"Design and Implementation of PV, Wind and Fuel Cell Based Hybrid Power Generation System"

Ravindra Kumar(Mtech:Power System and Control)[1], Mr Deman Kosale (Asst. Professor)[2]
[12]*Electrical Engineering, Vishwavidyalaya Engineering College, Lakhanpur, Ambikapur (C.G.) India.*

Abstract- Now a day's electricity is most needed facility for the human being. All the conventional energy resources are depleting day by day. So we have to shift from conventional to non-conventional energy resources. In this the combination of two energy resources is takes place i.e. Fuel cell wind and solar energy. This process reviles the sustainable energy resources without damaging the nature. We can give uninterrupted power by using hybrid energy system. Basically this system involves the integration of two energy system that will give continuous power. Solar panels are used for converting solar energy and wind turbines are used for converting wind energy into electricity. This electrical power can utilize for various purpose. Generation of electricity will be takes place at affordable cost. This paper deals with the generation of electricity by using two sources combine which leads to generate electricity with affordable cost without damaging the nature balance.

Keywords- Socio –Economic development, Nigeria, Hybrid system, Solar and Wind Power, Rural Communities ICT infrastructure, Simulation

I. INTRODUCTION

Electricity is most needed for our day to day life. There are two ways of electricity generation either by conventional energy resources or by non-conventional energy resources. Electrical energy demand increases in word so to fulfill demand we have to generate electrical energy. Now a day's electrical energy is generated by the conventional energy resources like coal, diesel, and nuclear etc. The main drawback of these sources is that it produces waste like ash in coal power plant, nuclear waste in nuclear power plant and taking care of this wastage is very costly. And it also damages he nature. The nuclear waste is very harmful to human being also. The conventional energy resources are depleting day by day. Soon it will be completely vanishes from the earth so we have to find another way to generate electricity. The new source should be reliable, pollution free and economical. The non-conventional energy resources should be good alternative energy resources for the conventional energy resources. There are many non-conventional energy resources like geothermal, tidal, wind, solar etc. the tidal energy has drawbacks like it can only implemented on sea shores. While geothermal energy needs very lager step to extract heat from earth. Solar and wind are easily available in all condition. The non-conventional energy resources like solar, wind can be good alternative source.

II. HYBRID ENERGY SYSTEM

Hybrid energy system is the mixture of two electricity sources for giving electricity to the load. In other phrase it can described as "Energy machine which is fabricated or designed to extract electricity by means of using two energy sources is referred to as as the hybrid electricity system." Hybrid strength gadget has good reliability, efficiency, much less emission, and lower cost. In this proposed system photo voltaic and wind energy is used for generating power. Solar and wind has right advantages than other than any different non-conventional energy sources. Both the power sources have greater availability in all areas. It needs lower cost. There is no need to find different place to set up this machine [2].

Solar Energy:

Solar strength is that strength which is gets by means of the radiation of the sun. Solar energy is existing on the earth continually and in considerable manner. Solar strength is freely available. It doesn't produce any gases that suggest it is pollution free. It is low priced in cost. It has low upkeep cost. Only problem with solar gadget it cannot produce strength in bad weather condition. But it has higher efficiency than other strength sources. It solely want preliminary investment. It has long lifestyles span and has decrease emission.

B. Wind Energy:

Wind strength is the electricity which is extracted from wind. For extraction we use wind mill. Ii is renewable power sources. The wind strength desires much less cost for era of electricity. Maintenance fee is additionally less for wind energy system. Wind energy is existing almost 24 hours of the day. It has less emission. Initial value is additionally much less of the system. Generation of electricity from wind is depend upon the velocity of wind flowing.

C. Fuel cell technology:

Fuel mobile technological know-how can belong to either of the above categories. If the hydrogen gasoline wished to energy the gasoline cellphone is generated from a renewable source, the gasoline cell electricity generating unit is considered a renewable electricity technology. two i.e., wind and photo voltaic strength used to generate hydrogen to gasoline a gasoline phone stack. On the contrary, if hydrogen is produced from a fossil gasoline supply (e.g., herbal fuel or methane), the gas telephone is viewed a nonrenewable electricity technology. Through careful design, chosen fossil

fuel pushed DGs can two be constructed to oxidize some of the fossil fuel (by combining with oxygen) to produce heat. Such operation modes, whether in electromechanical (rotational) or electrochemical (fuel cell) systems, are referred to as mixed warmness and electricity (CHP) operation mode. two two

III. PROBLEM IDENTIFICATION & MOTIVATION

The main dangers of using unbiased renewable power assets are that unavailability of electricity for all time. For overcoming this we use photo voltaic and wind power together. So that any one source of power fails other will take care of the generation. In this proposed gadget we can use each sources combine. Another way is that we can use any one supply and keep every other source as a stand by using unit. This will leads to continuity of generation. This will make device reliable. The primary negative aspects of this gadget are that it desires excessive preliminary cost. Except that it is reliable, it has much less emission. Maintains cost is less. Life span of this machine is more. Efficiency is greater A fundamental gain of this system is that it offers non-stop energy provide [5].

