© March 2023| IJIRT | Volume 9 Issue 10 | ISSN: 2349-6002

Smart Energy Management Network for Home

Iyer Anish Subramanian
Keraleeya Samajam's Model College, Dombivli East, Mumbai, Maharashtra, India, *Fourth Semester,Department of Infromation Technology, University of Mumbai, Mumbai*

***Abstract*— Previous energy management systems are they are not fully automated and do not take battery status into account. This work attempts to solve these problems by using real-time battery health monitoring capability and prevent over discharge which eventually leads to extended battery life. The solution given in this work entitled Smart Energy Management System for Homes (SEMS-H) are expected to help in optimal utilization solar energy in homes. It consists of sensor networks, microcontroller, battery bank, load control/switching and regulated power units. In addition to that includes the ability to supply power to loads and connected devices in order of preference with some others smart features. Project fulfilment accomplished design specifications with respect to the period day, battery charge status, load, battery the level and extent and status of the Internet connection on any moments in time.**

***Keywords*—Current, Energy, Load Management, Microcontroller, Smart System**

I. INTRODUCTION

Insufficient electrical power is becoming a critical problem today, especially in developing countries like Nigeria. The consumption of electricity grows every year with the growing number of inhabitants, commercial and industrial appliances are created installed. Increasing energy consumption is usually not compensated with increased investments in electricity production, transmission and distribution networks [1]. Consequently, the need to optimize the use of available electrical energy becomes more critical. Traditional sources of electricity, as fossil fuels it was received less favourably attention to energy production because of their negative impact on the environment [2]. This scenario also contributed to that to increase the search for clean and ecological gentle renewable sources of electricity. Solar is one from net sources estimates that, if fully utilized, the amount reaching Earth would be more than five times that all other energy sources currently produce [3]. This abundance is a strong reason to invest in solar energy harvesting. Two basic components are required for this make the most of solar energy, which the systems are for capture and storage. The capture unit collects its incident radiation and transforms it into other forms of energy (like heat or electricity). However, due to non-constants nature of solar radiation, storage unit (usually battery) is required. When the sky is clear, the available irradiance can they reach an average value of 1000 W/m2, whereas when there is a lot of cloud cover or there is minimal or no radiation at night available. The storage unit can store the additional energy generated during periods of high production and release it for use when productivity declines. In fact, it is a backup power source it is usually added when the amount of energy required is exceeded both the amount of energy produced and the quantity energy held by the storage unit [4]. In practice, most of them experience significant inefficiencies current solar energy collection systems during collection and storage. When solar panels are used to charge banks lead-acid batteries (the most popular storage technique), a significant part of the energy is lost [5], [6]. Unlike the fact that solar panels are expensive and that large many of them are needed to harvest a significant amount energy, many current systems use dumb brute force charging systems in which all the batteries are in the battery banks are charged at the same time, regardless of the individual battery state of charge (SOC) or usage [7].

In practice, most of them face significant inefficiency current solar energy collection systems during collection and storage. When solar panels are used to charge banks lead-acid batteries (the most popular storage technique), a significant part of the energy is lost [5], [6]. Unlike the fact that solar panels are expensive and large many of them are needed to harvest a significant amount energy, many current systems use dumb brute force charging systems in which all the batteries are in the battery banks are charged at the same time, regardless of the individual battery state of charge (SOC) or usage [7].

II. LITERATURE REVIEW

Amount of electricity produced using photovoltaics (PV) technology is constantly growing. An example of this is the Sarnia PV solar plant, the largest in Canada as of 2010 with a power of 97 MWp [8], which was surpassed by several much larger plants, including 900 MWp installed in India's Kurnool Ultra Mega Solar Park [9], completed April 2017. Predict and predict the amount of electrical energy that can be harvested, all of them these plants depend on the relationship between incidents radiation physics and PV conversion. In [10] some basic PV-based direct current generating relationships were described with the ability of the PV panel to produce DC power summarized as

$$P_{dc} = P_g \frac{G_{eff}}{G_{STC}} \frac{\eta_g}{\eta_{g(STC)}} \quad (1)$$

In equation (1), represents the solar panel (array) rated power, the effective incident irradiance, denotes effective incident irradiance at F standard test conditions (STC), which is taken as received power of 1000 W/m2; and $\frac{\eta_g}{\eta_{g(STC)}}$ represents incurred thermal losses normalized to STC (i.e. at a temperature of 25oC). In terms of PV conversion physics, [10] describes the current and voltage relationship in a PV panel using a single-diode equivalent electrical circuit model as

$$I = f(I,V) = I_{ph} - I_0\left[e^{\left(\frac{V+IR_{ser}}{aV_t}\right)} - 1\right] - \theta\left(\frac{V+IR_{ser}}{R_{sh}}\right) \quad (2)$$

According to the above, storage batteries are the weakest link in solar electric systems, and therefore many research efforts have been focused on improving their life cycle. One such recent advance was reported in [16], which recommended a lithium or sodium based glass electrolyte rechargeable battery. However, recent trends suggest that it is more practical to improve system performance by reducing energy conversion and electricity use inefficiencies rather than battery efficiency. [17] and [18] proposed a Home Energy Management System (HEMS) to reduce energy consumption. Automatic and manual scheduling and control of driven (connected) devices/loads, continuous monitoring of battery charge status, and timely notification of the user to take necessary corrective action are all features of HEMS. However, the work does not consider the production of energy; instead, it uses a device control module to manage home appliances on the network. Other solar energy management systems have been proposed to make homes smart [18, 19, 20, 21].

These studies use renewable energy systems but do not take into account the energy consumption of such houses. [22] introduced an efficient power distribution system to distribute the energy produced from these renewable sources, [23] proposed a smart solar charge controller that prevents mains battery overcharge. Although the design uses a voltage feedback configuration to prevent this battery overcharging, still charging all connected batteries at the same time, regardless of their state of charge or residual capacity. Previous power management systems are not fully automated and usually do not prioritize battery health. This work is an attempt to solve these problems with the ability to monitor the battery condition in real-time and prevent over-discharge, resulting in longer battery life. This paper presents SMES-H, which has many features that can be useful for both domestic and industrial applications, with improvements on previous works. The system enables an efficient way of charging and discharging a non-homogeneous battery bank. In addition, it includes the ability to supply power to loads and connected devices in order of preference with some other smart features.

