International Journal of Science and Research (IJSR)
ISSN (Online): 2319-7064
Index Copernicus Value (2013): 6.14 | Impact Factor (2014): 5.611

Modeling of Intelligent Energy Distribution System

Manju Sharma, Himanshu Doraya

Department of Electrical Engineering Rajasthan College of Engineering for Women, Jaipur, India

Abstract: ***Like non-renewable sources have some disadvantage renewable sources also have some issues like installation cost of plant, change in chemical condition and decrement in security of wildlife. In this paper we are focusing on solar energy only. Solar energy can only be harnessed when it is daytime and sunny. Solar power stations can be built but they do not match the power output of similar sized conventional power stations. They are also very expensive. Large areas of land are required to capture the suns energy. Collectors are usually arranged together especially when electricity is to be produced and used in the same location. Solar power is used to charge batteries so that solar powered devices can be used at night. However, the batteries are large and heavy and need storage space. They also need replacing from time to time. So, some extra attempts are needed to make it more dependable because of weather protectorate and low coherence of solar energy. This can be done by making the whole system smart, computerized solar energy and intelligent distribution system. This can be used more effective as we are using it only when there is a decline in the normal supply voltage. We proposed a user oriented method to run the devices by setting the priorities. The device with the highest priority will run for a long time and then compared to the devices having least priority. Because of which efficiency increases in the point of user.***

Keywords: Smart grid, solar energy, intelligent system, energy storage, distribution system

1. Introduction

During the recent decades, both domestic and global consumption of energy is growing rapidly. According to 2010 report of the International Energy Agency, in United States, total consumption of energy in 2008 was 26.6 TWh, compared with 22.3 TWh back in 1990. This represents a growth of 20%. The global energy demand is even more dramatic. In 1990, the global demand was 102.3 TWh and in 2008 it was 142.3 TWh which increased by 39%. The global demand of energy is rising more rapidly than in the United States [10]. It is estimated that annual rate of energy consumption will increase to the tune of 5% from 2010 [19].

Conventional energy resources typically include coal, fuel oil, natural gas and nuclear power. Materials to generate conventional energy are cheap and the power stations in which these resources are handled can be built almost anywhere. However, drawbacks of conventional energy solution are apparent. First, the quantity of material for generating conventional energy is limited and it could cost thousands of years for earth to cycle and regenerate these resources. Therefore, these resources will stop being available eventually. Second, the process of generation itself in conventional way often causes damage to surrounded environments and can lead to further serious pollution.

Solar energy is clean and is available in large quantities. Solar technologies use the sun to provide heat, light, electricity, etc for domestic and industrial applications. The energy potential of the sun is extremely large, but despite this unlimited solar energy resource, harvesting it is a challenge mainly because of the limited efficiency of the array cells. The best conversion efficiency of most commercially available solar cells is in the range 10-20s% [20].

Although recent breakthrough in the technology of solar cells shows significant improvement but the fact that the maximum solar cell efficiency still falls in the less than 20s% range shows there are enormous room for improvement. Solar technology is also improving consistently from time to time and as our non-renewable source decline it is important for the whole world to move towards renewable sources of energy. Sunlight can be used to directly generate electricity by the use of photovoltaic technology.

Utilizing the solar power in smart grid makes the use of electric energy more efficiently. Smart grid means "computerizing" the electric utility grid. Using the smart system, solar energy can be utilized more effectively. Whenever the supply of grid is below the some standard level the whole load can transferred to the solar based supply system. Solar energy was earlier stored in batteries. These batteries start feeding the loads. Loads will be decided on priority basis and with the discharging of batteries least priority load will be disconnected automatically.

Management of energy has been complex and imperative since various sources are to be integrated to a single management system. Therefore, Smart Grid is being invented. Typical electrical grid is made up of four parts: generation, transmission, distribution and customers [8]. Smart grid is supposed to make everything better by establishing necessary 2-way data communications among components within the electrical grid. Therefore the management of energy is becoming more interactive. The possible benefits of smart grid are reported to be reduced finance costs, fewer environmental damages and possibly eliminating power outages. So, Intelligent energy distribution system is plays the most significant role in order to determine how effectively the power is distributed generated from renewable sources. The system decides when to use the energy stored in the battery, that is whenever the power generated from the commercial electricity grid is very low then the switching action takes place, switches to the solar grid. If the energy generated from the solar panel is sufficient then power supplied as usual as the commercial grid otherwise controlling action takes place.