IV. OBJECTIVES OF THE HYBRID SYSTEM

The main objective of the thesis is to design and assess the performance of a wind-solar fuel cell hybrid system for electricity generation at a chosen location in India.

Specific Objectives:

- Discuss energy market in India
- Discuss problems of energy sector and need for renewable energy in India.
- Study the Wind – Solar and fuel cell potential in different geographical locations in India by analyzing data from different sources.
- Design a wind – solar and fuel cell hybrid system for a selected suitable location.
- Economic analysis of the wind-solar hybrid power generation system.

V. DESIGN OF PROPOSED HYBRID ENERGY SYSTEM (WIND-SOLAR FUEL CELL)

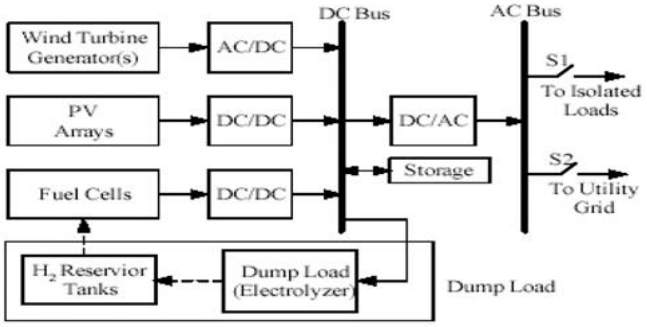


Fig.1: wind -solar and fuel cell.

a. PROPOSED CALCULATION

- **PHOTOVOLTAIC SYSTEM:**

The photoelectric effect was first noted by French physicist Edmund Becquerel in 1839. He proposed that certain materials have property of producing small a mounts of electric current when exposed to sunlight. In 1905, Albert Einstein explained the nature of light and the photoelectric effect which has become the basic principle for photovoltaic technology. In 1954 the first photovoltaic module was built by Bell Laboratories.

Photovoltaic arrangements Photovoltaic cell:

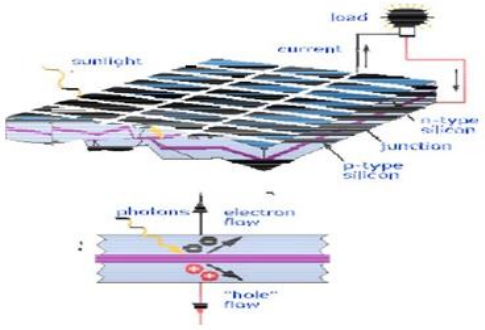


Fig.2: Basic structure of PV cell.

- **Photovoltaic array**

A photovoltaic array (PV system) is an interconnection of modules which in turn is made up of many PV cells in sequence or parallel. The strength produced by means of single module is now not sufficient to meet the requirements of business applications, so modules are related to form array to supply the load. In an array the connection of the modules is same as that of cells in a module. The modules in a PV array are generally first related in collection to obtain the favored voltages; the character modules are then linked in parallel to allow the device to produce more current. In urban uses, usually the arrays are mounted on a rooftop. PV array output can at once feed to a DC motor in agricultural purposes [7-8-9].

- **WINDENERGY:**

Windenergyisaconvertedformofsolarenergywhichisproducedb ythenuclear fusion of hydrogen (H) into helium (He) in its core. The H and He fusion process creates heat and electromagnetic radiation streams out from the sun into space in all directions. Though only a small portion of solar radiation is intercepted by the earth, it provides almost all of earth's energyneeds [10].

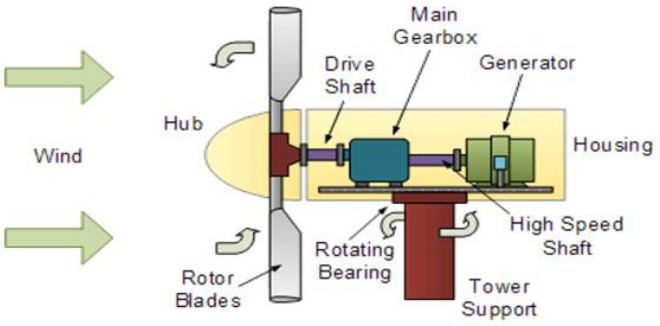


Fig.3: Wind based power generation.

