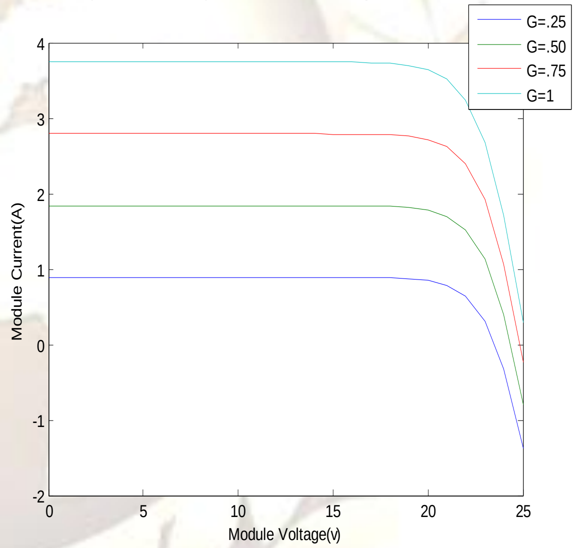

Figure 4: Output Module Current (A) vs Module voltage (V)

Wind energy system

The wind turbine captures the wind's kinetic energy in a rotor consisting of two or more blades mechanically coupled to an electrical to be used for system control. The fundamental equation governing the mechanical power capture of the wind turbine rotor blades, which drives the electrical generator, is given by:

Pwin (t) = 1/2 *ℓ*A*V (t) ^ 3* Cp* Effad (2)

Were ℓ = air density (kg/m^3)
A = area swept of rotar (m^2)
V = wind speed (m/s)

Effad = efficiency of the AC/DC Converter

The theoretical maximum value of the power coefficient Cpis 0.59 and it is often expressed as function of the rotor tip-speed to wind-speed ratio (*TSR*). *TSR* is defined as the linear speed of the rotor to the wind speed.

TSR =ω□*R/V*(3)

Where *R* and ω□ are the turbine radius and the angular speed, respectively. Whatever maximum value is attainable with a given wind turbine, it must be maintained constant at that value for the efficient capture of maximum wind power.

Power is directly proportional to wind speed, as the wind speed increases the power delivered by a wind turbine also increases. If wind speed is between the rated wind speed and the furling speed of the wind turbine, the power output will be equal to the rated power of the turbine. Finally, if the wind speed is less than the cut-in speed or greater than the furling speed there will be no output power from the turbine.

The graph for power generated by a wind turbine for different value of Cp is shown below.

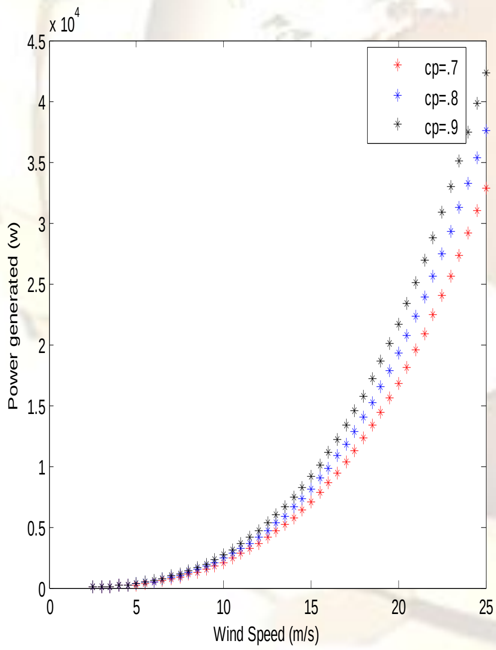

Figure 5: Power output of Wind energy system

Power output of the fuel cell

The power output of the fuel cell is shown in the graph. The fuel cell used in the present SOFC (solid oxide fuel cell), the following fuel cell is used because of it following advantages operate at higher temperature, which reduces the need for expensive precious metals (such as platinum) to increase their electrical efficiency.

1. Can operate on a number of different hydrocarbon fuels,
2. Better start up time.
3. High electrical efficiency (70%)
4. Near zero emission and quite operation with little maintenance cost.

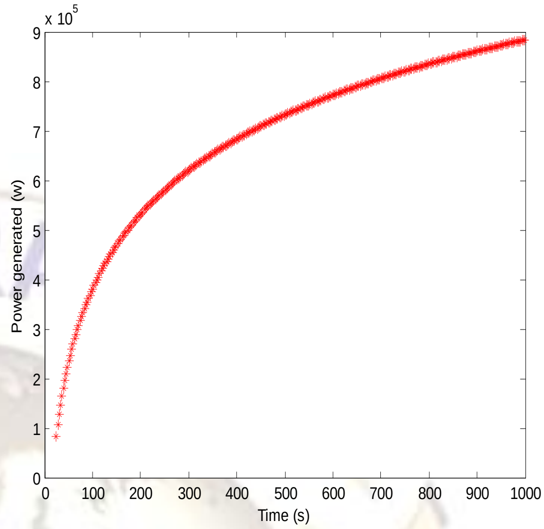

Figure 6: Power output of fuel cell

The graph shows the voltage response of the FC, initially voltage is low until the current reaches a relative high level, the voltage reaches the peak just pass 1000s, and then starts to drop, and this is typical of FCs and has to do with irreversibility when current reaches certain level[5].