III. METHODOLOGY

Fig. 1 is a block diagram of the developed system. It consists of sensor networks, microcontroller, battery bank, load control/switching and regulated power supply Units. A network of sensors captures various information throughout the system to perform the required autonomous energy control, the microcontroller performs smart battery bank provides energy storage for the load control circuit receives signals from the system microcontroller for automatic switching of various loads, while a 5-volt regulated power supply provides the necessary 5V to operate the entire system The supply voltage regulator circuit is designed so that supply regulated power at 5V from the LM7805, it will ATMEGA328P power supply, LED indicator and more design components. System operation is controlled by ATmega328 microcontroller, programmed in C. The Microcontroller Unit (MCU) is attached into some sub-circuits designed to perform specific tasks. The first module is a dark sensing circuit which uses a voltage divider network to connect the system to both day (light) or night mode. Consists of Light Dependent resistor (LDR) and resistor. The increase of darkness will be increase the resistance of LDR (which is R2) which will lead to an increase in the output voltage going to microcontroller analog pin. Once the increment reaches predefined threshold that the microcontroller will switch system into night mode. The second module is sensing the battery voltage level circuit. This circuit also uses the voltage divider principle. It is it consists of 10k ohm and 1k ohm resistors. This circuit divides the input voltage which is the actual battery level 0.0909 because the mains output will be connected to a microcontroller analog pin. Being ATMEL328 transistor-transistor logic (TTL) cannot handle the voltage directly above 5V. The microcontroller returns a value of actual battery value using the same factor that was used its reduction. The complete wiring diagram is shown in Fig. 2, it shows the interconnectedness of components and sections in developed by SEMS-H. The output voltage sensing module of the converter is used for this sense the actual output AC voltage of the inverter and send as feedback to the microcontroller. The circuit is made up of a step-down transformer to reduce the voltage to a level that the conversion circuit can easily handle. The MCU is also connected to some actuator circuits and each circuit consists of a BC547 NPN transistor, 1k ohmic resistance and 12V DC relays with different current ratings ranging from 5 A to 120 A depending on the load attached to it. Each actuator receives its signal from different MCU output pins, depending on assigned operations from on/off to connecting/ disconnecting loads. The system uses a current sensor connected in series with a battery to measure the amount of current drawn solar panel and some other current sensors to measure the amount of current drawn by various loads. Energy drawn or used by different loads is estimated and used determine how energy can be efficiently used, either k turn a specific load on or off. Output from of sensors is connected to the analog input of the microcontroller pins. An ESP8266 WIFI module is connected to the MCU serially across the Tx and Rx pins. This allows the system have access to the Internet to save the data obtained cloud for analysis and prediction. The system uses the LM044L (LCD 4 x 22) to display some information about system status to the user. The system was designed basically to do two functions. The first is the intelligent management of energy consumption in a self-contained house based on solar energy information collected from various connected sensors different loads. The second is sending power consumption data to the cloud in real time for future deep learning forecasting and energy management.

