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Simulink Simulation of PV, Wind and Fuel Cell Based Hybrid Power Generation System

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***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

Most people in the rural villages use kerosene for lamp, diesel for water pumping and flour mills, fire wood for cooking, and dry cells for radio and tape recorders. Desertification of the land is getting worse and worse due to deforestation and backward agricultural practices. Hence, the communities that live in the rural villages are suffering from lack of electricity. Therefore, women are forced to do their day-to-day domestic activities such as cooking, using fuel wood which leads to a rapid growth of deforestation; they travel long distances to fetch water; and they also use kerosene lamp at night. Additionally, due to lack of access to electricity, the communities in the rural villages are not able to benefit from social services such as clinics and schools sufficiently.

Therefore, village electrification is a vital step for improving the socioeconomic conditions of rural areas and crucial for the country's overall development. The villages' welfare is one of the main aims of the rural electrification program. Enormous benefits can be achieved in irrigation, food preservation, crop processing, agriculture, and rural small-scale industries [1, 2]. It creates employment opportunities for the villages' youth and promotes a better standard of life. Hence, availability of electricity reduces poverty and helps economic development by enhancing the health, education, and water supply (for drinking and irrigation) needs of the rural population [3–5]. Keeping in mind the above facts, the authors of this work believes that designing and implementing cost-effective renewable energy-based hybrid systems to supply electric loads is a best candidate solution.

II. RESESRACH MOTIVATION

The development of micro grid power systems is one way to increase the share of renewable energy systems in the energy mix. Grid-tied, off-grid and hybrid renewable (wind, solar, biomass, geothermal, hydro) energy systems can be developed and integrated with existing or new residential and commercial buildings. The micro grid power systems will use distributed energy systems using renewable energy resources, energy storage, and power conditioning units such as inverters and rectifiers. The micro grid renewable power system can be connected to the utility grid (grid-connection or grid-tied renewable energy systems) or can operate as stand-alone or off-grid power system.

A grid-connection solar PV for example will help to save more money through better efficiency rates, net metering, plus lower equipment and installation costs (higher capital cost and operation and maintenance of the off grid solar PV/battery system): The system will also help to sell electricity back to the grid (excess power). An off grid or stand-alone solar PV system is an alternative to the grid-tied solar PV system. This is a good option for residential building that has no access to the grid. The off-grid solar systems require battery storage and a backup generator. The battery bank needs to be replaced after approximately 10 years, are expensive, and decrease the overall system efficiency (losses during the charge and discharge of the battery). Several studies can be found in the literature on the use of micro grid power systems for different applications [3-7]. Simulation and optimization techniques were used in previous studies for the optimized design of hybrid renewable power systems. HOMER software (Hybrid Optimization Model for Electric Renewable) and Simulink [8-13] have been used to identify the optimal grid-tied and off-grid system architectures for the power systems. This study focuses on the use of renewable energy system to power commercial building. Fossil fuel is the main or the primary fuel to generate electricity for these buildings. New energy systems using renewable energy resources and sustainable and renewable fuels can be used as alternative to the conventional fossil fuel based power systems. This represents a sustainable solution to the high energy consumption of commercial buildings. For example, Hazem etal. [14] developed optimal design of stand-alone hybrid photovoltaics and fuel cell power system without battery storage to supply the electric load demand of the city of Brest in France. The results of the numerical simulation showed that the hybrid power systems based on solar PV and fuel cells are a viable alternative to diesel generators. The fuel cell generator can efficiently complement the fluctuating renewable resource of the solar PV system to satisfy the energy demand of the city.

III. OBJECTIVE

The principal objective of this study is to design and optimized grid-connected solar PV, Wind and fuel cell hybrid power system in order to meet the desired electric load of the commercial building (University of Sharjah Administration building). The goal is to design a grid-tied renewable power system with high renewable fraction, low levelized cost of energy and with low environmental impacts (reduce the CO2 emissions).