The energy stored in the battery is always compared with the preset levels and if it is low then it communicates with control room to take necessary steps. According to the energy levels in the stored battery the controlling of devices takes place. If the energy level is below the first preset level then the power that goes to the least priority devices are automatically shut off and the high priority devices are run and if the energy is below that then the next priority devices are shut off and allows to run only the highest priority devices giving a signal to take the necessary actions.

2. Literature Survey

Chen Jian, Che Yanbo, Zhao Lihua, they have shown the Design and research of off-grid wind-solar hybrid power generation systems. The supportive nature of wind and solar determines the advantages and capability of hybrid power generation systems. For remote areas and island like coast defense in China, Off-grid wind-solar hybrid power generation systems are very important. This paper classifies and summaries the structure of off-grid hybrid power generation systems. As advantages and disadvantages of different system structures are very important to be known are described by them in detail. [4]

M. G. Villalva, J. R. Gazoli, E. Ruppert F, they have designed Circuit-based simulation of photovoltaic arrays. In this, they presented a straightforward and faultless method of modeling photovoltaic array. The method is used to obtain the parameters of the array model using information from the datasheet. The photovoltaic array model can be simulated with any circuit simulator. The equations of the model are presented in details and the model is validated with experimental data. This paper is useful for power electronics designers and researchers who need an effective and straightforward way to model and simulate photovoltaic arrays. [17]

Anurag Pandey, Hanuman Prasad agrawal, They designed a hybrid power system which is helpful in providing electricity to a university. In this, they presented the technical data of generator, transformer and energy audit details. Hybrid model is simulated with the help of HOMER software. This paper is useful for power system designers, researchers and for small industries, Colleges to reduce the electricity bill. [22]

M. A. Hannan, Z. Abd Ghani, and A.Mohamed, They represent a simulation modeling and prototype development of an inverter controller for photovoltaic (PV) applications using the dSPACE DS1104 controller platform. For this work dSPACE DS1104 controller was used as an inverter control platform, which enables the linkage between the MATLAB/SIMULINK inverter models and the real hardware by introducing the dSPACE DS1104 input-output (I/O) interface blocks into the SIMULINK models. Figure 1 shows the diagram of dSPACE controlled inverter with the help of which development of inverter controller for PV is done.

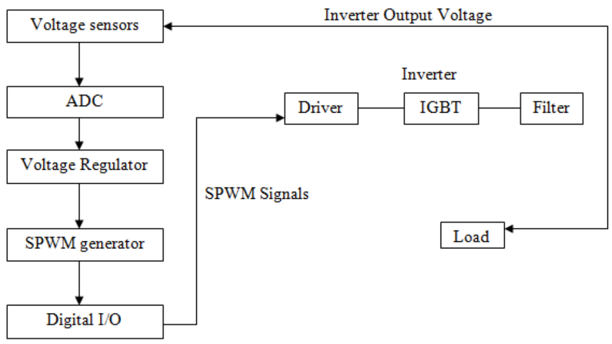

Figure 1: Block diagram of the dSPACE controlled inverter

The controller platform can link the simulation model developed in the MATLAB/SIMULINK environment to its prototype hardware. In the dSPACE controller, the voltage regulator controls the inverter by employing a proportional integral (PI) controller and the Park transformation method to generate sinusoidal pulse width modulation (SPWM) signals. [16]

3. Implementation of Intelligent Distribution System

Implementation of this system starts, when the electricity generated from the thermal plants is enough then it is connected to the energy meter through the power grid network, otherwise when the this electricity is not available then the energy generated from the solar panel is connected to the energy meter trough the grid inverter and distributed to the devices according to the prioritization which increases the efficiency of the solar power. Always the power requires is compared with the stored value in the battery and generates the control signals according to conditions specified. As the consumption of power increases, the energy stored in the battery decreases causes that no longer the devices operate with the solar energy. It is required to distribute the energy intelligently to increase the efficiency of the solar system, sends a control signal from the control room to turn off the least priority devices and keep on monitoring the battery status. If the battery value reaches the threshold value which is set for safe operation runs only the highest priority device making all remaining devices turn off. Fig.5.1 shows the efficient distribution system that distributes the power generated from the solar panel. To make the switching action between commercial electricity and solar power a relay is placed. To monitor the electricity from power grid network, 5v input is given to the MCU whenever the monitor pin reads 0V then relay connects the solar system to the energy meter and it displayed on the LCD display and on the PC in control room. Zigbee provides the communication between the control station and distribution system. The control commands are given remotely to control power going to the devices depending on the battery status.