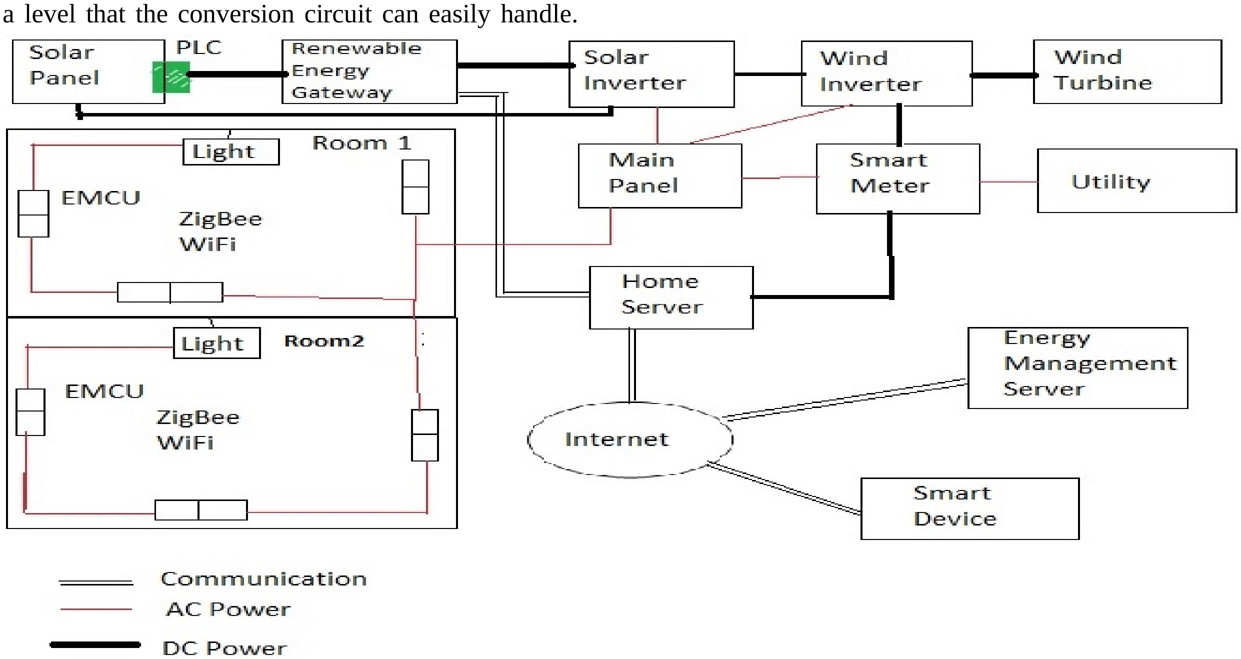

Fig. 1. Block diagram of the Smart Energy Management System for Homes

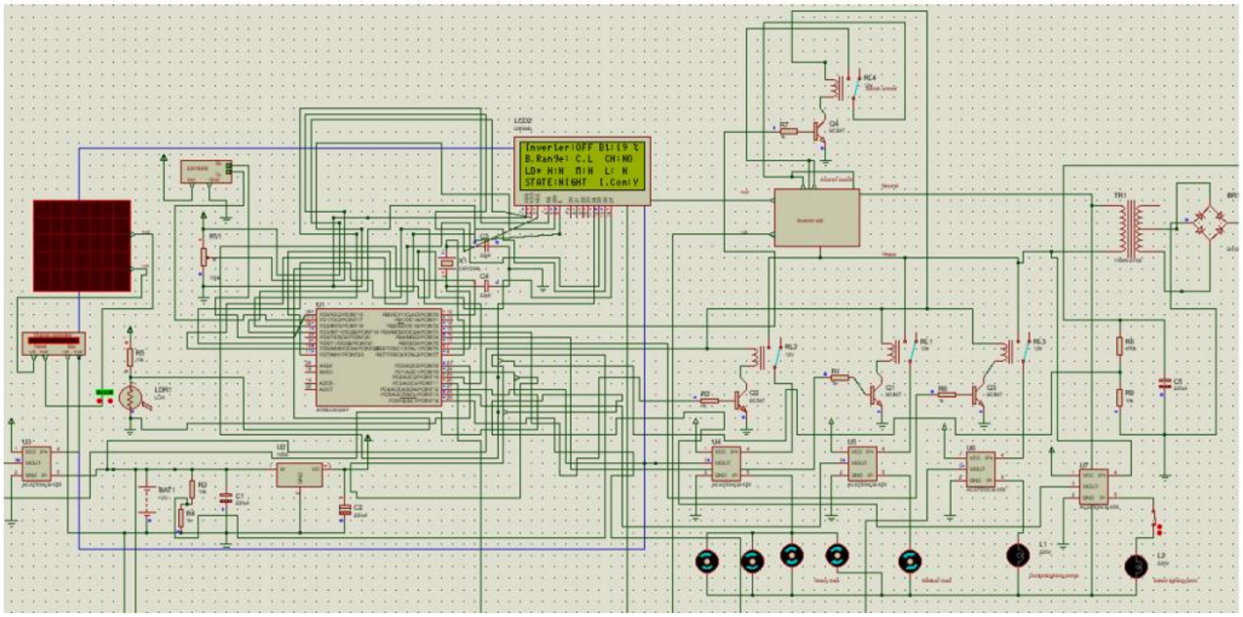

Fig. 2. Automated Energy Management System Complete Circuit Diagram

A. Smart control of appliances for efficient energy consumption management

The system will take into account some factors, e.g battery level, energy obtained by solar panel and required tenure (day or night) for each house appliance. Loads are divided into three: heavy, medium and light loads. The battery level is also divided into three: high, medium and low. Heavy loads are loads with energy consumption greater than or equal to 500 watts, such as air conditioners, electric stoves and presses. Medium loads are those with power consumption with values between 150 and 500 watts, such as a television and a fan light loads are those with lower energy consumption or equal to 150 watts, such as lighting points. High battery level is divided into three categories: 71% to 100% as high, 51% to 70% as medium and 20% to 50% as low. Battery level less than 20% is considered critically low and the system is programmed to automatically turn off when this occurs. Operation in day mode: Operation of the system during the day is further divided into two, based on the level of sunlight: sunny and non-sunny days. Heavy and moderate during the day loads will be powered but light loads will be switched off. If the battery is at medium level, only medium load will be on while the other two loads will be off When the battery level is low, only the light is on the loads will be switched on. Whenever the battery level increases back to medium level, the system turns on system back and turn on the appropriate load. It is assumed that the number of solar panels will be used by the system will be able to supply more than enough current required to charge the battery during a sunny day. Once the current sensor is connected to the charge controller feels that the amount of current required to charge the battery already passes the sensor, the system can turn on the medium load even when the battery level is low medium.

B. Night-mode Operations

When the battery charge level is high, all loads will be switched on. If the battery is at medium level, it is heavy the loads will be switched off leaving medium and low loads on. If the battery level drops to low, the system will just exit the lights are on but when the battery level is critical low, the inverter shuts down to ensure a good battery managing for durability.

C. Data upload to the cloud

Google Firebase will serve as cloud storage credentials will be used in the code uploaded to microcontroller so that the microcontroller will have option to send information to the database. System it gets access to the Internet through a WiFi module which is connected to an internet hotspot. These current and voltage data for charging, discharging and the load is sent to Firebase in real-time for data analysis and forecast. Giant. 3. Shows the flow char induced System.

D. Inverter output voltage sensor

The subcircuit shown in Fig. 4 measures the output inverter voltage. This allows the system to accurately measure the amount of energy consumed by the load. The the circuit consists of a step-down transformer, a bridge diode, capacitor and two resistors. Transformer steps reduce the voltage from 220 V AC voltage to 12 V AC. The 12V AC voltage is then converted to DC using a bridge rectifier. The output voltage is filtered using an electrolyte capacitor 220uf, 35V. The filtered DC output voltage is then scaled down using a voltage divider network using 470k as R1 and 10k as R2. Vout is connected to one of the analog pins of the microcontroller. Microcontroller amplifies the signal back to the actual voltage value using the factor by which the signal was scaled.