Wind results from the movement of air due to atmospheric pressure gradients. Wind flows from regions of higher pressure to regions of lower pressure. The larger the atmospheric pressure gradient, the higher the wind speed and thus, the greater the wind power that can be captured from the wind by means of wind energy-converting machinery. The generation and movement of wind are complicated due to a number of factors. Among them, the most important factors are uneven solar heating, the Coriolis Effect due to the earth's self-rotation, and local geographical conditions

- **WIND ENERGYCHARACTERISTICS:**

Windenergyisaspecialformofkineticenergyinairasitflows.Wind energy can be either converted into electrical energy by power converting machines or directly used for pumping water, sailing ships, or grinding gain.

- **Windpower:**

Kineticenergyexistswheneveranobjectofagivenmassisinmotion withatranslational or rotational speed. When air is in motion, the kinetic energy in moving air can be determined as-

$$E_k = \frac{1}{2} m\bar{u}^2 \quad \text{..... (1)}$$

- **Turbine power output :**

PT = ½ * ρ * A * v 3 *

Where *m* is the air mass and *u*– is the mean wind speed over a suitable time period, **Cp = 16/27**. The wind power can be obtained by differentiating the kinetic energy in wind with respect to time, i.e.:

$$P_w = \frac{dE_k}{dt} = \frac{1}{2}\dot{m}\bar{u}^2 \quad \text{..... (2)}$$

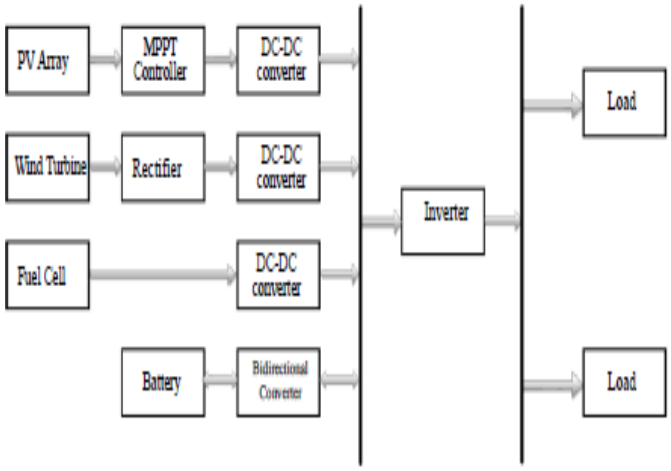
However, only a small portion of wind power can be converted into electrical power. When wind passes through a wind turbine and drives blades to rotate, the corresponding wind mass flow rate is

$$\dot{m} = \rho A \bar{u} \quad \text{..... (3)}$$

Where *r* is the air density and *A* is the swept area of blades. Substituting (3) into (2), the available power in wind *P* w can be expressed as

$$P_w = \frac{1}{2}\rho A \bar{u}^3 \quad \text{..... (4)}$$

An examination of eqn (4) reveals that in order to obtain a higher wind power, it requires a higher wind speed, a longer length of blades for gaining a larger swept area, and a higher air density. Because the wind power output is proportional to the cubic power of the mean wind speed, a small variation in wind speed can result in a large change in wind power.



- **FUEL CELLS WORKING PRINCIPLE:**

The structure and the functioning of a fuel cell are similar to that of a battery except that the fuel can be continuously fed into the cell. The physical structure of a fuel cell consists of two porous electrodes (anode and cathode) and an electrolyte layer in the middle. The Schematic of individual fuel cell is shown in figure 5.3 shows the basic workings of a fuel cell with positive ion flow through the electrolyte, which is based on electrochemical principles. Hydrogen and oxygen molecules combine to form water. The process is By breaking the hydrogen molecules to electrons and positive ions (protons), with the help of a catalyst to facilitate faster reaction, the protons move from the cathode to anode through the membrane (electrolyte), but the electrons cannot.

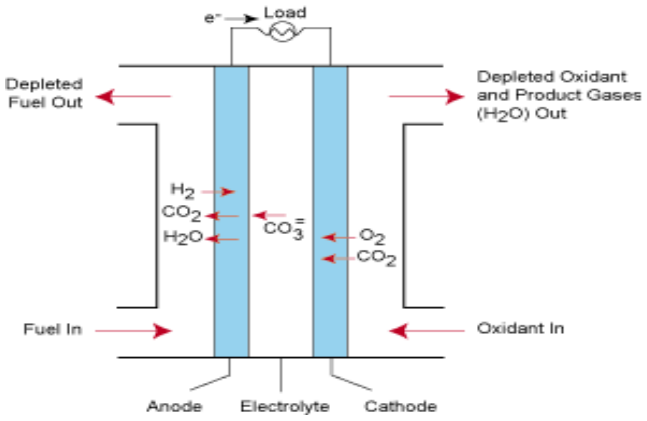


Fig.4: Working Principle in fuel cell.

