DESIGN AND ANALYSIS OF A MICROGRID SYSTEM FOR A RELIABLE ELECTRIFICATION IN EZIOBODO

Vincent Okonji Agumuete[1] Uzoechi Lazarus Okechukwu[2] Akwukwaegbu Isidore Onyema[3]

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ABSTRACT

This research work is on the Design and Analysis of a Microgrid system for a Reliable electrification in Eziobodo. It harnesses the available renewable energy resources in Eziobodo community in order to achieve a sustainable off-grid electricity. The methods used in achieving this included the use of Homer Pro Software to collate data such as monthly rainfall, sunlight and wind speed. The Homer Pro software allows the researchers to key in the location of the research, parameters of interest (renewable energies) and then relates them to the National Aeronautics and Space Administration (NASA) database. Thereafter, the software has inbuilt renewable energy components which are used in building up the system online. At the end, it suggests the best for deployment. The resources were downloaded based on the location (Owerri) of this design. It was observed from the simulation result that the peak load monthly consumption was July**.** By summing the individual load profile of each building in chapter 3, a total of 40.6409kw/day was realized. This simply means that the energy resources available in the location of this design must produce enough energy to run the available loads seamlessly. And from the Homer pro design schematic, 64.80kwh/d was realized which was more than enough to power buildings having a total load consumption of 40.6409kw/day.

Key words: Eziobodo**,** Homer Pro, NASA, Internet, Grid, Solar, Renewable Energy, off-grid, Inverter, Solar panel, Personal Computer and Battery.

1.1 BACKGROUND OF THE STUDY

Today, energy sources are being decentralized that don't rely on the traditional electric power grid and continue to grow. This is changing the face of the energy industry; from solar cells to combined heat and power plants. This has led to the development of microgrids which are small-scale power networks. Through the integration of multiple power sources, microgrids can maximize efficiency and ensure uninterrupted power.

A microgrid is a flexible and localized power generation system that combines multiple assets. While each system is unique, they all share common elements. A microgrid utilizes renewable energy sources such as solar panels, wind turbines, battery storage, diesel gen-sets and Combined Heat and Power (CHP) modules–operating separately or in parallel. Diesel or gas generator sets may also be included, along with battery banks to store electricity and deliver it when needed. Control systems are a critical component to every microgrid, designed to provide exactly the right energy mix for the customer. Since a microgrid is used primarily for local demand, typical users are local energy consumers which include residential, industrial, service providers, municipal services, among others. These users may be on the power grid with unlimited access or running self-sufficient off the grid.