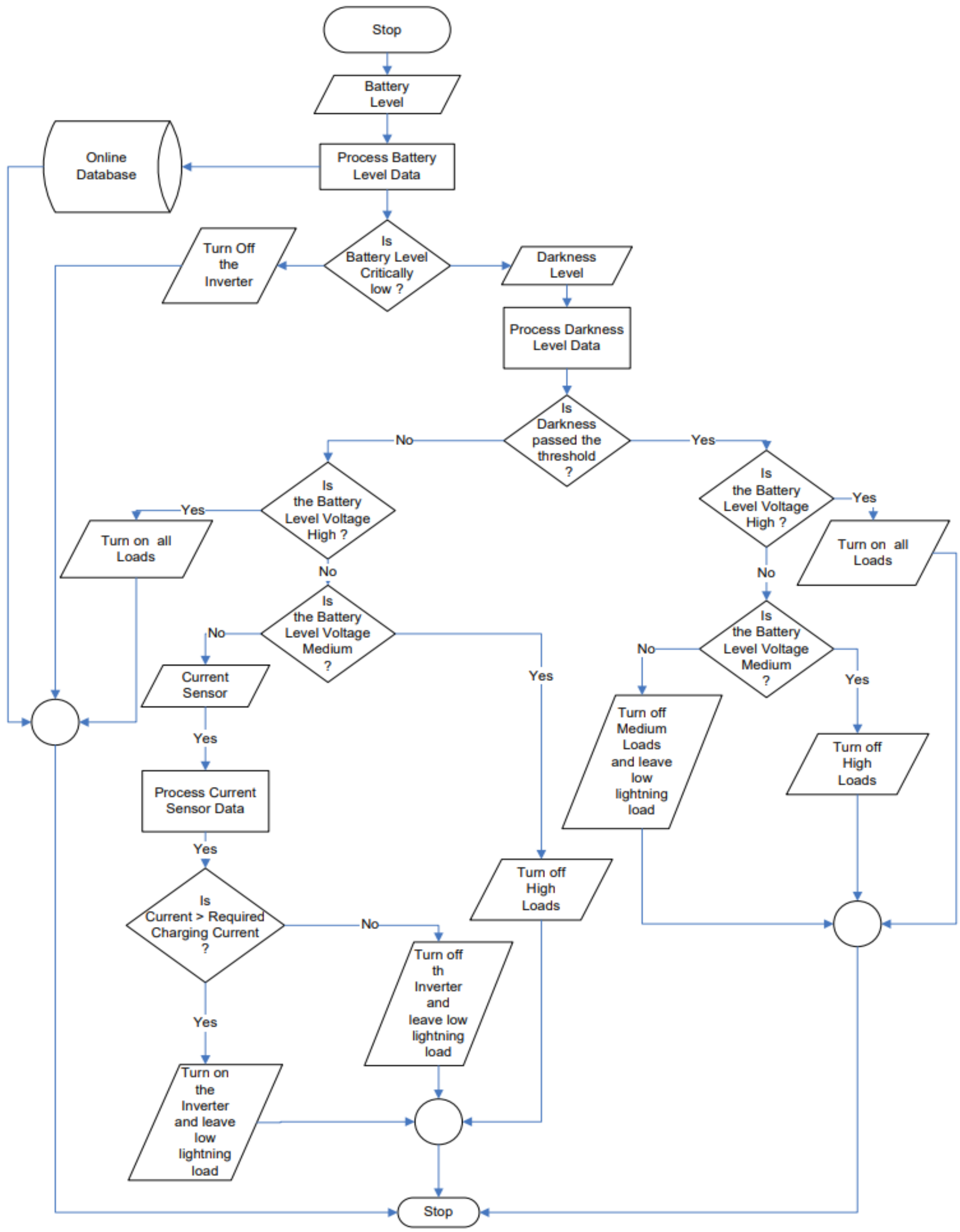

Fig. 3. Flowchart of the Developed SEMS-H

E. Inverter switching section

This is the sub-circuit that enables the MCU to power on and turn off the inverter unit. The circuit is made up of 12V relay, BC547 NPN transistor and 1k ohm current limiting resistance. A transistor receives a digital signal from microcontroller through 1k ohm resistor to activate or deactivate the inverter according to system mode operation. The switching sub-circuit of the inverter is shown in Giant.

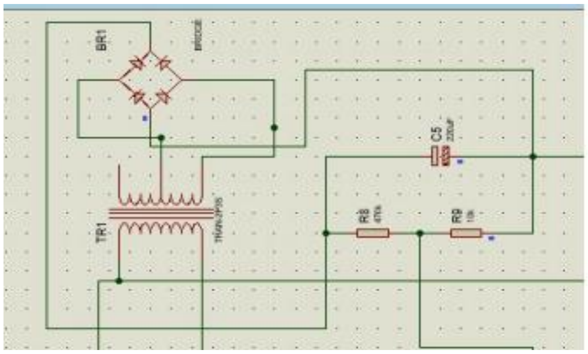

Fig. 4. Invert output voltage sensor

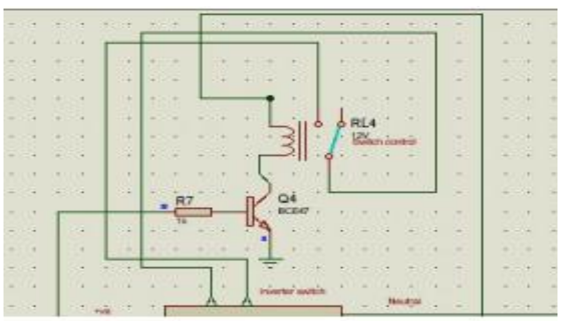

Fig. 5. Inverter control; for switching it on and off

F. Charging section

This section is made up of a monocrystalline solar panel and a PWM charge controller. The charge controller is charging battery and also monitors the battery level to prevent this from overcharging. Circuit is connection is shown in Fig. 6.

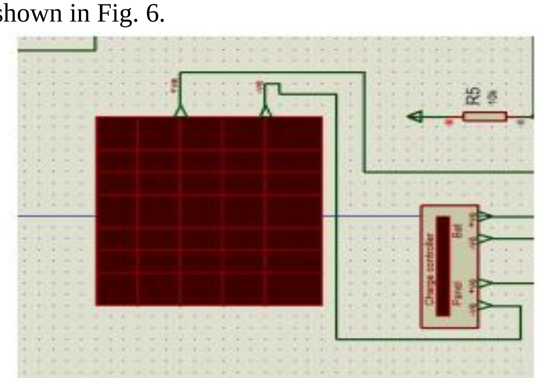

Fig. 6. Solar panel and charge controller

G. Internet Connectivity section

This section allows the system to access the Internet. The system uses the ESP8266 wifi module to connect to the hotspot. The Wifi module is connected to the MCU using serial communication via the Rx and Tx pins. It is shown in Fig. 7.

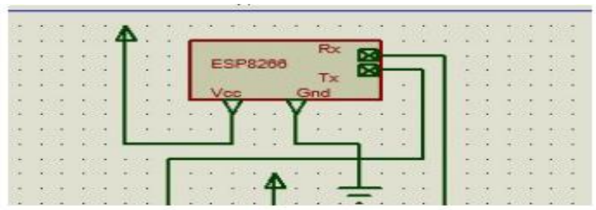

Fig. 7. Wifi module, ESP8266

H. LCD Section

Liquid Crystal Displays (LCDs) are used to display status and parameters in systems. Four data pins (D4-D7) and three control pins (register select, read and write, enable) are connected to digital pins microcontroller to control LCD operation. The control pins configure the LCD in command mode, data mode, read mode and write mode. Wiring circuits The LCD to the microcontroller is shown in Fig. 8.

I. Load Switching Subsection

The power supplied to the load is controlled by a controller circuit shown in Fig. 9. The circuit consists of relays, transistors and resistors. The microcontroller sends a digital signal to MCU base via current limiting resistance. The rated current of the relay depends on load for which it is designed.

J. Battery level sensing section

Knowing the battery level is essential for system to perform the required task for which it was designed. The battery condition is measured using a voltage divider network and its circuit is shown in Fig. 10. The circuit is assembled of two resistors and a capacitor. The network has shrunk battery at a voltage lower than 5V, so the microcontroller can work with it. The output signal is connected to one of the analog pins of the microcontroller from which it reads a value.