The electrons travel through an external electrical circuit (load) to recombine with the hydrogen protons and oxygen molecules at the cathode (again, with the help of the catalyst) to produce water. The actual chemical reaction inside a hydrogen fuel cell can be broken down into two half reactions, the oxidation half reaction and the reduction half reaction.

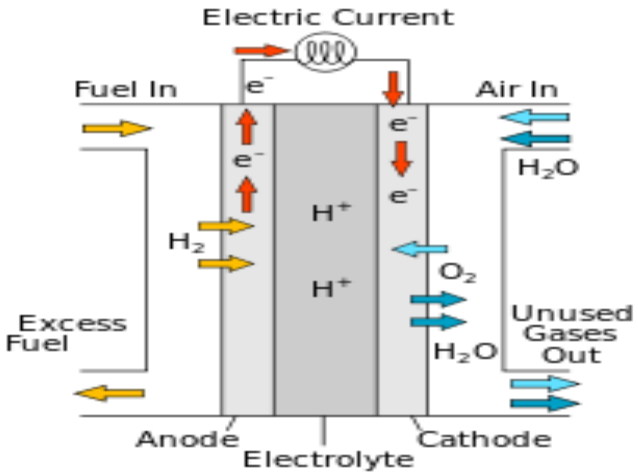


Fig.5: Current generation.

- **Battery Storage Back-up Unit:**

The battery energy storage system is in the form of electrochemical and is most widely used for energy storage purpose in variety of applications. For obtaining the mathematical model calculations for observing the performance, the configuration of battery is represented in 8 by its equivalent electrical circuit.

- **Inverter:**

Inverter is a electronic system, converters direct current into alternating current, i.e. DC into AC. The stored electrical energy in the batteries is DC in nature. And it cannot utilized for various kinds of load. So, for delivering AC supply to the load inverter system is required. Inverter is either analog or digital kind. Digital inverter is microcontroller based which increase the buildup cost of the system also, is uses MOSFET technology providing more efficiency. But, considering the financial aspect and resolution the proposed project designs and build the inverter analog in nature.

Fig.6: MPPT Techniques Solar PV System.

- **MPPT Techniques**:

We know, the Maximum Power Transfer Theorem tells that the output strength of a circuit is maximum, when the Thevenins impedance of a circuit i.e. the source impedance suits with the load impedance and complicated conjugate to it. So, MPPT trouble is one variety of impedance matching problem. Solar cells have a very complex relationship between solar irradiation, temperature and the whole resistance that develops a non-linear output efficiency which can be analyzed primarily based on the I-V curve. So the foremost characteristic of MPPT is to sample the output of the cells and observe the ideal load to obtain the maximum strength for any given location, time, season and environmental conditions. The MPPT no longer solely permits an increase in the strength delivered from the PV module to the load, however additionally enhances the working lifetime of the PV system.There are a number of MPPT approach exists in order to maximizing the output power. The existing techniques are a) Perturb and remark method.

b) Incremental conductance method.

c) Parasitic capacitance method.

d) Voltage based peak power tracking method.

e) Current based peak power tracking method.

FAULT DETECTION & ITS EFFECT

The monitoring and everyday performance supervision on the functioning of grid-connected hybrid structures is quintessential to make sure an optimum strength harvesting and reliable strength production. The improvement of diagnostic techniques for fault detection in the hybrid systems conduct is particularly important nowadays due to the growth diploma of grid related hybrid structures and the want to optimize their reliability and performance. Based on the results of unique diagnoses, a fault detection gadget can offer quick and desirable preservation recommendation that radically simplifies the servicing and renovation of hybrid structures [13]. Several researches [14] have been carried out, using climate facts from satellites statement to generate the essential local weather facts at the desired location. This is a reasonably priced approach, for the reason that no local weather sensors are wished on the plant, though it offers low accuracy in estimation of anticipated electricity yield in some

particular climatic conditions [15]. Solar-wind -fuel telephone hybrid strength systems wants only initial investment. It will compete well in generation with the conventional power sources

VI. RESULT AND SIMULATION

Solar, Wind, Fuel cell input parameter:

Input parameters	**value**
Temperature/Irradiation	1000
Per panel voltage	666v
MPPT Power	$3X10^4$
V_{ocv}	406v
Wind speed	12p
Wind generation voltage	$2.3x10^4$
Mean transient time	T<0.2s

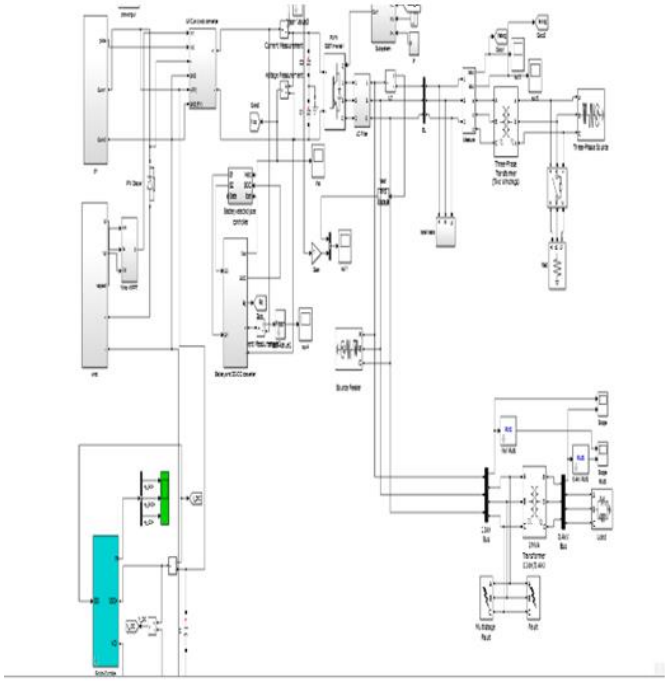


Fig.7: Simulink modelling.

Fig 7 this is shows of hybrid modelling of Simulink in matlab 2015a.This model to connecting a faulty grid consist of Single and multistage fault.

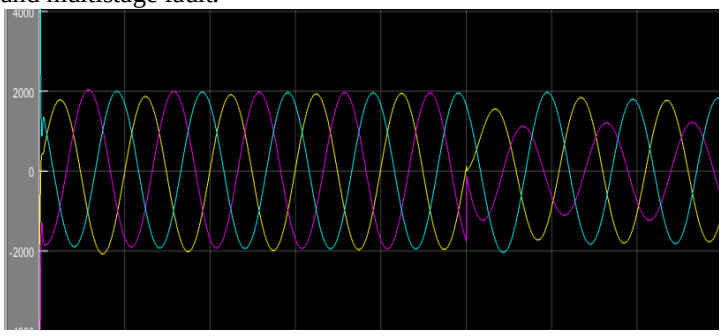


Fig.8: V_{abc} Voltage Waveforms.

Fig 8 show by a three phase voltage (Vabc) wave form of faulty grid connected hybrid system. This is show without any distortion of THD in three phase voltage outcome.

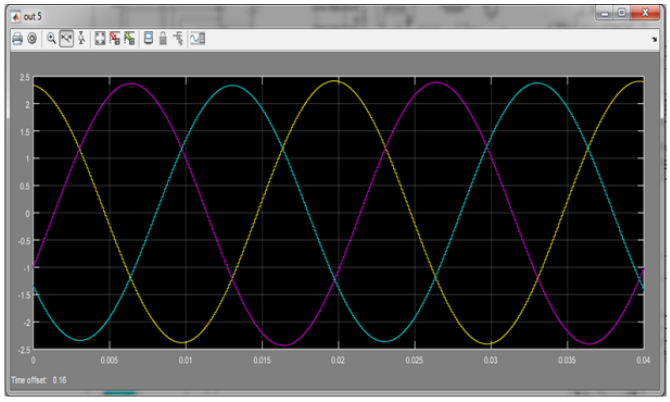


Fig.9: fault detection hybrid systems fault Effects.

Fig 9 show by a three phase current (Iabc) wave form of faulty grid connected hybrid system. This is show without any distortion of THD in three phase voltage outcome.