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A micro grid is a modern distributed power system using local sustainable power resources designed through various smart-grid initiatives. It also provides energy security for a local community as it can be operated without the presence of wider utility grid. Micro grid technology generally represents three important goals of a society such as reliability (physical, cyber), sustainability (environmental considerations), and economics (cost optimizing, efficiency). The “distributed generation” (DG) term refers to power generation located at or near the consumption sites. By comparison to “central generation”, DG can eliminate the generation, transmission, and distribution costs while increasing efficiency by removing elements of complexity and interdependency. In many cases, distributed generators can provide lower generation costs, higher reliability, and increased security not realized via traditional generators. For instance, Pike Research has identified 3.2 gigawatts (GW) of globally existing microgrid capacity (Hossain, Kabalci, Bayindir, and Perez (2014), Asmus, Lauderbaugh, and Adamson (2012), Ula, Kalkur, Mattmuller, Hofinger, Bhat, Chowdhury, Whitaker, and Buchmann (2005)). The North America leads the global microgrid generation with 2,088 MW operating capacity according to the report Asmus, Lauderbaugh, and Adamson (2012). On the other hand, Europe holds the second rank with 384 MW installed microgrid capacity while Asia Pacific follows with 303 MW of operating capacity. The installed microgrid capacity in the rest of world is around 404 MW. If each power user (building/company/hospital/market) cares about reliable power and keep their desire to back up energy source like generation/battery/diesel engine that would be the most expense power system. In a microgrid system, backup resources are unnecessary because a single user does not have to supply a general load during critical consumption periods. One billion dollars of energy consumption can be conserved by managing a few hundred-summer peak hours by shifting or eliminating loads. Therefore, reliability is a major justification for microgrid operation (Hossain et al. (2014)). Microgrids could also prove economically viable in the southwestern US. The sustainability is another most important factor for considering this new technology, but less so, in the US; it is more necessary in China where a great deal of environment issues is emerging nowadays. The microgrid could tackle the energy crisis since the transmission losses are greatly reduced. Additionally, a microgrid provides significant reduction in generation costs while providing reliable and sustainable energy to loads. The cyber security issue is addressed as well due to the localized nature of the system. Microgrid technology is suitable for regions with an underdeveloped transmission infrastructure, such as remote villages where an islanded microgrid would be the most advantageous kind of power network (Ula et al., 2005). Microgrids that are similar to a conventional grid structure in terms of power generation, distribution, transmission, and control features are assumed as a minor model of actual grid form. However, microgrid technology differs from a conventional grid owing to the distance between power generation and consumption cycles as a microgrid is installed near the load-sites. Microgrids also integrate with distributed generation plants such as combined heat and power (CHP), and renewable energy plants powered by solar energy, wind power, geothermal, biomass, and hydraulic resources (Ula et al., 2005, Mariam, Basu, and Conlon 2013). Although the power rate of microgrids is limited to a few MVA, it is relative to its application area and grid type. Power parks refer to interconnection of several microgrids that are installed to meet higher power demands where increased stability and control opportunities are necessary. Moreover, the interconnection of renewable sources and a microgrid contributes to decreased environmental emissions (Asmuset al. 2012, Eto, Lasseter, Schenkman, Stevens, Klapp, Volkommer, Linton, Hurtado, Roy, 2009). In a macrogrid (conventional grid application), only one-third of the fossil fuel consumed is converted to electricity; the remainder is dissipated as heat energy. A microgrid, on the other hand, can communicate with consumers and thus manage demand and supply easily. About 5-7% power is lost along transmission lines in a macrogrid whereas, in a microgrid, all the power stays at the distribution level. Another projected point is that a 20% of generation capacity exists to meet peak demand of 5% time for utility grid where it has a “domino effect failure” can lead to a blackout. In North America, in 2003, more than a hundred power plants were forced to stop power generation due to the cascading effect of failing plants. One feature of a microgrid is independent operation during widespread failure or during fluctuation of power (intentionally or unintentionally), or even for costoptimization purposes. In reality, microgrid has black start facility if it is required due to any sort of disaster (Cho, Jeon, Kim, Kwon, Park,and Kim, 2011, Eto et al. 2009, Lidula and Rajapakse 2011). This study will briefly describe the components, structure and types of microgrids. The paper presents an introduction to microgrids by assembling several comparisons, components, and control methods

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that are independently examined in current research. It is intended to lead the researcher to examine the real-world application of a microgrid and provide insight for potential improvements. Additionally, the comparison of microgrids in several regions with varying parameters will allow a conclusion on the design requirements for a particular microgrid application scenario with specific, available resources. It also tabulates all necessary information about microgrids, and then proposes a standard microgrid for optimal power quality and maximized energy harvest. Finally, it focuses on removing knowledge gaps related to power systems in light of a future trend and potential improvements (Hossain et al. 2012, Lidula and Rajapakse 2011, Ustun, Ozansoy, andZayegh (2011)).

1.2 STATEMENT OF THE PROBLEM

The power industry in Nigeria today faces many problems including the rising cost of energy, power quality and stability, an aging infrastructure, effects of climate change and greenhouse effects and so on. Those problems can be overcome using low-voltage distribution generation where all sources and loads are collocated.

The two most common causes of blackouts are extreme weather conditions and time-worn power lines. Serious cases of power outages threaten millions of people and already caused billion-dollar damages across many countries including Nigeria. Besides paralyzing life within the affected areas, a huge blackout can result in electronic device damage, important data loss, loss of production and loss of lives, among others.

Electricity distribution over long distances increases the temperature within power lines and thus causes significant energy losses in the form of heat. In the end, these losses are paid for by everyday electricity consumers. In 2019, fees related to electricity transmission losses represented 4.57 % of the final electricity price for households and 4 % for business owners in Slovakia (Larson, 2020). Even though the amount of energy that is loosed is relatively low in Europe, around 4-5 %, in other countries it is reaching much higher numbers, for example 19% in India and an astounding 50 % in Haiti (Larson, 2020).

Many of the electric transmission grids in service around the world were designed and built more than a half century ago. While changes and upgrades have obviously been made over the years, the systems were generally developed with very different resources in mind than what is regularly coming online today. However, most of the problems created by renewables and distr ibuted energy resources have workable solutions that can lead to a reliably functioning modern power grid.

A shift from electricity production in a few big power plants to a system of small local energy sources that ensure energy is consumed as close as possible to its source, even on the level of individual residential buildings is key to solving these problems.