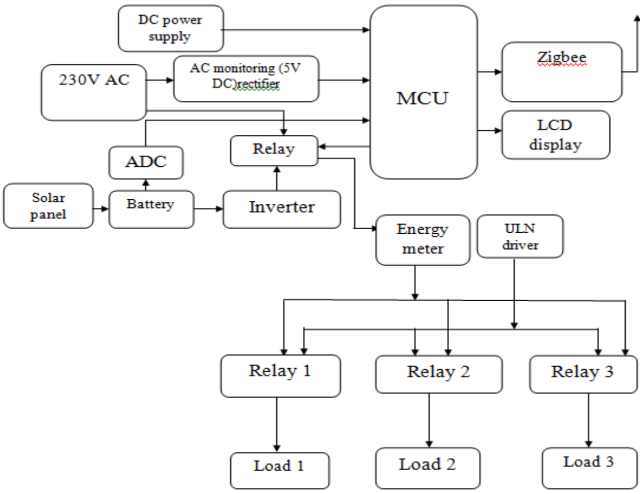

Figure 2: Hardware architecture of intelligent distribution system

The block diagram in fig.2 having three sockets is nothing but three loads. The intelligent system adequately distributes the power generated from the solar panel to these prioritized loads depending upon the status of the battery.

First of all the main supply is compared to the prescribed level using switch/relay, if the main supply level is above the prescribed level then the load will be feeded by the main supply but if it is below the level then the whole load will be transferred to the batteries which are being charged by the solar cells/ panels. Three levels are decided here, more levels can be settled. According to these levels, loads are decided on priority basis. Whenever the voltage level decreases below the first preset level, the least priority load will be disconnected and other load operate as usual and this process continues until only most priority load will be feeded by the batteries. In between if the voltage level increases the whole load will be start feeded by the main supply. This will help to utilize the solar energy completely and more effectively and reduce the risk of power interruption in case of power supply failure.

Figure 3: Efficient Distribution System

Control station is located remotely, communicates with the efficient system through the Zigbee and it displays the results on PC, when AC power and Solar power present AC power ON, Otherwise AC power off and solar power present and also display the voltage in the inverter. According to the battery status, system operates the loads given in the following table in this for demo purpose three loads are considered.

A. Algorithm

Step1: Initialization of devices.
Step2: Initially both AC and Inverter sections are in ON condition.
Step3: Devices are run with AC power
Step4: In microcontroller one pin is programmed to monitor the AC power, when it is goes off, the relay is connected to the inverter.
Step5: Now the solar energy is connected to the meter
Step6: In micro controller the stored energy is always compared with presetting levels
Step7: If the stored energy is greater than the power Consumption then the least priority device is automatically turn off.
Step8: Otherwise highest priority load will run by turning off other loads.
Step9: Whenever the AC power is available then the relay connects it to the energy meter.
Step10: Stop the process.

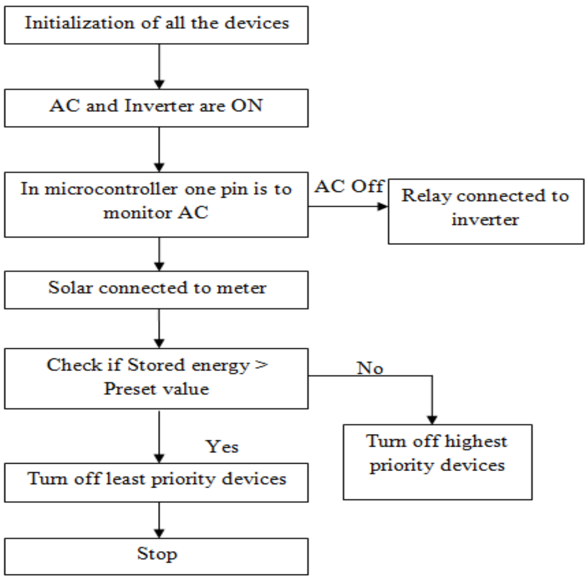

Figure 4: Block Diagram for Distributed System

4. Results

The results shows that, when the power from both power plant and solar system are present then the efficient distribution system connects the energy meter to power line generated from power plant and runs all the devices. Otherwise the remote control station sends the command signal to connect the solar system to the energy meter and compares the battery status continuously to run the prioritized devices.