IV. LITERATURE REVIEW

1. D.S. Chaudhari: The solar photovoltaic is considered to be the one of the most promising energy source in many applications, due to its safety and high reliability. Residential that uses solar power as their alternative power supply will bring benefits to them. In order to increases the efficiency of system during rapid changing environmental conditions; system will adapt some Maximum Power Point Tracking (MPPT) methods. This paper presents a review on various MPPT methods for variable environmental conditions (i.e. variable temperature and irradiation level), their difficulty while tracking and how those difficulties can be overcome efficiently by the other techniques. Apart from all the methods, an open circuit and slope detection tracking technique is found to be an efficient technique with respect to tracking speed and accuracy. This technique can avoid the unnecessary amount of power loss and therefore maintaining the power efficiency.

2. PAWAN D. KALE: These modern days that consume a lot of energy e.g. fuel-oil, gas, coal etc. that will deplete in its source one day so, much of the focus have been given on the topic of renewable energy. Renewable energies are energy that can be renewed or have no worries of depletion. For instance wind, thermal, bio-mass and solar energy are some of the examples for renewable energy. Solar energy is one of the main renewable energy sources that are widely used in power generating application. Solar energy is an unlimited resource available in nature and set to become important in longer terms for providing heat energy and electricity to the user. This kind of energy resources does not create much pollution as the conventional power sources moreover it has the potential to be the major energy supply in future. In the last decade, there was a consistent development in the worldwide market of photovoltaic PV system. By the end of 2008, 13 GW of energy had been generated by the installed PV systems throughout the world. Out of the total system installed 6% were standalone systems, 33% were grid-connected centralized systems, and 61% were grid-connected distributed system. In 2008 alone, photovoltaic systems which generate up to 5.56 GW energy were installed. This represents the growth in PV systems increased by 1.5 times as compared with the previous year.

3. Ghislain Remy: This paper presents a review of maximum power point tracking (MPPT) techniques for photovoltaic systems PV. After a brief introduction of the key factors for the power extraction of photovoltaic panel, a review of the commonly used MPPT 10 techniques is presented and detailed with an overall approach. Then, a comparison of the main industrialized ones is discussed for a photovoltaic system. In the last part, the pros and cons of each of the considered MPPT techniques are presented.

4. Mohamed Azab: In this paper a new maximum power point tracking algorithm for photovoltaic arrays is proposed. The algorithm detects the maximum power point of the PV. The computed maximum power is used as a reference value (set point) of the control system. ON/OFF power controller with hysteresis band is used to control the operation of a Buck chopper such that the PV module always operates at its maximum power computed from the MPPT algorithm. The major difference between the proposed algorithm and other techniques is that the proposed algorithm is used to control directly the power drawn from the PV. The proposed MPPT has several advantages: simplicity, high convergence speed, and independent on PV array characteristics. The algorithm is tested under various operating conditions. The obtained results have proven that the MPP is tracked even under sudden change of irradiation level.

5. M.S.Sivagamasundari: Energy especially alternative source of energy is vital for the development of a country.

In future, the world anticipates developing more of its solar resource potential as an alternative energy source to overcome the persistent shortages and unreliability of power supply. In order to maximize the power output the system components of the photovoltaic system should be optimized. For the optimization maximum power point tracking (MPPT) is promising technique that grid tie inverters, solar battery chargers and similar devices use to get the maximum possible power from one or more solar panels. Among the 11 different methods used to track the maximum power point, Perturb and Observe method is a type of strategy to optimize the power output of an array. In this method, the controller adjusts the voltage by a small amount from the array and measures power, if the power increases, further adjustments in that direction are tried until power no longer increases. In this research paper the system performance is optimized by perturb and observe method using buck boost converter. By varying the duty cycle of the buck boost converter, the source impedance can be matched to adjust the load impedance to improve the efficiency of the system. The Performance has been studied by the MATLAB/Simulink.