1.3 AIM AND OBJECTIVES

The main aim of this work is the design and analysis of a microgrid system for a reliable rural electrification in Eziobodo. The specific objectives include

i. Development of a microgrid architecture for Eziobodo
ii. Design of the microgrid for Eziobodo
iii. Simulation of the microgrid using Homer Pro solar energy simulation software
iv. Analysis of the designed microgrid

1.4 JUSTIFICATION OF THE STUDY

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The need to enhance the production and utilization of electricity within the study area is very paramount. This is due to the incessant outages experienced in the area and the need to mitigate the noise pollution as a result of deployment of generators and the global issue climate change as a result of greenhouse gases. Also, the transmission line losses and the aging infrastructure contribute in no small measure to the existing epileptic power supply being experienced. It is hopeful that at the end of this work, the power supply from alternative sources will drastically improve.

1.5 SCOPE OF STUDY

This work will be limited to the design and analysis of a microgrid system for the Eziobodo Community. The system architecture will be developed while only a simulation of the proposed microgrid will be carried out. The control of the microgrid developed for the study area will not be performed.

2.1 LITERATURE REVIEW: THE TRADITIONAL POWER GRID

The traditional electric power grid connected large central generating stations through a high voltage (HV) transmission system to a distribution system that directly fed customer demand. Generating stations consisted primarily of steam stations that used fossil fuels and hydro turbines that turned high inertia turbines to produce electricity. The transmission system grew from local and regional grids into a large, interconnected network that was managed by coordinated operating and planning procedures. Peak demand and energy consumption grew at predictable rates, and technology evolved in a relatively well-defined operational and regulatory environment. Over the last hundred years, there have been considerable technological advances in the bulk power grid. The power grid has been continually updated with new technologies including

i. increased efficient and environmentally friendly generating sources
ii. higher voltage equipment
iii. power electronics in the form of HV direct current (HVDC) and flexible alternating current transmission systems (FACTS)
iv. advancements in computerized monitoring, protection, control, and grid management techniques for planning, real-time operations, and maintenance
v. methods of demand response and energy-efficient load management. The rate of change in the electric power industry continues to accelerate annually.

2.1.1 Drivers for Change

Public policies, economics, and technological innovations are driving the rapid rate of change in the electric power system. The power system advances toward the goal of supplying reliable electricity from increasingly clean and inexpensive resources. The electrical power system has transitioned to the new two-way power flow system with a fast rate and continues to move forward as in Figure 2.1 while Figure 2.2 shows the transition from the existing system to the new electrical system components.

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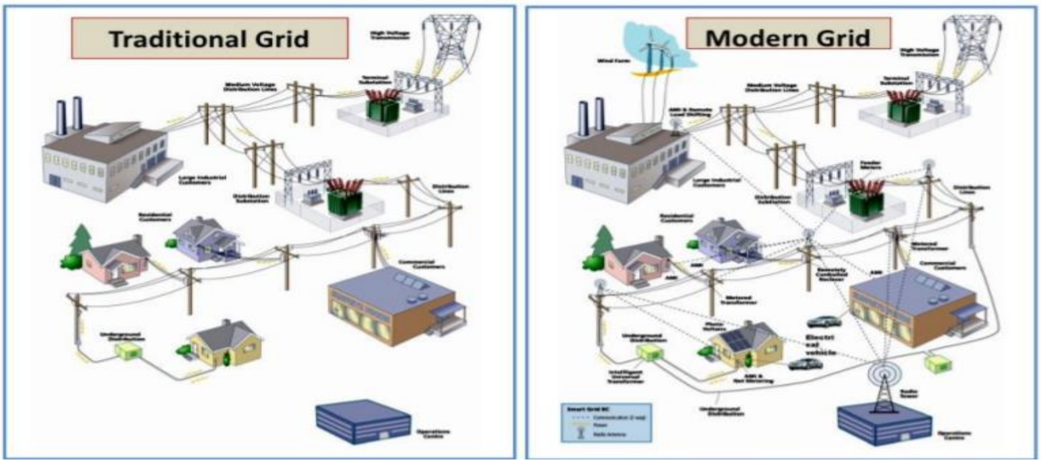

Figure 2.1: Transition from a traditional to new electrical grid with two-way power flow [Source: Henderson, Novosel, and Crow, 2017]