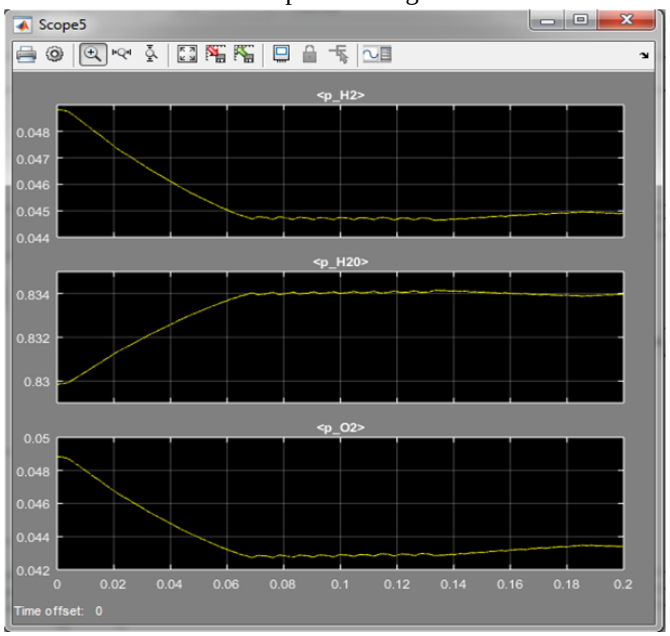


Fig.10: fuel cell H_2, O2 H2O gradient.

Fig 10 show by fuel cell chemical gradient of the power generation across the all over grid.The oxidation half reaction, represented by (1), shows the dissociation of hydrogen molecules to protons and electrons at the anode. After the dissociation, the protons are free and pass through the electrolyte, and recombine with the electrons (which move through the external circuit) at the cathode. In this process, which is often called the reduction half reaction, the electrons

and hydrogen protons combine with the oxygen molecules from the surrounding air, according to (2), to form water.

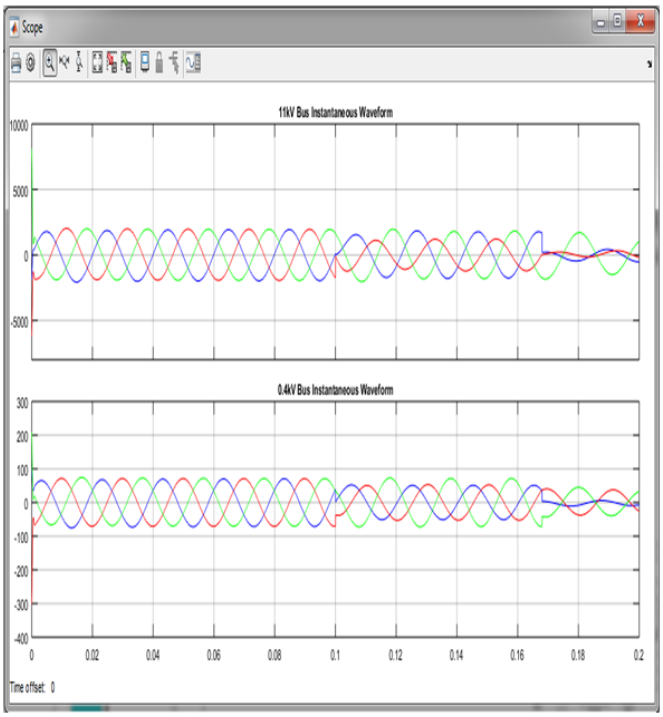


Fig.11: fault detection.

Fig 11 show byislanding fault identification of three phase. This is shows of line to ground fault of system.

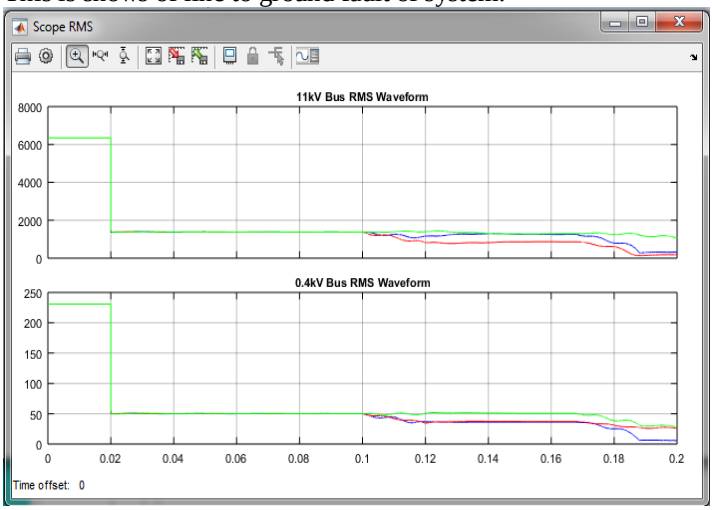


Fig.12: fault detection in RMS value.

Fig. 12 show by islanding RMS value voltage of three phase fault identification of three phase. This is shows of line to ground fault of system.