IV. RESULT AND DISCUSSION

The system is simulated in the proteus® a circuit design simulator software. The simulation runs on an Arduino programming language (code). The software offers a wide a number of components and the ability to change components specifications to meet the desired outputs. This way they can make mistakes can be easily detected and corrected during simulation output values can be obtained during software testing designed system. The results are shown in Fig. 11 to 14, which shows pictures of the automated Smart Energy Control system simulation for different battery levels and time of day. The LCD constantly displays the status system operation at each level, information about inverter status (on/off); battery level (high/low/critical low); charging (on/off), load level (high, medium, low) traffic status (on or off) and internet status connection (yes/no) will be displayed on the LCD

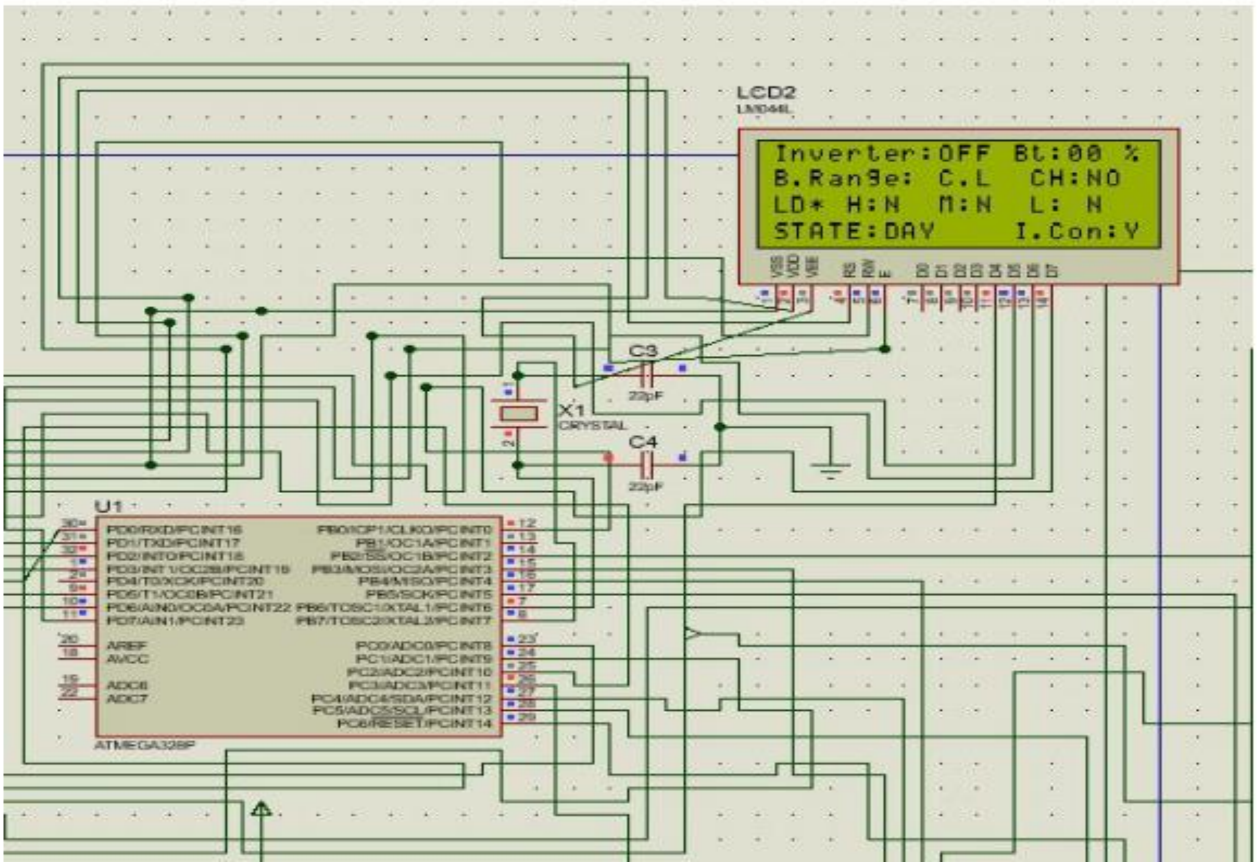

Fig. 8. The microcontroller and the LCD

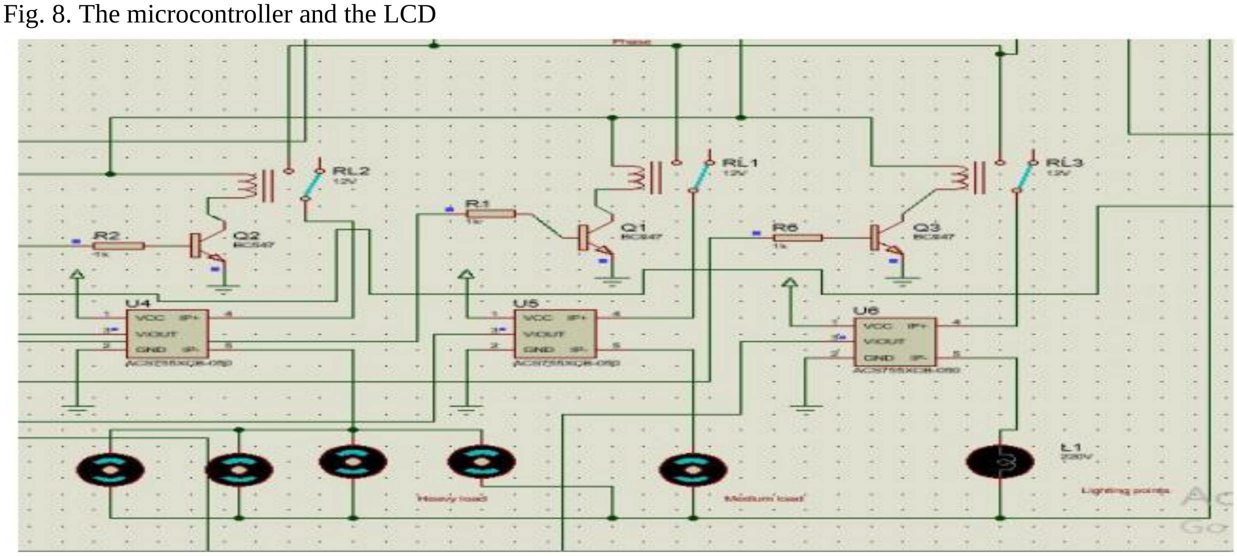

Fig. 9. Loads, current sensors, and relays (for control)

