International Research Journal of Engineering and Technology (IRJET) e-ISSN: 2395-0056
Volume: 09 Issue: 08 | Aug 2022 www.irjet.net p-ISSN: 2395-0072

A Low-cost Renewable Energy Solution for Improved Energy Access in Nigeria

Augustine C. Onuora[1], Chiemezuo C. Njoku[2], Prince Ana[3]

[1] *Department of Computer Science, Akanu Ibiam Federal Polytechnic Unwana, Ebonyi State, Nigeria.*
[2]*Department of Electrical Electronics Engineering Technology, Akanu Ibiam Federal Polytechnic Unwana, Ebonyi State, Nigeria.*
[3]*Department of Computer Science, Cross River State University of Technology, Calabar, Cross-River State, Nigeria.*

Abstract - *Inadequate access to constant electricity supply has become one of the key attributes of Nigeria. Power outage is no longer a new issue in Nigeria. Emphatically, more than eighty million Nigerians do not have access to constant electricity. The electricity grid in Nigeria has been characterized by constant collapse. In this paper an attempt is made to present a low-cost solar powered energy source for households in Nigeria. The focus of this study is Afikpo, a town in Ebonyi state south-east of Nigeria. Inhabitants of this town have never enjoyed power from the national grid for quit some years now. To this effect, residents are resorting to alternative means of power. The planning, analysis, design and implementation stages of the solar powered inverter system are presented here in. As a result of this study, the residents of Afikpo are currently enjoying constant power with benefits stated in this paper.*

Key Words: DC-AC power converters, Energy storage, Inverters, Power generation, Solar Panels, Batteries

1. INTRODUCTION

Inadequate electricity has become one of the major challenges in Nigeria [1]. Currently, more than eighty million Nigerians do not have access to electricity. This means that more than 40% of the populace are energy starved. Thus, Nigeria is the largest energy deficient country in the world [2]. Sardonically, the grid-connected citizens are not sure of constant electricity supply. Oftentimes, the grid has been characterized with downtime [3], [4]. Nigeria currently has the capacity of generating about 12,522 MW. This power is primarily generated from the hydro (Kainji and Jebba hydro power) and thermal plants in the country. But it is most unfortunate that the country can only disseminate about 4,000MW of this power to the whole country which is insufficient to cater for the energy needs of the populace in Nigeria [5].

The federal government have taken several steps to improve the condition of the power sector in Nigeria. The have privatized the sector and released huge amount of funds to its revitalization. Several Collaborations with international organizations like African Development Bank (AfDB) for funding have happened and yet, we still have a power grid failure [6].

Currently, the situation of power in the country is still not satisfactory and this has made many citizens to seek for alternative means of power generation. Afikpo as a town in Afikpo – North Local government of Ebonyi state has suffered epileptic power supply for more than twelve year now. Even when other suburb of the state has power that of Afikpo is always a "tale by moonlight".

Power generating sets popularly called "generators" has remained a cheap alternative to power in Afikpo. Generators have their side effects, and this is not this paper intends to cover. One of the side effects is the emission of carbon monoxide that affect our atmosphere.

Solar energy is one of the alternative energy sources that has been thoroughly studied as a means of fulfilling society's needs after fossil fuels have been depleted.

These days, Renewable energy has now been advocated as an alternative for power in residential building and offices. To this effect this paper x-rayed the design and implementation of solar energy project for a residential building in Afikpo metropolis.Finally, complete content and organizational editing before formatting. Please take note of the following items when proofreading spelling and grammar:

2. REVIEW OF RELATED LITERATURE

According to [7], the School Solar Panel System (SSPS) was designed to improve the supply of electricity to promote teacher professionalism in the classroom, so that the energy supply is available even though there is a power outage. [8] demonstrated a hybrid Energy Neutral Home (ENH) that is planned, applied, and evaluated for cost effectiveness in both rural and urban areas of Bangladesh, demonstrating the system's applicability in both areas. In their study, biogas and solar systems are primarily used as hybrid clean energy sources for electricity production.

According to [9] described the design and implementation of an intelligent microgrid on Pulau Ubin Island that uses a high percentage of clean and renewable energy resources to meet current and future electricity demand. To produce electricity, photovoltaic (PV) and biodiesel-powered doubly

fed induction generators were used. The energy storage device was appropriately sized to optimize the usage of green energy while still extending the life of the batteries. To maximize energy generation, track energy demand, regulate instantaneous power distribution, improve electricity efficiency, and produce fault warnings, smart-grid technology such as smart meters, micro grid controllers, and remote management systems with SCADA functions was used.