6. SALEH ELKELANI BABAA: Maximum power point tracking (MPPT) controllers play an important role in photovoltaic systems. They maximize the output power of a PV(AC/DC SMART GRID) array for a given set of conditions. This paper presents an overview of the different MPPT techniques. Each technique is evaluated on its ability to detect multiple maxima, convergence speed, ease of implementation, efficiency over a wide output power range, and cost of implementation. The perturbation and observation (P & O), and incremental conductance (IC) algorithms are widely used techniques, with many variants and optimization techniques reported. For this reason, this paper evaluates the performance of these two common approaches from a dynamic and steady state perspective.

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

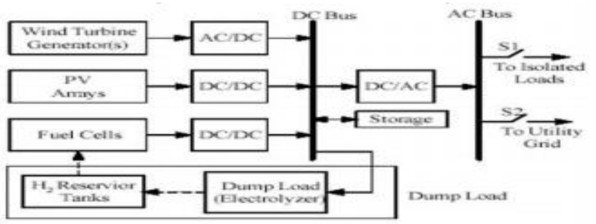

Fig 1 wind -solar and fuel cell hybrid system.

1. PV:

Photovoltaics is the field of technology and research related to the devices which directly convert sunlight into electricity. The solar cell is the elementary building block of the photovoltaic technology. Solar cells are made of semiconductor materials, such as silicon. One of the properties of semiconductors that makes them most useful is that their conductivity may easily be modified by introducing impurities into their crystal lattice. For instance, in the fabrication of a photovoltaic solar cell, silicon, which has four valence electrons, is treated to increase its conductivity. On one side of the cell, the impurities, which are phosphorus atoms with five valence electrons (n-donor), donate weakly bound valence electrons to the silicon material, creating excess negative charge carriers. On the other side, atoms of boron with three valence electrons (p-donor) create a greater affinity than silicon to attract electrons. Because the p-type silicon is in intimate contact with the n-type silicon a p-n junction is established and a diffusion of electrons occurs from the region of high electron concentration (the n-type side) into the region of low electron concentration (p-type side). When the electrons diffuse across the p-n junction, they recombine with holes on the p-type side.

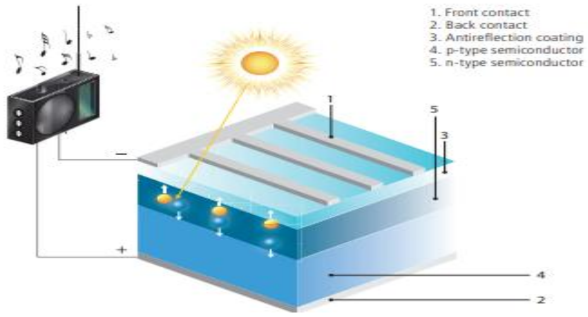

Fig 2 PV system.

However, the diffusion of carriers does not occur indefinitely, because the imbalance of charge immediately on either sides of the junction originates an electric field. This electric field forms a diode that promotes current to flow in only one direction. Ohmic metal-semiconductor contacts are made to both the n-type and p-type sides of the solar cell, and the electrodes are ready to be connected to an external load When photons of light fall on the cell, they transfer their energy to the charge carriers.

The electric field across the junction separates photo-generated positive charge carriers (holes) from their negative counterpart (electrons). In this way an electrical current is extracted once the circuit is closed on an external load. There are several types of solar cells. However, more than 90 % of the solar cells currently made worldwide consist of wafer-based silicon cells. They are either cut from a single crystal rod or from a block composed of many crystals and are correspondingly called mono-crystalline or multi-crystalline silicon solar cells. Wafer-based silicon solar cells are approximately 200 μm thick. Another important family of solar cells is based on thin-films, which are approximately 1-2 μm thick and therefore require significantly less active, semiconducting material. Thin-film solar cells can be

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manufactured at lower cost in large production quantities; hence their market share will likely increase in the future. However, they indicate lower efficiencies than wafer-based silicon solar cells, which means that more exposure surface and material for the installation is required for a similar performance.

2. WIND system power generation

Wind power installed capacity is growing exponentially [3]. Integration of wind power is proceeding at a rapid pace, and it is feasible that the United States may receive 20% of its electrical energy from wind by 2030 [2]. This 20% target corresponds to 300 GW installed capacity (mostly asynchronous). Wind turbine technology has been evolving continuously and has come a long way since the energy crisis of the 1970s when wind power began its resurgence [4], with individual wind turbines of 5-MW capacity being installed today as compared to wind turbines of the past which were rated in tens of kilowatts.