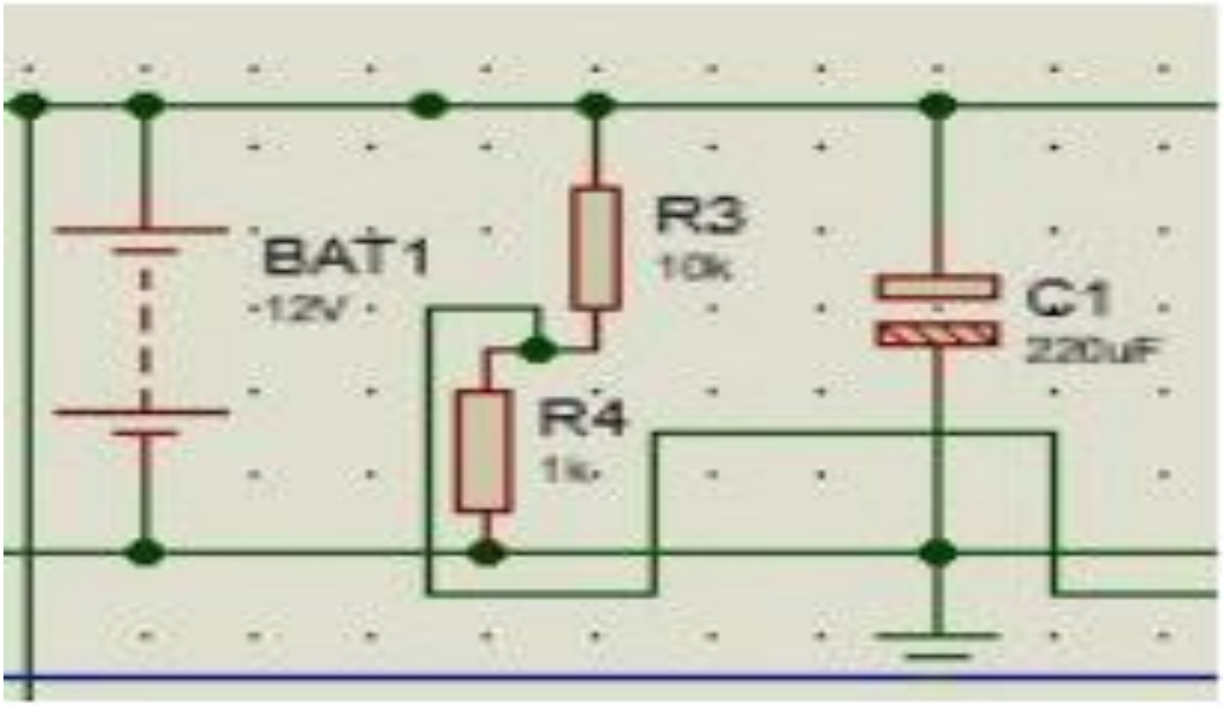

Fig. 10. Battery and voltage level sensing circuit.