ANN BASED ALLOCATION AND SIZING OF DG

Distributed or dispersed generation (DG) or embedded generation (EG) is small-scale power generation that is usually connected to or embedded in the distribution system. The term DG also implies the use of any modular technology that is sited throughout a utility's service area (interconnected to the distribution or sub-transmission system) to lower the cost of service [1]. The benefits of DG are numerous [2, 3] and the reasons for implementing DGs are an energy efficiency or rational use of energy, deregulation or competition policy, diversification of energy sources, availability of modular generating plant, ease of finding sites for smaller generators, shorter construction times and lower capital costs of smaller plants and proximity of the generation plant to heavy loads, which reduces transmission costs. Also it is accepted by many countries that the reduction in gaseous emissions offered by DGs is major legal driver for DG implementation [4].

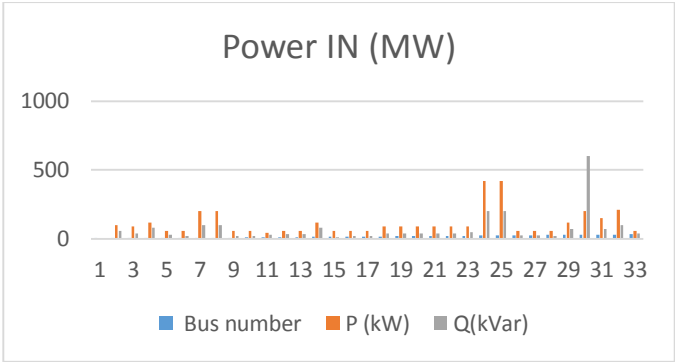


Fig.13: 33 Bus System power variation.

Fig 13 The ANN is first tested on one terminal, randomly selectedfor DG implementation. The output of the ANN estimation is precise and accurate, regardless of on which number of implementation terminals and DG power it is tested.

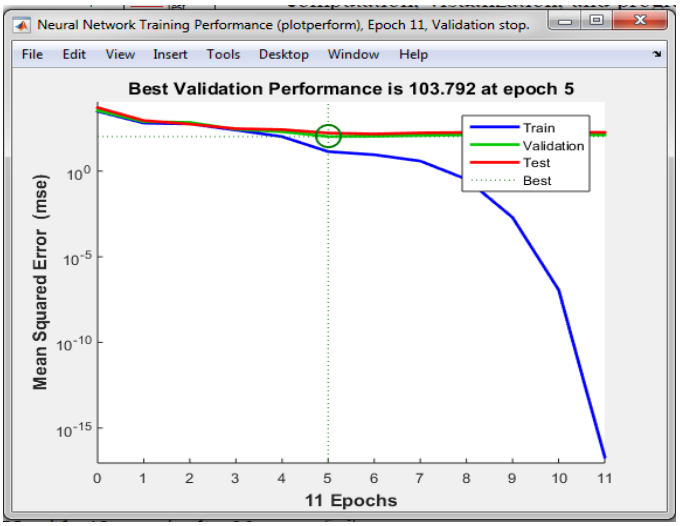


Fig.14: Performance **of ANN training.**

Fig.14 Shows for a part of distribution network with a nominal voltage 35(20)kV and 0.4 kV with 48 terminals, 23 transformers and 25 different low-voltage loads. The distribution network is connected to the transmission network on two sides, but it is never doubly-fed due to operator technical conditions. If fully loaded, the voltage drops under 0.89 p.u.

Table (1) Bus location and Size.

S.N.	DG Size	Critical Bus Location
1.	1.7636	33
2.	0.1558	69

Table (2) MSE of Our method

S.N.	DG MSE	Proposed MSE
1.	10^{-7}	10^{-15}

ADVANTAGES OF HYBRID SYSTEM

The advantages covered by the propose system are listed as,

- Overcoming disadvantages of standalone renewable electrical energy generation system.
- Producing much more efficiency as two or more renewable energy generation system working together in the terms of electrical energy generation.
- Since, the system doesn't have microcontroller or microprocessor the complexity of system testing and understanding became easy in terms of difficulties.
- System maintains is remarkably reduced and becomes easy.
- Renewable energy sources like, sun, wind,. Are utilized so, no waste production.
- Producing clean, friendly to environment, renewable energy.
- Once the system is designed and developed or manufactured, the installation of system is easy.
- Within certain time period the installation cost gets covered.
- If the system gets damaged in case, no need of changing entire system or subsystem. Just, changing a damage component will work out.

DISADVANTAGES

There's no system without having a disadvantage. So as, the system have disadvantages as follow:

- The first time installation cost is huge in terms of finance.
- The circuit designing complexity is more as there in no micro-computer for controlling action.