As wind turbine technology matures and wind power penetration levels increase, interconnecting a large-scale wind power plant (WPP) into the bulk power system has become a more important issue. The literature available suggests that large-scale WPPs can have a significant impact on the grid [5–12] , and the topic has been a matter of interest in the United States since the late 1970s and early 1980s. This was a period when wind turbine technology was starting to become viable, and concerns about the effects of large-scale WPPs on the grid began to be voiced [13–18]. The intermittent and variable nature of wind, the reliance of most wind power plants on induction generators, and the fact that wind generation tends to displace conventional generation, negatively affect system stability [19]. Some experiences of integrating wind power into the existing grid in Denmark, Sweden, Germany, California, the Midwestern United States and India have been discussed in [20].

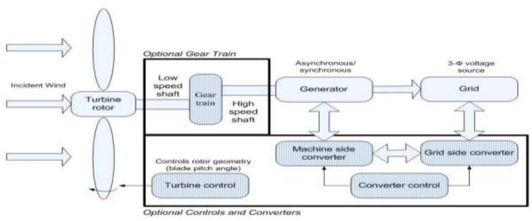

Fig 3 WIND System.

The work described in this report directly addresses these effects of wind power integration on the grid through the development of generic, manufacturer-independent wind power plant simulation models for interconnection studies. Right now, there is a need for wind turbine dynamic models, with potential users being power system planners and operators, researchers, consultants, wind plant developers. Reliability entities also need validated, non-proprietary models to meet reliability standards such as those set by the North American Electric Reliability Corporation (NERC). The purpose of these models is to observe the impact of wind turbine generators (WTGs) on the power system during dynamic events such as loss of load, loss of generation, loss of line, loss of wind, short circuits and voltage ride-through. Interconnection studies require steady-state and dynamic transient models of a WPP along with its collector system. Failure to perform proper interconnection studies could lead to non-optimal designs and operations of the WPP. Numerical power system simulation tools developed specifically for power systems and dynamic modeling, such as PSCAD/EMTDC, SIMPOW, or PSS/E may be used for these interconnection studies [21–23].

General purpose modeling software such as MATLAB/Simulink may also be used. The dynamic models of wind plants for power system studies are not usually built-in in these software tools, and have to be developed independently. Model development is an involved process, as is model validation. Models developed for system stability studies also need to be able to reproduce events on a timescale ranging from milliseconds to tens of seconds. Existing models are proprietary and manufacturer-specific, and are bound by the manufacturer's non-disclosure agreements. They are usually positive sequence models, and hence, cannot model unbalanced faults. In addition, they are usually not detailed; they often model the generator alone, and do not model aerodynamics and mechanics of the wind turbine and generator. Most models are also not validated using real data. The need for robust generic wind turbine and wind power plant models has been the motivation behind the research described here.

3. 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 2(a). Figure 2(b) 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. 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.

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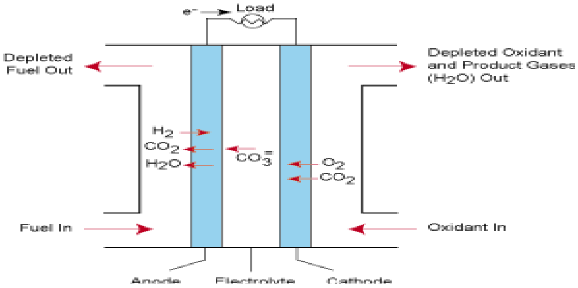

Fig 4 Working Principle in fuel cell.

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.