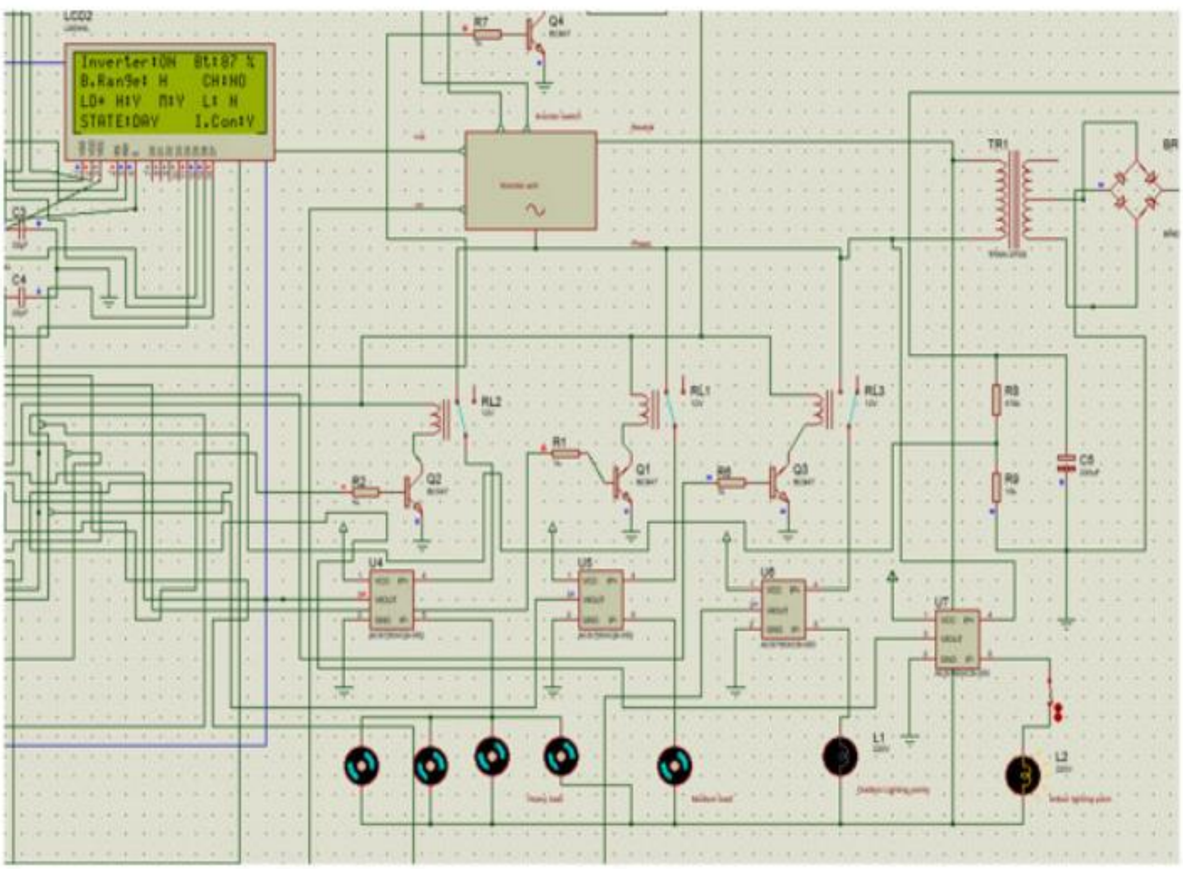

Fig. 11. During the Night with indoor Lightning up

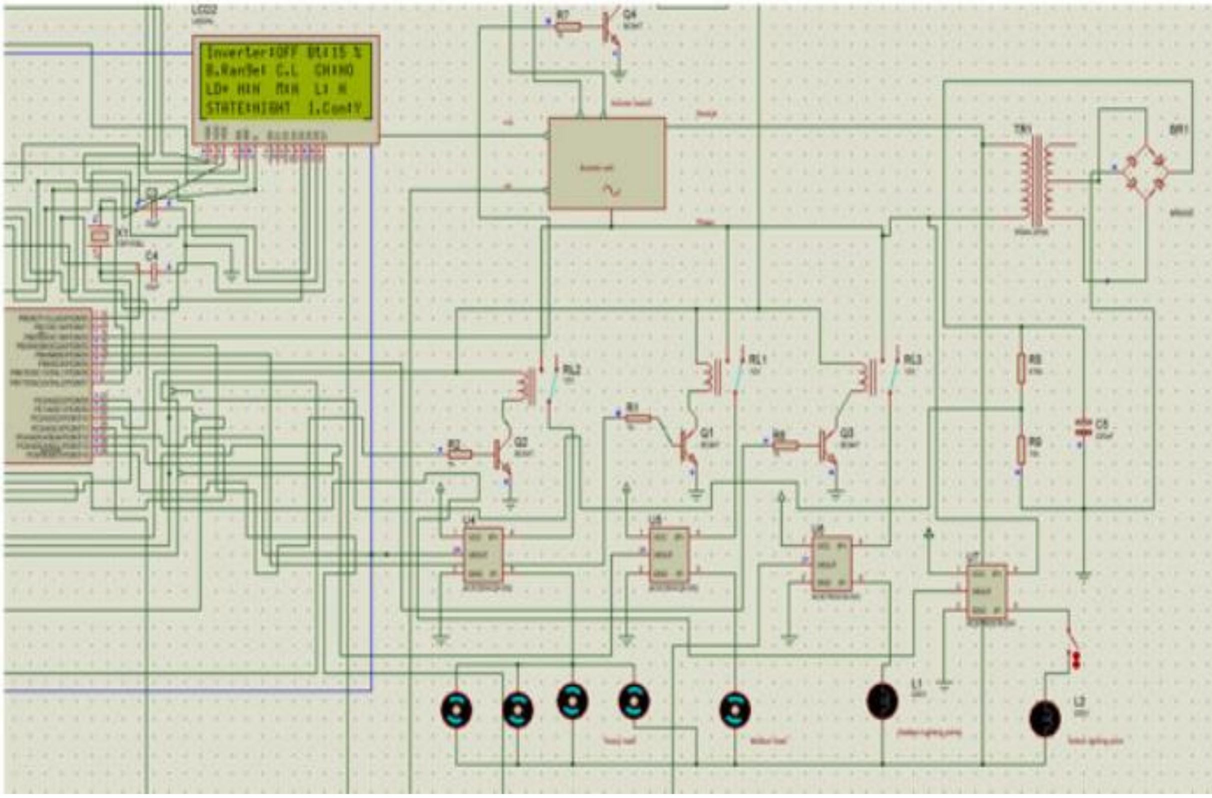

Fig. 12. Battery at Critical Level

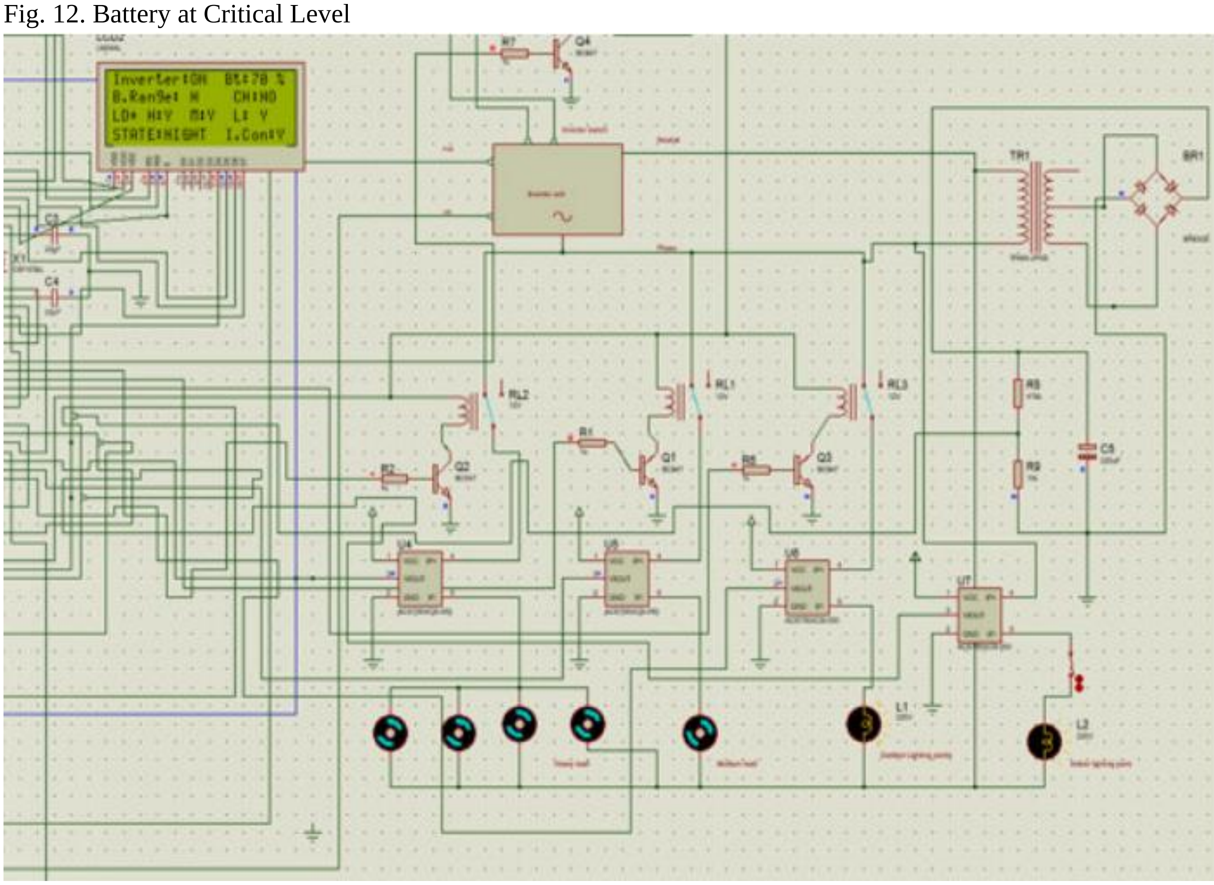

Fig. 13. At Night with all the loads on

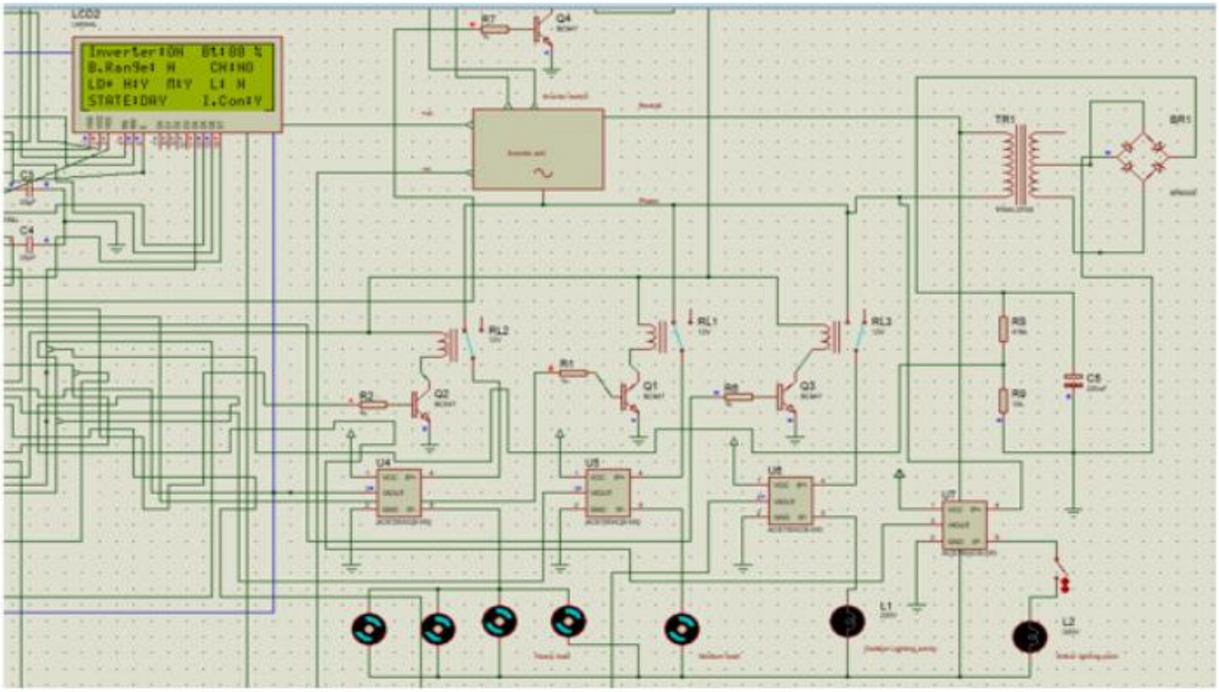

Fig. 14. During the day with all the loads on

V. CONCLUSION

This thesis describes the proposed Smart Energy Management system for households, design and simulation results. He fulfilled the performance of the project design specifications and exact time of day, battery charge status, load line status, battery status and the range and status of the Internet connection at any given time the time is displayed on the 16x2 LCD display. The system is it has been shown to be effective in autonomous driving using the energy of the solar system, which is the goal design.

REFERENCE

[1] C. A. Awosope, Public Lecture, Topic: Nigeria Electricity Industry: ― Issues, Challenges and solutions. School of Applied Engineering College of Engineering, Covenant University, Ota. Public Lecture Series. Vol. 3, No. 2, October, 2014.

[2] A. G. Chmielewski, ―Environmental Effects of Fossil Fuel Combustion‖ in S. H. Kubota, Y. Magara (Eds) Encyclopaedia of Life Support Systems (EOLSS). EOLSS Publishers, Oxford, UK, 2002, www.eolss.net

[3] R. K Rajput, A Textbook of Power Plant Engineering. 4th ed., LAXMI, 2009.

[4] N. Nick; Harvest the Sun: Solar Construction in the Snowbelt; Ayer's Cliff, Quebec: Ayer‗s Cliff Center for Solar Research; 1978

[5] Solar efficiency limit‖, internet: http://solarcellcentral.com/limits_page.html, [Oct 22, 2018].

[6] D. Akinyele, J. Belikov, D and Y. Levron, ―Battery Storage Technologies for Electrical Applications: Impact in Stand-Alone Photovoltaic Systems. ‖ Energies — Open Access Journal of Energy Research, Engineering and Policy, 2nd November 2017. https://doi.org/10.3390/en10111760