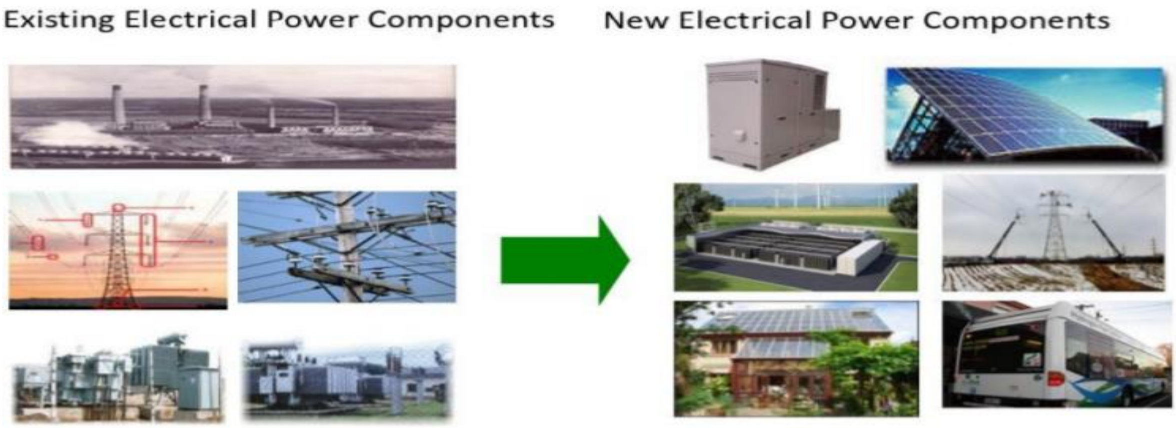

Figure 2.2: Transition to the new electrical system components from the existing [Source: Henderson, Novosel, and Crow, 2017]

The re-regulation of electric power industries in the United States and elsewhere introduced wholesale electric markets. Competition shifted the risk away from rate payers to investors, reduced consumer costs, and supported rapid innovation. The advent of markets and environmental policies prompted significant changes in the fuel mix of generating stations that shifted from coal and nuclear generation to efficient natural-gas-fired combined cycle units. A tension exists between the wholesale electric markets and public policies that subsidize, or in other ways promote, the use of renewable resources, energy efficiency, and demand response. However, the economics of these technologies have become increasingly favorable, and their applications have resulted in lower costs to consumers and greater environmental sustainability. Recent developments include the advent of retail access and even distribution markets, which offer more consumer choices and business opportunities but complicate managing the electric power grid. Regulatory reform continues driving changes to the electric power industry. The regulatory revolution helped spur technological development. The Internet of Things (IoT) facilitates more customer choice that can be managed locally, remotely, or automatically and enables changes in consumer behaviour and expectations. The distribution system was originally designed and built to serve peak demand and passively deliver power through radial infrastructure. Today, however, many customers are increasingly using the grid as a means to balance their own generation and demand and also as a backup supplier when their locally sourced generation is unavailable. More and more, customers are becoming prosumers and expect to deliver excess generation back to the grid and be paid for it, without restrictions on their production. However, customers still expect the grid to be available to provide power when they need it. These competing interests have dramatically changed distribution system operation. The digital revolution also

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manifests itself through dramatic improvements in monitoring and control equipment in the traditional power system. Additionally, innovative analysis and techniques have allowed more rapid situational awareness to grid operators. Advances in material science and controls have led to new applications of power electronics; one example of new technology is smart inverters for photovoltaic (PV) systems that can actively interact with the distribution system. Innovations in solar and wind generation and energy storage have resulted in both performance improvements and cost reductions. Increased sales as well as technological advances have reduced the pricing of solar panels. Several states in the United States, such as California and New York, and countries such as Germany, Spain, and Australia have ambitious goals for achieving high penetration levels of renewable generation and Distributed Energy Resources (DERs) in the coming years. Regulatory policies, such as net-zero metering, can be used to encourage growth in PV installations. Net-zero metering allows consumers to sell surplus power to the grid and subsidizes the owners for installing PV panels. However, even consumers who have a net-zero footprint will often use grid power during cloudy days and at night, still relying on the availability of the distribution grid. Unfortunately, the net-zero metering policy causes customers who do not have solar panels to subsidize those who do, since the expansion and maintenance costs of the distribution system are included in the rate base. Therefore, customers who consume more electricity from the traditional grid bear a disproportionately larger share of the infrastructure costs. This effect is further exacerbated since PV panels are typically installed by consumers who are financially better off.