Control station that is remotely located, communicates with the efficient system through the Zigbee and it displays the results like on PC like, when AC power and Solar power present AC power ON, Otherwise AC power off and solar power present and also display the voltage in the inverter. According to the battery status it operates the loads given in the following table. Here Solar PV cells generate electricity.

Table 1: Load Distribution

Battery status	Loads condition
Less than 45V	Three loads are running
Less than 30V	Load -3 turn off(least priority device)
Less than 20V	Load-1 ON(highest priority), other are turns off

Three loads are there. Above 45 Volt all the three loads are working, below this voltage condition gets changed. Between 30 Volt and more than 20 volt, one load gets off. Only two loads will work because it is also above the third condition which is minimum load. Less than 20 Volt, only one will work.

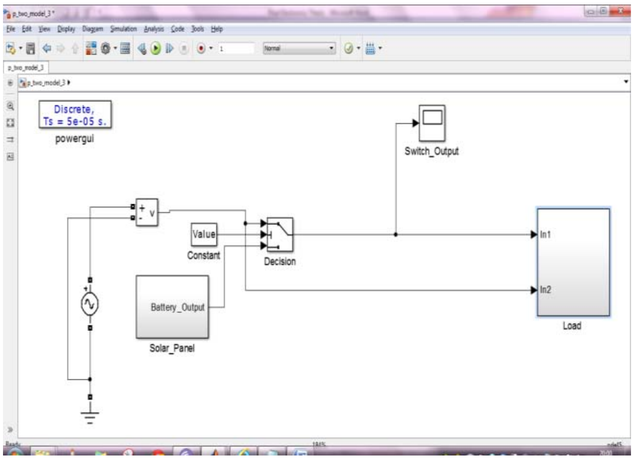

Figure 5: Simulink model

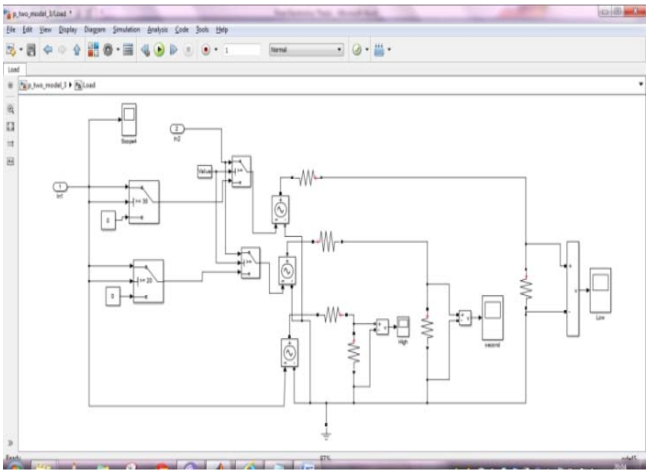

Figure 6: Simulink model (load circuitry)

When main voltage is greater than 60 Volt than it is sinusoidal and connected to grid and below 60, it gets disconnected from grid and connected to battery, even if there is a difference of only 1 volt. For e.g. when we switch on a fan then it directly/currently on, it's not like that power is supplying and fan will take time to start. When the power changes from 60 to 59 volt then also it gets disconnected from grid and connected to battery. We cannot consider initial condition, because all these are transient conditions.