[7] Vincent B. Umoh, Josiah J. Obot, Unwana. M. Ekpe. Development Of A Smart Solar Energy Management System. International Journal of Advanced Research and Publications. Vol. 3, No. 2, pp 1-5, February, 2019.

[8] K. Paasch, M. Nymand, F. Haase, ―Distributed Measurement System for Long Term Monitoring of Clouding Effects on Large PV Plant.‖ 15th European Conference on Power Electronics and Applications EPE, Lille, France, 2-6 Sept. 2013. Electronic ISBN: 978-1-4799-0116-6

[9] S. Meena, S. Nigam ―Success Story of Solar Parks in India‖ internet: https://mnre.gov.in/filemanager/akshay-urja/october2017/Images/37- 41.pdf [Oct. 23, 2018]
[10] O. Perpinan, E. Lorenzo and M. A. Castro, ―On the Calculation of Energy Produced by a PV Grid Connected System. ‖ Progress in Photovoltaics: Research and Applications 15 (3), pp 265 – 274, 2007
[11] A. O. Ekwue, and O. A. Akintunde, ―The Impact of Distributed Generation on Distribution Networks, ‖ Nigerian Journal of Technology (NIJOTECH) Vol. 34 No. 2, April 2015, pp. 325 – 331
[12] X. Wang and M. Yue, ―Modeling and Control System Design for an Integrated Solar Generation and Energy Storage System with a Ride-Through Capability, ‖ IEEE Energy Conversion Conference and Exposition Raleigh, North Carolina September 15–20, 2012. NREL/CP-5500-55726
[13] A. Singh, A. Agrawal: ―Solar charge controller, ‖ International Journal of Academic Research and Development Volume 2; Issue 6; November 2017; Page No. 994-1001
[14] J. Doucet, D. Eggleston and J. Shaw, ―DC/AC Pure Sine Wave Inverter, ‖ thesis, Worchester Polytechnic Institute, MQP Terms ABC 2006 - 2007
[15] I. Abasi-Obot, I. Nkan and U. Ekpe ―Comparative Analysis of the Performance of Different Photovoltaic (PV) Technologies Based on PVSyst Thermal Model, ‖ Science Journal of Energy Engineering. Vol. 4, No. 6, 2016, pp. 62-67
[16] M. H. Braga, N. S. Grundish, A. J. Murchison and J. B. Goodenough, ―Alternative Strategy for a Safe Rechargeable Battery, Energy Environ. Sci., 2017, 10, pp 331 - 336