[10] analyzed the potential of renewable energy in Sarawak, East Malaysia. The feasibility of photovoltaic (PV), Battery and Fuel Cell (FC) based systems were investigated for the load of a village longhouse comprising 50 families located in Kapit, Sarawak. Both systems, including FC (PV/Battery/FC) and excluding FC (PV/Battery) were analyzed and compared with conventional diesel based system. The analysis focuses on net present cost (NPC) and cost of energy (COE). PV and battery was found to have a long term advantage.

The transition to green energies and the smart grid in the power sector has already begun. The microgrid, which is a smaller power grid with connections to all of the critical infrastructure of a larger grid, is the first step toward smart grid. [11] detailed pitfalls to avoid in Microgrid technology and provided an interdisciplinary approach to design and problem solving for smart microgrids.

[12] reviewed variety of projects that was established in various micro-communities, such as small islands and remote settlements, both in terms of actual implementation and assessment studies. Various metrics related to island characterization, energy demand, and possible technological solutions were also considered in his work.

Blockchain technology was used by [13] to implement a blockchain-based microgrid energy market that eliminates the need for middlemen. The case study also showed that blockchains are a viable technology for running decentralized microgrid electricity markets.

3. METHODOLOGY

The methodology employed the system development life cycle (SDLC) [7] [14]. This system development comprises of the planning, Analysis, Design and Implementation. This stages were carefully observed to get the best for optimal performance.

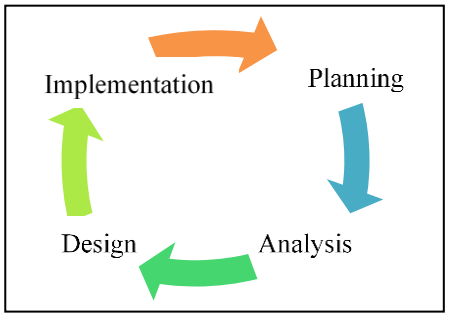

Fig1. System development life cycle

3.1 Planning

During this stage, we have to put into consideration, the amount of energy we need to generate. At this stage we observed that the residents of Afikpo don't have electricity entirely. This made us to adjust in the materials to be used. The renewal energy was not an alternative but the only means of energy to this building. This led us into the next stage.

3.2 Analysis

The analysis of this project was done a thorough investigation of the power need of the residence in question. The following appliances were used in the residence and their power rating were put into consideration. They are

1. One Home theatre
2. Two satellite receiver
3. Two LED television set
4. One Blender
5. One borehole pumping machine
6. One Pressing iron
7. One 1HP air conditioner
8. One deep freezer
9. Thirteen lighting points
10. Five ceiling fans
11. One Microwave oven

3.3 Design

Having known the electricity need of the said residence, a conceptual design of the whole implementation was conceived. The design took into consideration the types of battery cells, solar panel (photovoltaic cells), Inverter and placement.

3.4 Implementation

Inverter: Based on the requirement analysis, we opted for a 5.5kva inverter. This inverter was chosen as a careful

consideration of the loads it going to carry. We also looked at the option of adding more load in the future, so we made the allowance by using a larger inverter instead of the defector 2.5kva or 3.5kva.

Solar Panel: Solar energy can be transformed directly into electricity using a photovoltaic (PV) solar cell, which uses the photoelectric effect to turn sunlight into electricity.

The efficiency of the photovoltaic module, on the other hand, is dependent on the sun's light strength, which is dependent on the atmosphere and the solar panel's orientation [15].

Photovoltaic modules (4 x 200w monolithic solar panels) were used. Two were connected in series and then parallel into the charge controllers.

Battery: Batteries are used to store electricity provided from renewable energy resources so that it can be used when renewable energy is unavailable, such as when solar power is unavailable at night. This is to ensure power supply [16].

The battery used here is a 12v 100Ah battery with a life expectancy of 10 years. Four of such batteries were procured and were connected in series 2 x 2 to get an output of 24v 200Ah battery bank.