Neglecting the ohmic losses the total power generated by the FC (Pfc) is

Pfc =NoVI (4)

Were no = number of fuel cell

V = stack voltage

I = stack current

The total output power delivered can be increased by increasing the number of fuel cell; the power delivered by each fuel cell is different as the chemical reaction which makes chemical energy of fuel into electrical energy is different in each fuel cell[6].

IV. COMBINE POWER OUTPUT

Combine power output power from a Wind and a PVmodule

The total wind- and PV-generated power during each hour is first computed as follows:

$$P_{Gen}(t) = P_{Wind}(t) + N_{PV} \times P_{PV}(t)$$

Where NPVis the number of PV panels, and PWind(t) is the power from the wind at time T[7][8].

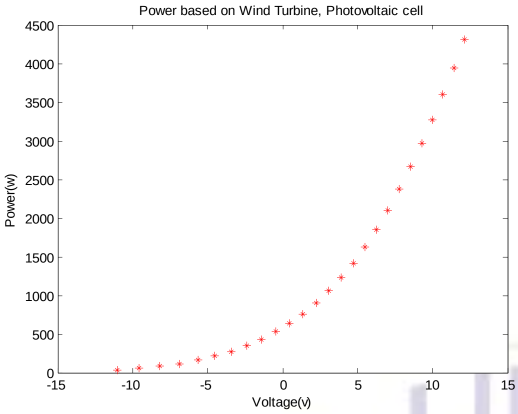

Figure 7: Combine power output power from a Wind and a PV module

Combine power output power from a Wind /PV module/fuel cell

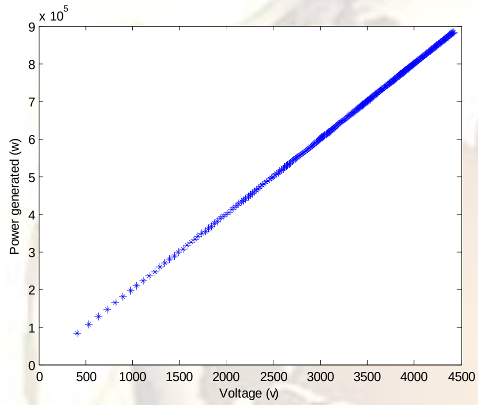

Figure 8: Combine power output power from a Wind /PV module/fuel cell

The graph here shows a linear variation which means the power delivered by the system increases as we increase the voltage to the system, more over its easy to find out the power delivered by the system to a particular voltage as the graph here is a linear one[9].

V. CONCLUSION

In this paper the hybrid model of wind/pv solar cell is improved by adding the fuel cell in the hybrid model .the power output of the new hybrid model of wind/pv solar cell/fuel cell si shown by using simulation tool .the output graph shows that the power output of new hybrid model is higher and more efficient the power output of the wind/pv hybrid model

REFERENCES

[1] J. BhagwanReddey, D.N. Reddy "Probablistic Performance Assessment of a Roof Top Wind, Solar Photo Voltaic Hybrid Energy System".

[2] Stanley R. Bull, "Renewable Energy Today and Tomorrow", Proceedings of the IEEE, Vol. 89, No. 8 August 2001.

[3] R. Chedid& H. Akiki, "A decision Support Technique for the Design of Hybrid Solar-Wind Power System", IEEE Transaction of Energy Conversion Vol. 13, No.1, March 1998.

[4] D.B. Nelson, M.H. Nehrir and C. Wang, "Unit Sizing of Stand – Alone Hybrid Wind/PV/Fuel Cell Power Generation System".

[5] M.A. Laughton, "Fuel Cells", Engineering Science and Education Journal, February 2002

[6] Jegerson M. Correa, Felix A. Farret, Jonas R. Gonos and Marcelo Godoy Simoes, "Simulation of Fuel Cell Stacks using a Computer – Controlled Power Rectifier with the Purposes of Actual High-Power Injection Applications", IEEE Transaction on Industry Application, Vo.39,No.4,July/August 2003

[7] JozefPaska, Piot&Biczel, MariuszKlos, "Experience with Hybrid Power Generating System".

[8] Dr. RecayiPecen, Dr. MD Salim&AyhanZora, "A Lab View Based Instrument System for a Wind-solar Hybrid Power Station," Vol 20, No-3 June 2004 through August 2004

[9] KourashSedghisigarchi& Ali Fellachi, "Impact of Fuel Cells on Load – Frequency Control in Power Distribution Systems", IEEE Transaction of Energy Conversion Vol. 21, No.1, March 2006.

.

VI. AUTHOR'S PROFILE

Er.HartejSinghSaini is a Technical graduate in Electrical and Electronics Engg and pursing post graduation in Electrical Engg. The area of interest of the author is Control system, Non conventional energy sources and load flow analysis.

Er.Harinder Singh Sandhu is a Assistant Professor in the ADESH Group, Faridkot.He is technical graduate and post graduate in the Electrical Engineering. The area of interest of the author is Non conventional energy sources and Load flow analysis.