These examples are from the United States. However, in any electrical system around the world, extreme care must be taken so that the adoption of renewable technologies and the shift in fuel sources do not undermine the reliability and resilience of the electric grid. The worldwide power industry needs to reliably generate its electricity, given the various environmental policies and economic considerations, while assuring that the reliability and resiliency of the electric power system is not negatively affected by this change

2.2 NEED FOR A NEW GRID

In achieving these goals, a key question is how much should be invested in the grid as more and more DER systems serve loads without utilizing the grid for extended periods of time. The reliability and safety of serving electrical power loads may potentially be negatively affected if the transmission and distribution (T&D) grid is not available or capable of providing backup for renewable power intermittencies. Therefore, increasing the ability of the T&D system to host and enable the use of increasing penetration levels of DERs is necessary. Grid modernization and DER proliferation are certainly interrelated, but the latter is not a requirement for the former. Utilities such as Commonwealth Edison (ComEd) and CenterPoint, which operate in service territories with incipient penetration levels of DERs, have successfully implemented grid modernization initiatives with the purpose of improving grid reliability, resiliency, and system efficiency; addressing growing expectations regarding customer service; and replacing foundational aging infrastructure. For example, ComEd's Energy Infrastructure Modernization Act, which includes the deployment of 2,600 smart switches and 4 million smart meters, has been able to avoid over 4.8 million customer interruptions since 2012. An additional benefit of this modernized infrastructure will be to facilitate the transition toward a new paradigm that includes a high penetration of DERs. Utilities operating in states such as California and Hawaii aggressively promote DER adoption to achieve RPS goals and move toward a modernized distribution grid at a fast pace. Furthermore, since an even larger-scale adoption of DERs is inevitable, given the planned achievement of grid parity by distributed generation in these markets, additions in grid modernization infrastructures and systems should be considered necessary investments to enable the normal operation of modern and future distribution systems.

2.2.1 Future of Grids

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In Fig. 2.3, the application market of microgrids in 2022 is predicted where the majority of applications would be for campus type microgrids.

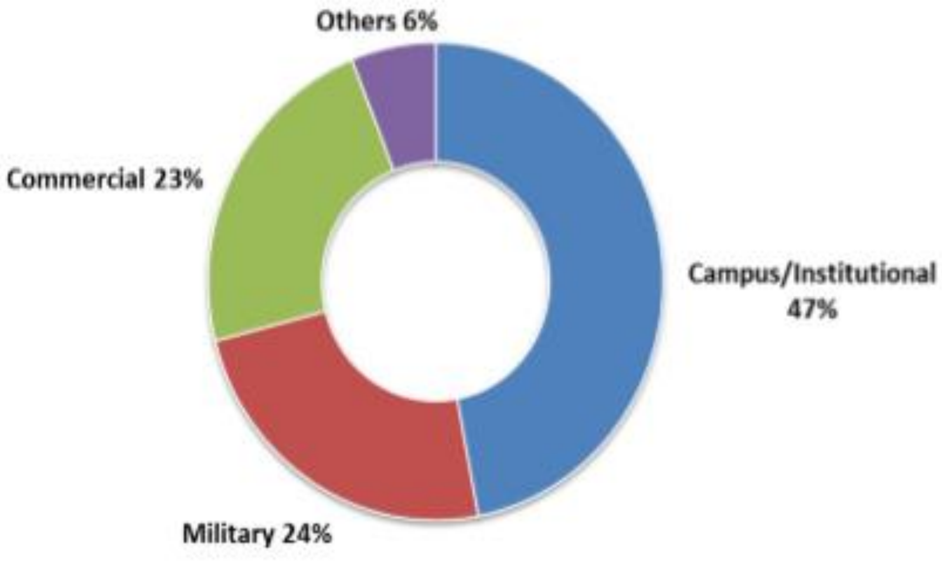

Figure 2.3: Microgrid application market forecasted in 2022 [Source: https://www.ornl.gov/sites/default/files/Grid%20Modernization.pdf]

The projected microgrid market growth and the growth of microgrid revenue by region have been shown in Fig. 2.4 and Fig. 2.5 where North America holds the largest share. An estimation of microgrid growth follows as (Fast Market Research (2013), Yu (2014), Ise (2006), Marnay and Venkataramanan (2006), Peças Lopes, Moreira, and Resende (2005)).