Case 1: when Voltage is 100v then the switch connects the load to the main grid

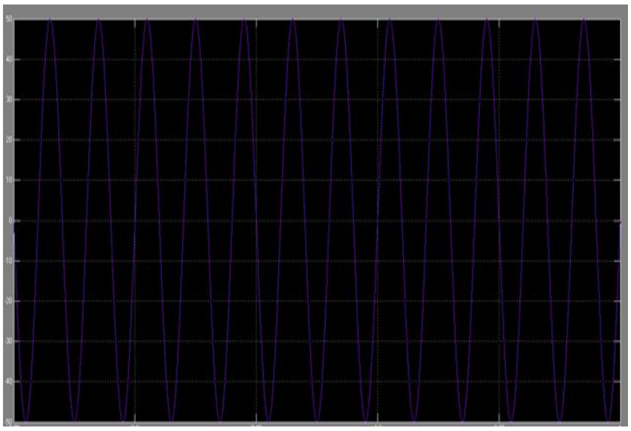

Figure 7: High priority load

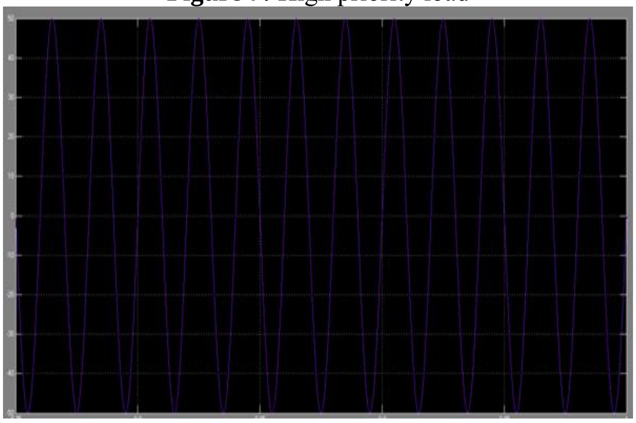

Figure 8: Medium Priority load

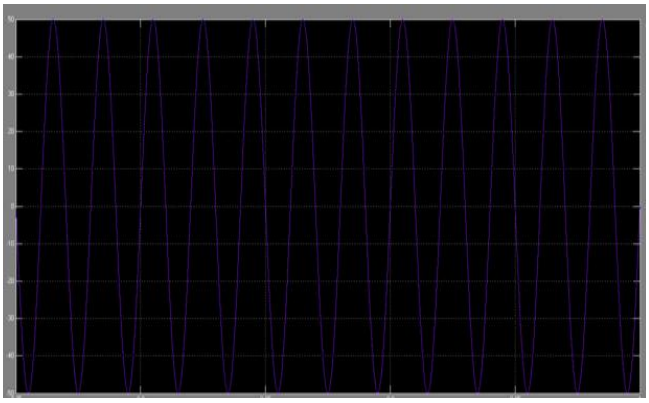

Figure 9: Low priority load

As the grid voltage is 100v, the voltage is equally distributed in the low, medium and high priority load

Case 2: Grid voltage is less than threshold (Threshold voltage is 60v)

When the grid voltage is less than the threshold voltage then switch connect the load to the battery voltage or solar voltage

Case 2a: when battery voltage is less than 30

When the battery voltage is more than 30v then the entire 3 load are connected to the voltage and it is equally distributed

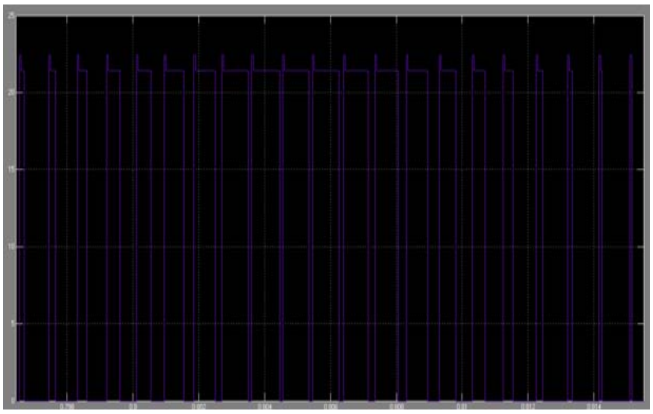

Figure 10: Load output

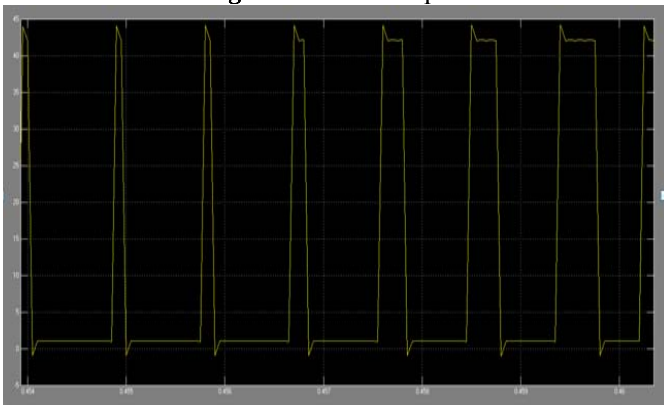

Figure 11: Switch output

Case 2b: When battery voltage is less than 30v and more than 20v

When battery voltage is less than 30v and more than 20v, then the least priority load will be disconnected and voltage across the low priority will be zero, battery voltage is equally distributed across highest and medium priority