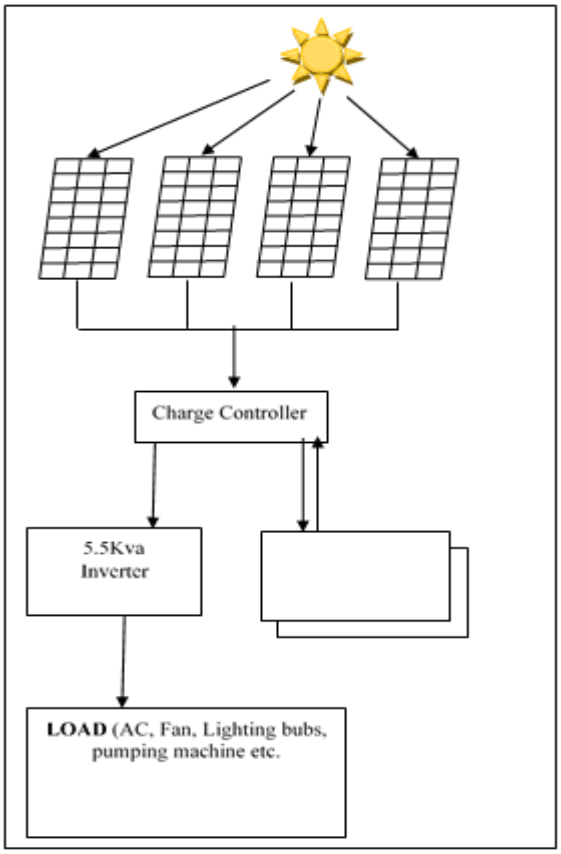

Fig 2: Design concept for Implementation

Charge Controller: A charge controller, also known as a charge regulator, is a voltage and/or current regulator that prevents batteries from being overcharged. It controls the voltage and current going to the battery from the solar panels. As a DC-coupled device, solar charge controllers regulate the energy flowing from the PV array and send it directly to the batteries, which is the most reliable and effective method.

A 60 amps MPPT charge controller was used for the implementation of this project. The choice was that the charge controller always keep the battery on fill voltage condition, 2. Prevent the battery from over-charging and over-discharging. It also prevent the battery from reverse charging to solar panels during nights. When the battery voltage is low, the controller will automatically cut off the load from the system. If the voltage of battery is back to normal and the load will restart working.

4. RESULTS AND DISCUSSION

The components were connected to produce the desired solar home. Residence have been powered by this system for six month now and there has been uninterrupted power in the building. Fig. 3 shows an array of photovoltaic panels while Fig. 4 shows the battery and inverter set-up.

Many residential houses are adopting this solution and are enjoying constant electrical power for six months now. The uninterrupted power been enjoyed by residents have made them to dispose their generating sets (generator) which works with fuel (gasoline).

Residents also confessed that ever since the installation, they have not spent money for purchasing fuel which is a huge savings to them.

Furthermore, there has been noise reduction since power generating sets makes a lot of noise and the cost of constant repairs from generator repairers have ended.

Fig 3: Array of PV panels.

Fig 3: Array of Batteries and Inverter.

5. CONCLUSIONS

For as many that can afford the start-up components, it is highly advisable that they embrace the Solar home. This energy system is clean and hassle free. Residence of Afikpo metropolis and other parts of Nigeria by extension are encouraged to embrace this alternative means of generating power in residential buildings so that they do not live in black out anymore.

We recommend that the government should as well create an intervention scheme to help low-income earners also participate in the installation of this solar home as it is the practice in Korea [17].

Future research that will be geared towards the determination of cheaper ways of providing and implementing renewable energy to low-income citizens.

Policy formulation: the government should enact policies that will aid the citizens in the middle or low class of this country to implement renewable energy in their homes. Also, Government policies should encourage the rich investors to fund mini renewable energy grids for communities.

More research should be done in writing quality software [18] for tracking renewable energy usage as this will help in energy data usage gathering. When these data is analyzed, certain patterns can be identified that can help improve the whole system for sustainability.

ACKNOWLEDGEMENT (Optional)

The authors gratefully acknowledge the contributions of Mrs Gloria Onuora, Mr. Henry O. Nvene and Mr. Obanla Anthony for their effort towards making this project a reality.

REFERENCES

[1] R. E. Ogu and G. A. Chukwudebe, "Development of a Cost-Effective Electricity Theft Detection and Prevention System based on IoT Technology," in IEEE 3rd International Conference on Electro- Technology for National Development (NIGERCON) Development, 2 017, pp. 756–760.