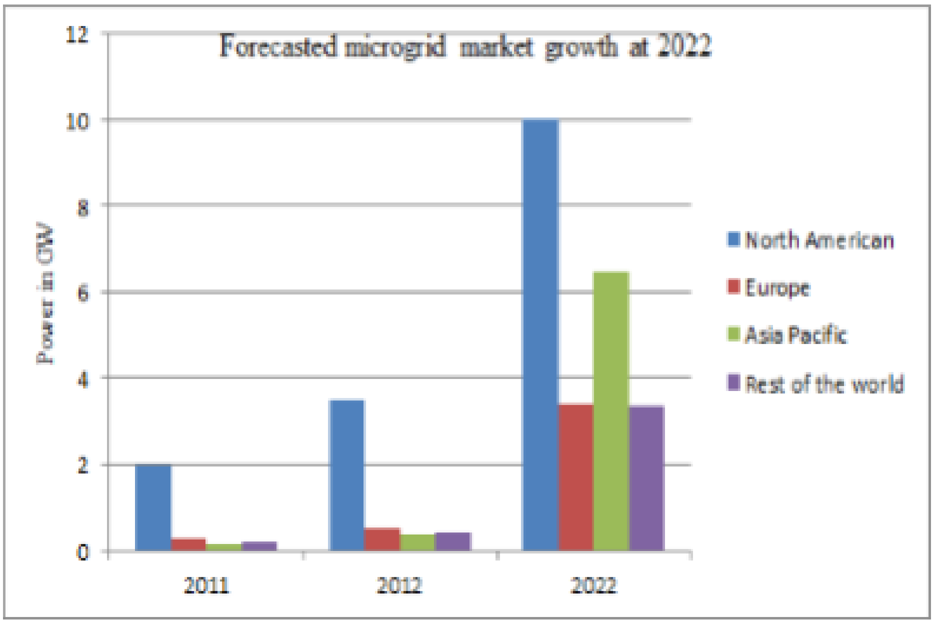

Figure 2.4: Microgrid market forecasted growth in 2022[Source: https://www.ornl.gov/sites/default/files/Grid%20Modernization.pdf]

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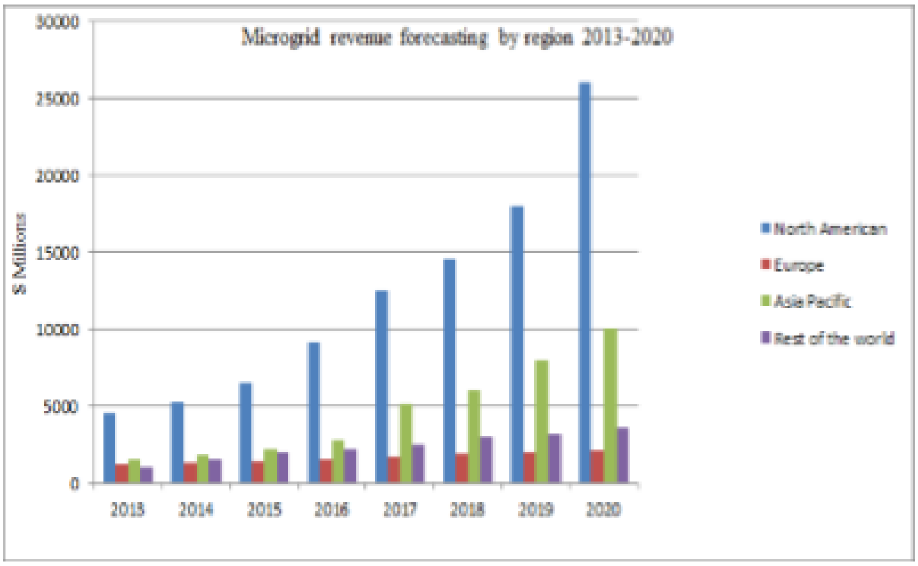

Figure 2.5 Growth of microgrid according to region [Source: https://www.ornl.gov/sites/default/files/Grid%20Modernization.pdf]

i. The growth of globally installed microgrid capacity has increased dramatically since 2011 and is forecasted to reach a total installed capacity of over 15GW by 2022.
ii. The market presents a potential of over $5billion and is likely to reach over $27 billion by 2022, in terms of market value for dealers
iii. At present, campus/institutional microgrids are the largest by application and is forecasted to grow at a compound annual growth rate (CAGR) of 18.83% from 2012-2022.
iv. Military, defense-based and commercial microgrids are forecasted to have a similar installed capacity by 2022.
v. Off-grid microgrids continue to grow at the highest CAGR for next 5-6 years, while the hybrid market is expected to grow at the highest CAGR during 2012-2022.
vi. A longer payback period requires for a completely developed microgrid.

There are many research opportunities still available before microgrids begin to play an important role in communities. Several vital issues have been explained below (Marnay and Venkataramanan (2006), Peças Lopes, Moreira, and Resende (2005)).