VII. FUTURE SCOPE

As the awareness of non-renewable sources and pollution causes by them, the clean energy production with renewable sources is widely preferred and day by day implementation of such sources going on, so, research and resources are also increasing for such plants and projects. As the first time installation cost is higher due to design and manufacturing perspective. The system can be monitories using graphical user interference on computer. So, the whole information will be available to user and/or stored regarding further applications and development.

VIII. CONCLUSIONS

Developing hybrid systems is one of the most convenient and effective solution for producing electricity as compared to non-renewable energy resources. It is not only less costly but also it does not cause any harm to the environment. Another thing is that it can be used to generate electricity in hilly areas, where it is quite difficult to transmit electricity by conventional methods. Depending on the requirement its setup can be decided. All the people in this world should be motivated to use non-conventional resources to produce electricity in order to make them self-reliable to some extent. Long life span, less maintenance are some of its plus point. It just requires some high initial investment.

IX. REFERENCES

[1]. S. Bose, Y. Liu, K. Bahei-Eldin, J.de Bedout, and M. Adamiak, "Tie line Controls in Smart grid Applications," in *iREP Symposium Bulk Power System Dynamics and ControlVII, Revitalizing Operational Reliability*, pp. 1-9, Aug. 2007.

[2]. R. H. Lasseter, "Smart grids," in *Proc. IEEE-PES'02* , pp. 305-308, 2002.

[3]. Michael Angelo Pedrasa and Ted Spooner, "A Survey o f Techniques Used to Control Smart grid Generation and Storage during Island Operation," in *AUPEC*, 2006.

[4]. F. D. Kanellos, A. I. Tsouchnikas, and N. D. Hatziargyriou, "Smart grid Simulation during Grid-Connected and Islanded Mode of Operation," in *Int. Conf. Power SystemsTransients (IPST'05),* June. 2005.

[5]. Y. W. Li, D. M. Vilathgamuwa, and P. C. Loh, Design, analysis, and real-time testing of a controller for multi bus Smart grid system, *IEEE Trans. Power Electron.*, vol. 19, pp. 1195-1204, Sep. 2004.

[6]. R. H. Lasseter and P. Paigi, "Smart grid: A conceptu al solution," in *Proc. IEEE-PESC'04* , pp. 4285-4290, 2004.
[7]. F. Katiraei and M. R. Iravani, "Power Management St rategies for a Smart grid with Multiple Distributed Generation Units," *IEEE trans. Power System*, vol. 21, no. 4, Nov. 2006.
[8]. P. Piagi and R. H. Lasseter, "Autonomous control of Smart grids," in *Proc. IEEE-PES'06* , 2006, *IEEE*, 2006.
[9]. M. Barnes, J. Kondoh, H. Asano, and J. Oyarzabal, " Real-World Smart grids- an Overview," in *IEEE Int. Conf. Systems of Systems Engineering*, pp.1-8, 2007.
[10]. Chi Jin, Poh Chiang Loh, Peng Wang, Yang Mi, and Frede Blaabjerg, "Autonomous Operation of Hybrid AC-DC Smart grids," in *IEEE Int. Conf. Sustainable EnergyTechnologies*, pp. 1-7, 2010.
[11]. T.S. Balaji Damodhar and A. Sethil Kumar, "Design of high step up modified for hybrid solar/wind energy system," Middle-East Journal of Scientific Research 23 (6) pp. 1041-1046, ISSN 1990-9233, 2015.
[12]. Walaa Elshafee Malik Elamin, "Hybrid wind solar electric power system," report, University of Khartoum, Index-084085, July 2013.
[13]. Sandeep Kumar and Vijay Garg, "Hybrid system of PV solar/wind & fuel cell," IJAREEIE, Vol. 2, Issue 8, ISSN 2320-3765, August 2013.
[14]. Rakeshkumar B. Shah, "Wind solar hybrid energy conversion system- leterature review," International Journal of Scientific Research, Vol. 4, Issue 6, ISSN 2277-8179, June 2015.
[15]. Ugur FESLI, Raif BAYIR, Mahmut OZER, "Design & Implementation of Domestic Solar-Wind Hybrid Energy System", Zonguldak Karaelmas University, Department of Electrical and Electronics Engineering, Zonguldak, Turkey.
[16]. Nazih Moubayed, Ali El-Ali, Rachid Outbib, "Control of an Hybrid Solar-Wind System with Acid Battery for Storage", Wseas Transactions on Power System, Labortory of Science in Information and System (LSI), Axi-Marseille University, France