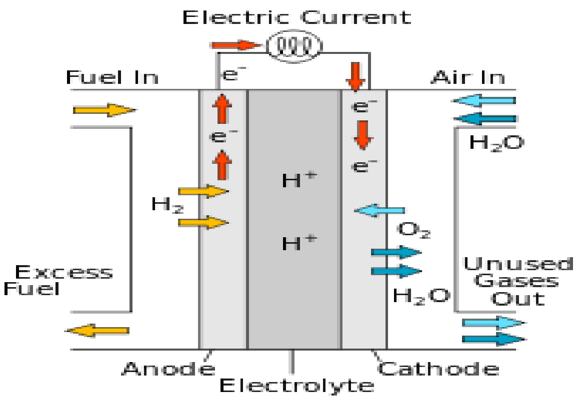

Fig 5 Current generation.

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.

VI. RESULT AND SIMULATION

A hybrid Smart grid whose parameters are given result is simulated using MATLAB/SIMULINK environment. The operation is carried out for the grid connected mode. Along with the hybrid Smart grid, the performance of the doubly fed induction generator, photovoltaic system is analyzed. The solar irradiation, cell temperature and wind speed are also taken into consideration for the study of hybrid Smart grid. The performance analysis is done using simulated results which are found using MATLAB.

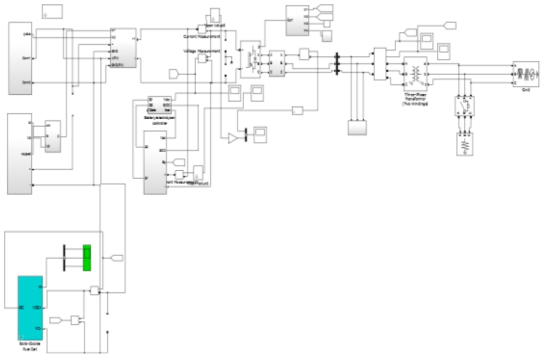
Fig 6 MATLAB Hybrid Power Generation System.

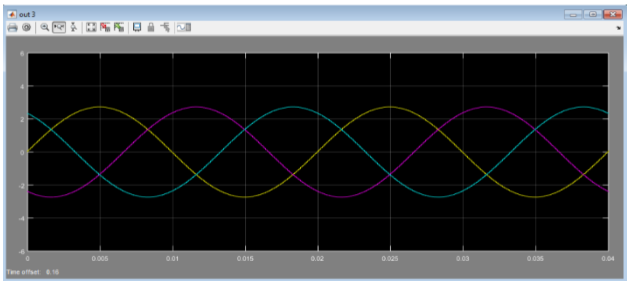
Fig 7 Output voltage Hybrid Power Generation System.

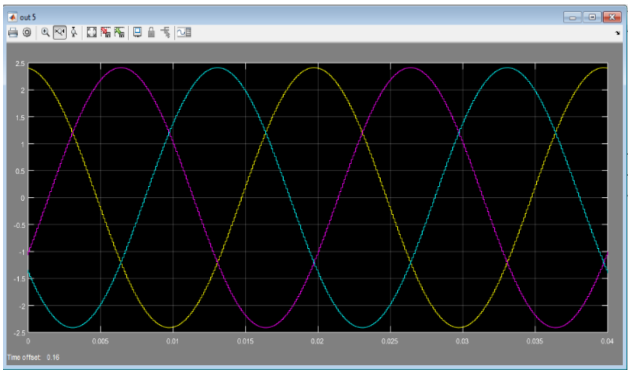
Fig 8 Output current Hybrid Power Generation System.

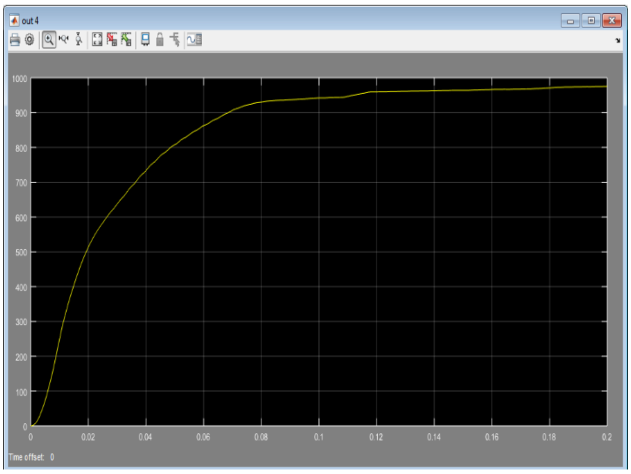
Fig 9 Output Transient response Hybrid Power Generation System.