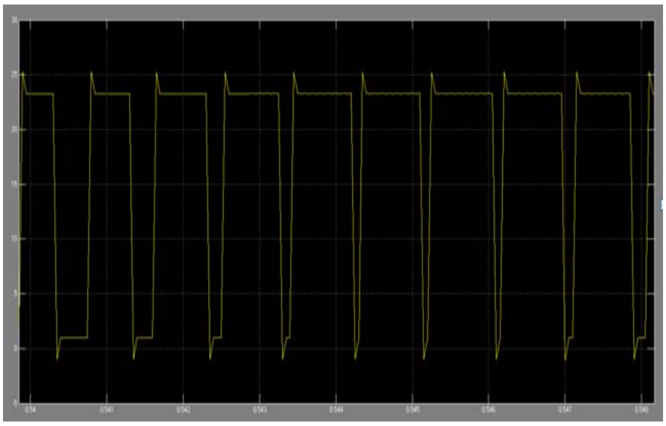

Figure 12: Switch output

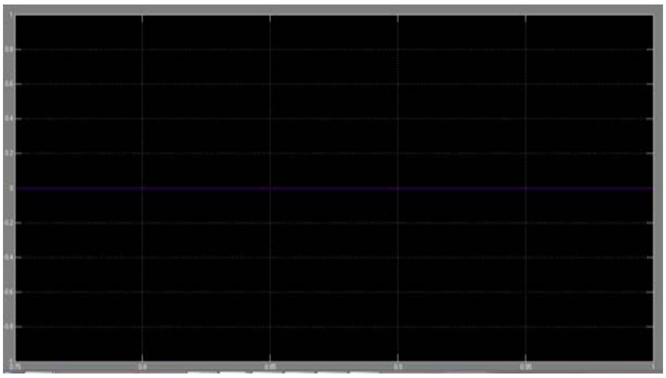

Figure 13: Low Priority load

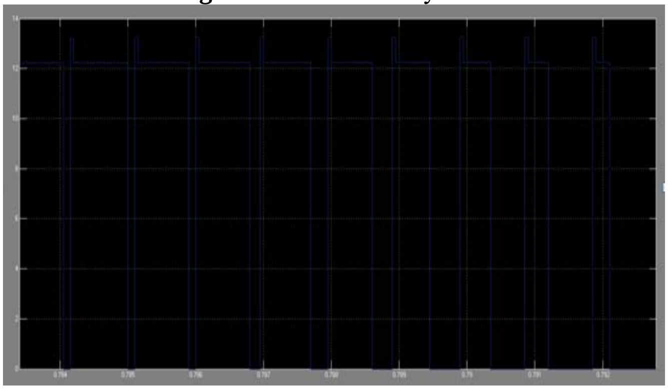

Figure 14: High and Medium Priority Load

Case 2c: when battery voltage is 20v and less

When battery voltage is 20v or less, highest priority load is connected to battery voltage and voltage across medium and least priority load will be zero