The electric power industry faces significant challenges in achieving grid parity. The successful integration of variable energy resources presents opportunities for a cleaner environment but poses issues that include an increased need for regulation, ramping, and reserves. Applications of HVDC and FACTS provide performance solutions, but they may further complicate network operation and planning. The need for network control becomes exacerbated by the large-scale growth of energy efficiency and demand utilizing inverter-based technologies, including applications of electric transportation vehicles. The development of demand energy resources and demand response presents additional changes to the distribution system that must then perform with power flows in two directions where, historically, power flowed in only one direction. Microgrids provide reliability and resiliency but also significantly change the physical attributes of the network. While the electrical power system is becoming more distributed, and will continue to do so, it is important to note that today's interconnected grid began as a series of distributed grids. Interconnected grids were created to improve grid cost-efficiency, reliability, service quality, and safety. As technology advancements made it easier to deploy distributed renewable resources, the fundamental benefits of a connected grid still hold. While the present grid is very reliable, users will demand even more reliability from electric power delivery in the future, including resilience during major weather or security events. The integration of DERs and distributed grids can increase efficiencies in the use of the existing grid as well as become part of the overall development strategy to balance supply and demand uncertainties and risks with a variety of

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different resources, assuring resilient, flexible, and safe power delivery to consumers. Furthermore, innovative changes to the regulatory climate will also affect paradigms of the electric power business. Rates based purely on energy sales will rapidly diminish. Traditional utilities will transform into electricity providers that deliver services, such as installing distributed resources, aggregating customers who participate in the wholesale electric markets, and arranging for backup energy on demand.

2.3 MICROGRID

A micro grid is a flexible and localized power generation system that combines multiple assets. While each system is unique, they all share common elements. A micro grid utilizes renewable energy sources such as solar panels, wind turbines, battery storage, diesel gen sets and Combined Heat and Power (CHP) modules–operating separately or in parallel. Diesel or gas generator sets may also be included, along with battery banks to store electricity and deliver it when needed. Control systems are a critical component to every microgrid, designed to provide exactly the right energy mix for the customer. Since a microgrid is used primarily for local demand, typical users are local energy consumers which include residential, industrial, service providers, municipal services, among others. These users may be on the power grid with unlimited access or running self-sufficient off the grid.

A micro grid is a modern distributed power system using local sustainable power resources designed through various smart-grid initiatives. It also provides energy security for a local community as it can be operated without the presence of wider utility grid. Micro grid technology generally represents three important goals of a society such as reliability (physical, cyber), sustainability (environmental considerations), and economics (cost optimizing, efficiency). The “distributed generation” (DG) term refers to power generation located at or near the consumption sites. By comparison to “central generation”, DG can eliminate the generation, transmission, and distribution costs while increasing efficiency by removing elements of complexity and interdependency. In many cases, distributed generators can provide lower generation costs, higher reliability, and increased security not realized via traditional generators. For instance, Pike Research has identified 3.2 gigawatts (GW) of globally existing microgrid capacity (Hossain, Kabalci, Bayindir, and Perez (2014), Asmus, Lauderbaugh, and Adamson (2012), Ula, Kalkur, Mattmuller, Hofinger, Bhat, Chowdhury, Whitaker, and Buchmann (2005)).

2.3.1 Overview of the Microgrid

Researchers are extensively studying microgrids in order to construct test beds and demonstration sites; the classification of microgrids and relevant key technologies should, therefore, be addressed (Hossain, et al. (2014), Majumder (2013), Ma and Hous (2012)). In this paper, we categorize microgrids into three types: facility microgrids, remote microgrids, and utility microgrids. The following characteristics are considered: their respective integration levels into the power utility grid; their impact on main utility providers; their different responsibilities and application areas; and their relevant key technologies. Facility microgrids and utility microgrids have utility connection modes while remote microgrids do not. Remote microgrids are located in highly dispersed consumption areas as compared to facility and utility microgrids. Facility microgrids can keep on operating in an intentional or an unintentional island mode. However, in every type of microgrid, the micro sources, loads, network parameters, and control topologies will vary (Hossain, et al. (2014), Majumder (2013), Ma and Hous (2012)). First, a definition: “a microgrid is a localized group of electricity sources and loads that normally operate interconnected, and acts as a single controllable unit that is synchronous with the traditional centralized grid (macrogrid) but can disconnect and function autonomously as physical and/or economic conditions dictate” (Wang, Li, Xu and Li, 2011). As shown in Fig. 1, a microgrid is made up of various renewable distributed generators, nonrenewable distributed generators, energy storage devices, different types of microgrid loads, interfaced distributed energy resources (DER), interconnected microgrids, stability and control systems, and communication systems (Ula et al. (2005), Mariam, Basu, and Conlon (2013)). A point of common coupling (PCC) is the interconnection of a macrogrid and the

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distribution/generation side of a microgrid (Ding, Zhang, and M. Mao (2009), Fast Market Research (2013), Yu (2014), Ise (2006), Marnay and Venkataramanan (2006), Peças Lopes, Moreira, and Resende (2005)).