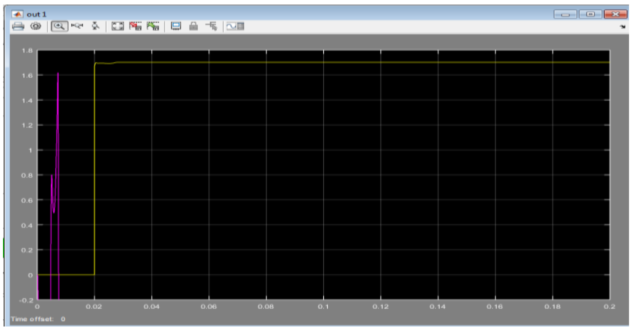

FIG 10Output power stabilization Hybrid Power Generation System.

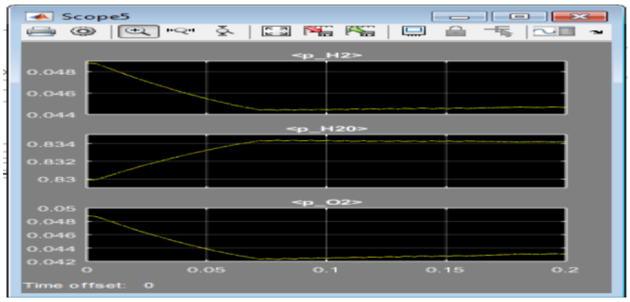

Fig 11 Fuel cell battery parameters.

VII.CONCLUSION AND SCOPE OF FUTURE WORK

1. Conclusion

The modeling of hybrid Smart grid for power system configuration is done in MATLAB/SIMULINK environment. The present work mainly includes the grid tied mode of operation of hybrid grid. The models are developed for all the converters to maintain stable system under various loads and resource conditions and also the control mechanism are studied. MPPT algorithm is used to harness maximum power from DC sources and to coordinate the power exchange between DC and AC grid. Although the hybrid grid can diminish the processes of DC/AC and AC/DC conversions in an individual AC or DC grid, there are many practical problems for the implementation of the hybrid grid based on the current AC dominated infrastructure. The efficiency of the total system depends on the diminution of conversion losses and the increase for an extra DC link. The hybrid grid can provide a reliable, high quality and more efficient power to consumer. The hybrid grid may be feasible for small isolated industrial plants with both PV systems and wind turbine generator as the major power supply.

2. Scope of future work

- The modeling and control can be done for the islanded mode of operation.
- The control mechanism can be developed for a Smart grid containing unbalanced and nonlinear loads.

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 Systems Transients (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. IEEEPESC’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. IEEEPES’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 FredeBlaabjerg, “Autonomous Operation of Hybrid AC-DC Smart grids,” in IEEE Int. Conf. Sustainable Energy Technologies, pp. 1-7, 2010.

[11] Y. Zoka, H. Sasaki, N.Yomo, K. Kawahara, C. C. Liu, “An Interaction Problem of Distributed Generators Installed in a Smart grid,” in Proc. IEEE Elect. Utility Deregulation, Restructuring and Power Technologies, pp. 795-799, Apr. 2004.

[12] H. Nikkhajoei, R. H. Lasseter, “Smart grid Protectio n,” in IEEE Power Engineering Society General Meeting, pp. 1-6, 2007.

[13] Zhenhua Jiang, and Xunwei Yu, “Hybrid DC- and AC-Li nked Smart grids: Towards Integration of Distributed Energy Resources,” in IEEE Energy2030 Conf., pp.1-8, 2008.

[14] Aleksandar Stjepanović, SladjanaStjepanović, FeridSoftić, Zlatko Bundalo, “Microcontroller Based Solar Tracking System”, TELSIKS, IEEE2009.