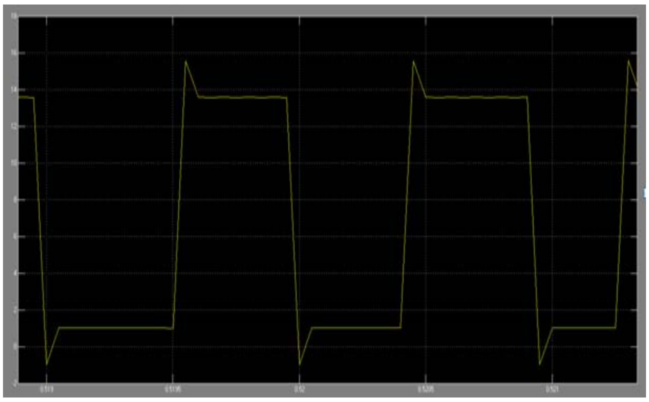

Figure 15: Switch output

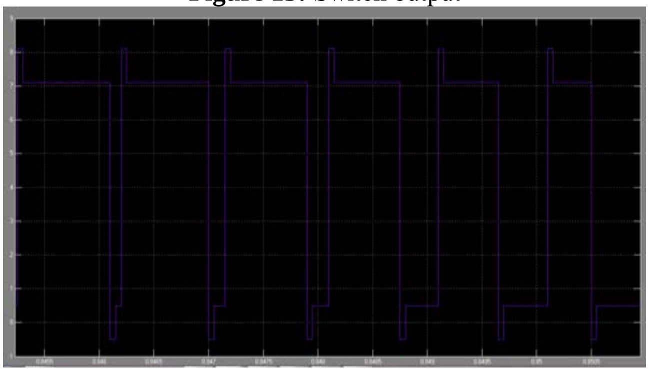

Figure 16: Highest priority Load

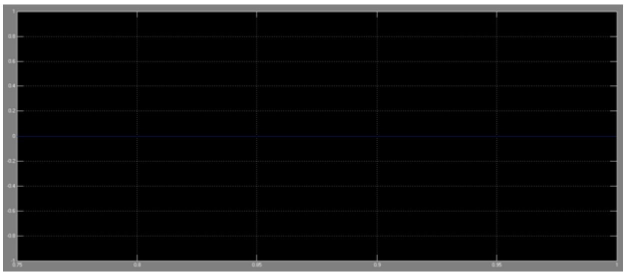

Figure 17: Medium and Low priority Load

5. Conclusion

Energy generation and consumption in India are on high growth rate. Smart grid technology can greatly overcome these issues. Climatic change concerns due to emission combined with resource and infrastructure constraints are dampers. With nearly 40 % of its 1.22 billion population deprived of grid electricity, present 186 GW installed power capacity may have to be doubled by the end of this decade to meet energy need of its growing population and expectations of a high GDP growth economy.

In this paper advantages and drawbacks of existing energy system is discussed because of which smart grid system was introduced. Although in most power-generating systems, the main source of energy (the fuel) can be manipulated, this is not true for solar and wind energies (renewable sources). The main problems with these energy sources are cost and availability. To avoid these problems smart grids were designed. In this paper, we proposed a system to distribute the power generated from renewable sources efficiently. It is possible to assemble a solar grid which is parallel to the commercial grid. This becomes possible by increasing the capacity of solar panel and capability of the battery. It can resolve the electricity issue in future. And it can be distributed effectively to solve the problem of electricity in rural and urban areas. But a problem comes with this distributed system. It requires huge inverter to store the largely volatile solar energy because of which its maintenance cost goes very high. This can be overcome by constructing solar grids parallel to the existed grids by the government.

References

[1] Alka, Bipul Kumar, Amita Singh, Manju Sharma," Improving the efficiency of solar photo voltaic system using organic solar cell and fuzzy logic based tilted panel sun tracking system", IJIREEICE, Vol. 3, Issue 7, July 2015, ISSN : 2321 – 2004, pp : 32-35.

[2] Atwa Y.M., El-Saadany E.F. , Salama M.M.A., Seethapathy, "Optimal Renewable Resources Mix for Distribution System Energy Loss Minimization".Power Systems, IEEE Transactions, Volume-25, Issue-1 , October 2009, ISSN : 0885-8950, pp : 360 – 370.

[3] Bilik P., Kvapil J. , Misak S., "Efficiency and internal power flow of renewable power supply system" , IEEE, 11th International Conference on Electrical Power Quality and Utilization (EPQU), Oct. 2011, ISSN : 2150-6647, pp : 1 – 4.

[4] Chen Jian, Che Yanbo, Zhao Lihua, "Design and research of off-grid wind-solar hybrid power generation systems," 4th International Conference on Power Electronics Systems and Applications (PESA), 2011 , Volume-1, pp : 8-10.

[5] Chao-Shun Chen, Chia-Hung Lin, Shih-Chieh Hsieh, Wei-Lin Hsieh, "Development of smart distribution grid" , IEEE International Symposium on Next-Generation Electronics (ISNE), 2013, ISSN : 978-1-4673-3036-7, pp : 4 – 6.

[6] Cericola D, Ruch PW, Kötz R, Novák P, Wokaun A. Simulation of a supercapacitor/ Li-ion battery hybrid for pulsed applications. Journal of Power Sources 2010;195:2731–6.

[7] Connolly D, Lund H, Mathiesen BV, Leahy M. The first step towards a 100% renewable energy-system for Ireland. Applied Energy 2011;88:502–7.

[8] Daniel HD, Paul CB, Abbas AA, Nancy HC, John DB. Batteries for large-scale stationary electrical energy storage. The Electrochemical Society Interface 2010:49–53 ([assessed 04.07.13])⟨www.electrochem.org⟩.