[2] World Bank.org "Nigeria to Improve Electricity Access and Services to Citizens." https://www.worldbank.org/ en/news/press-release/2021/02/05/nigeria-to-improve-electricity-access-and-services-to-citizens (accessed May 15, 2021).

[3] K. Olatunji, "Poor electricity supply worsens as national grid collapsesNigeria — The Guardian Nigeria News – Nigeria and World News," May 13, 2021.

[4] O. Udegbunam, "Nigeria's electricity grid collapses again | Premium Times Nigeria," May 12, 2021.

[5] Trade.gov. "Nigeria - Electricity and power systems." International Trade Administration | Trade.gov, 14 Sept. 2020, [Online]. Accessed on: May 11, 2021. Available: www.trade.gov/ country-commercial- guides/nigeria-electricity-and-power-systems.

[6] Tdworld.com. "AfDB approves financing to Kainji and Jebba hydro power project in Nigeria." T&D World, 2 Feb. 2017, [Online]. Accessed on: May 10, 2021. Available: www.tdworld.com/renewables/ article/20967515/afdb-approves-financing-to-kainji-and-jebba-hydro- power-project-in-nigeria.

[7] S. D. Riskiono et al. "Implementation of the School Solar Panel System to Support the Availability of Electricity Supply at Sdn 4 Mesuji Timur." International Journal Information System and Computer Science (IJISCS), vol.5 , no.1, 2021, www.ojs.stmikpringsewu.ac.id/ index.php /ijiscs/article/view/960.

[8] C. K. Das et al. "Design and Implementation of a Hybrid Energy Neutral Home System for Bangladesh." International Journal of Renewable Energy Resources, vol. 3, 2013, pp. 66-72.

[9] F. Yang, et al. "Design and Implementation of stand-alone smart grid employing renewable energy resources

on Pulau Ubin Island of Singapore." 2012 Asia-Pacific Symposium on Electromagnetic Compatibility, 2012.

[10] H. S. Das et al. "Feasibility analysis of hybrid photovoltaic/battery/fuel cell energy system for an indigenous residence in East Malaysia." Renewable and Sustainable Energy Reviews, vol. 76, 2017, pp. 1332-1347.

[11] F. Hassan. Smart Microgrids: Lessons from Campus Microgrid Design and Implementation. CRC P, 2016.

[12] N. Diana, et al. "Design and implementation of hybrid renewable energy systems on micro-communities: A review on case studies." Renewable and Sustainable Energy Reviews, vol. 31, 2014, pp. 935-946.

[13] E. Mengelkamp et al. "Designing microgrid energy markets." Applied Energy, vol. 210, 2018, pp. 870-880.

[14] World Bank. "Variable renewable energy integration and planning study." World Bank, Washington, DC. © World Bank, 2020. doi:10.1596/34586.

[15] K. R. Ajao, R. M. Ambali, and M. O. Mahmoud. "Determination of the optimal tilt angle for solar photovoltaic panel in Ilorin, Nigeria." Journal of Engineering Science and Technology Review 6, no. 1 (2013), 87-90. doi:10.25103/jestr.061.17.

[16] M. Kumar. "Design of Isolated Micro Grid Using Renewable Energy Resources with Energy Storage System via HOMER Software A Case Study of a Thar Community." Sukkur IBA Journal of Computing and Mathematical Sciences (SJCMS) 5, no. 1 (2021). https://doi.org/10.30537/sjcms.v5i1.811

[17] L, Joohyun, and M. M. Shepley. "Benefits of solar photovoltaic systems for low-income families in social housing of Korea: Renewable energy applications as solutions to energy poverty." Journal of Building Engineering 28 (2020), 101016. doi:10.1016/j.jobe.2019.101016.

[18] A. C. Onuora, P. Ana, U. N. Nwanhele and O. J. Idemudia. “Improving Software Quality by Developing Redundant Components.” International Research Journal of Engineering and Technology (IRJET). Vol 7. 2020, pp 151-155.

BIOGRAPHIES

Onuora, Augustine Chidiebere is a lecturer with the Department of Computer Science, AIFPU.

Chiemezuo C. Njoku is a lecturer with the department of Electrical Electronics Engineering Technology AIFPU.

Ana Prince is a Lecturer with the Department of Computer Science, Cross-River State University of Technology (CRUTECH).