[9] Grass Norbert, Kerber Georg , Witzmann Rolf , Sebeck Markus, "Increasing Grid Transmission Capacity and Power Quality by new Solar Inverter Concept and Inbuilt Data Communication", 4th international conference on Telecommunication-Energy Conference (TELESCON), May 2009, pp : 1-5.

[10] Green, Martin A. "Solar Cells; Operating Principles, Technology, and System Applications", Prentice-Hall Inc, 1982, pp : 62-184.

[11] Hill C.A., Such M.C. , Dongmei Chen , Gonzalez J, "Battery Energy Storage for Enabling Integration of Distributed Solar Power Generation", Smart Grid, IEEE Transaction, Volume -3, Issue-2, May 2012, ISSN : 1949-3053, pp : 850 – 857.

[12] Hao Liang, Tamang A.K., Weihua Zhuang, Shen X.S., Stochastic Information Management in Smart Grid, Communications Surveys & Tutorials, IEEE ,Volume-16 , Issue- 3 , ISSN : 1553-877X, pp : 1746 – 1770.

[13] Insung Hong, Byeongkwan Kang, Sehyun Park, "Design and implementation of intelligent energy distribution management with photovoltaic system", IEEE Transaction, Volume-58, Issue – 2, ISSN: 0098-3063, pp: 340 – 346.

[14] JinSung Byun, Insung Hong, Byeongkwan Kang, Sehyun Park,"A smart energy distribution and management system for renewable energy distribution and context-aware services based on user patterns and load forecasting", IEEE Transaction, Volume - 57, Issue - 2, May 2011, ISSN: 0098-3063, pp: 436-444.

[15] Kawakami N, Iijima Y, Sakanaka Y, Fukuhara M, Ogawa K, Bando M. Development and field experiences of stabilization system using 34 MW NAS batteries for a 51 MW wind farm. In: IEEE international symposium on industrial electronics (ISIE); 2010.

[16] M. A. Hannan, Z. Abd Ghani, and A.Mohamed , "An Enhanced Inverter Controller for PV Applications Using the dSPACE Platform "Hindawi Publishing Corporation, 2010 , Article ID 457562, 10 pages.

[17] M. G. Villalva, J. R. Gazoli, E. Ruppert F., "Modeling and Circuit-Based Simulation of Photovoltaic Arrays",

Brazilian journal of Power Electronics, 2009, Volume-14, Number-1, ISSN: 1414-8862, pp: 35-45.

[18] M.M.Amin and O.A. Mohammed," development of high performance Grid connected wind energy conversion systems for optimum utilization of variable speed wind Turbines" Sustainable energy. IEEE transaction on, vol - 2, 2011, pp: 235-245.

[19] Perera B.K. , Ciufo P. , Perera S. , "Power sharing among multiple solar photovoltaic (PV) systems in a radial distribution feeder" , Power Engineering Conference (AUPEC), 2013 Australasian Universities , pp: 1 – 6.

[20] P. Nagalaxmi, M. Veda Chary, "Efficient Energy Management System with Solar Energy", IJMER, Volume-3, Issue- 5, Sep - Oct. 2013 ISSN: 2249-6645, pp: 2836-2839.

[21] Rahman R., Khan M.F., "Performance Enhancement of PV system by mirror reflection", IEEE, International Conference on Electrical and Computer Engginering (ICECE), 2010, ISSN: 978-1-4244-6277-3, pp: 163-166.

[22] Anurag Pandey, Hanuman Prasad Agrawal," Design of hybrid power system for an academic institution", IEEE international conference on ICATCCT-2015, Davangere.

[23] Stuchly, J., Misak, S. ; Vramba, J. ; Uher, M. , "Control of autonomous active distribution grid – introduction", IEEE, 14th International Conference on Environment and Electrical Enggining, May 2014, ISSN: 978-1-4799-4661-7, pp: 328 – 333.

[24] Xianyi Qian, Zhongqiao Zheng, "The Study on the Distribution of Wind and Solar Energy and the Regional Power Supply Systems", IEEE, International Conference on Information Engineering and Computer Science, ICIECS 2009, ISSN: 978-1-4244-4994-1, pp: 1 – 4.

[25] Y. Wan, and B. K. Parsons, "Factors Relevant to Utility Integration of Intermittent Renewable Technologies," National Renewable Energy Laboratory, 1993, NREL/TP-463-4953.