2.3.2 Microgrid Loads

A microgrid system has various kinds of load and it plays a vital role for its operation, stability and control. An electrical load can be categorized as a static or motor/electronic load. The microgrid can supply various kinds of loads (such as household or industrial) which are assumed to be sensitive or critical, and demand high-level reliability. This kind of operation requires several considerations such as priority to critical loads, power quality improvement supplied to specific loads, and enhancement of reliability for pre-specified load categories. Additionally, local generation prevents unexpected disturbances with fast and accurate protection systems (Lidula and Rajapakse 2011, de Boer and Raadschelders; Planas, Gil-de-Muro, Andreu, Kortabarria, and Martínez de Alegría (2013)). The load classification is important to define the predicted operating strategy in a microgrid arrangement under the following considerations (Linton, Hurtado and Roy, 2009):

i. The load/source operation strategy required to meet the net active and reactive power in grid-tied mode, and stabilization of the voltage and frequency in island mode.
ii. improvement of power quality,
iii. reduction of maximum load to enhance the DER ratings,
iv. maintaining desired operation and control.

2.3.3 Types of Microgrids

According to the U.S. Department of Energy (https://microgridknowledge.com/nested-microgrid/), a microgrid is a group of interconnected loads and distributed energy resources (DER) within clearly defined electrical boundaries that act as a single controllable entity with respect to the grid. A microgrid can connect and disconnect from the grid to enable it to operate in either grid-connected or island mode. Additionally, the microgrid's operational controls need to be fully coordinated when connected to the main power grid or while islanded, requiring additional equipment, communications and control applications. Installing only a backup diesel genset at a premise is not technically considered a microgrid. However, significant opportunities exist to deploy DERs integrated to the grid while not technically comprising a microgrid.

There are three main types of microgrids, namely remote, grid-connected and networked.

a) **Remote Microgrids:** Also known as off-grid microgrids, they are physically isolated from the utility grid and operate in island mode at all times due to the lack of available and affordable transmission or distribution (T&D) infrastructure nearby. For these remote scenarios, renewables, such as wind and solar, typically provide a more economic and environmentally sustainable DER solution for the microgrid operator. Additionally, many remote microgrids are considering battery energy storage systems for backup power in lieu of conventional generators.
b) **Grid-connected Microgrids:** These microgrids have a physical connection to the utility grid via a switching mechanism at the point of common coupling (PCC), but they also can disconnect into island mode and reconnect back to the main grid as needed. In grid-connected scenarios, a microgrid that is effectively integrated with the utility service provider can provide grid services (e.g., frequency and voltage regulation, real and reactive power support, demand response, etc.) to help address potential capacity, power quality and reliability, and voltage issues on the utility grid.
   In islanded scenarios, local voltage and frequency controls are required within the microgrid and can be provided by energy storage (e.g., battery, flywheel) or a synchronous generator (e.g., CHP, natural gas, fuel cell diesel). Due to its ability to perform multiple functions for grid services and emergency backup power, battery energy storage systems have been

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gaining popularity for microgrids that need to operate in both grid-connected and island modes. When serving a relatively small geographic area, grid-connected microgrids demonstrate economic viability for educational campuses, medical complexes, public safety, military bases, agricultural farms, commercial buildings and industrial facilities.

c) **Networked Microgrids**: These systems, also known as nested microgrids, consist of several separate DERs and/or microgrids connected to the same utility grid circuit segment and serve a wide geographic area. Networked microgrids are typically managed and optimized by a supervisory control system to operate and coordinate each grid-connected or island mode at different tiers of hierarchy along the utility grid circuit segment. Community microgrids, smart cities and new utility adaptive protection schemes (e.g., closed-loop self-healing) are examples of networked microgrids.

2.4 REVIEW OF PREVIOUS WORKS

The work by Bayindir, Hossain, Kabalci and Perez (2014) presents an overall description and typical distributed generation technology of a microgrid. It also adds a comprehensive study on energy storage devices, microgrid loads, interfaced distributed energy resources (DER), power electronic interface modules and the interconnection of multiple microgrids. Details of stability, control and communication strategies are also provided in this work. It describes the existing control techniques of microgrids that are installed all over the world and has tabulated the comparison of various control methods with pros and cons.

Barnes, Kondoh, Oyarzabal, Ventakaramanan, Lasseter and Hatziargyriou (2007) summarizes and highlights the operating principles and key conclusions of research and field trials to-date. The range of hardware and control options for Microgrid operation are reviewed. An overview is given on demonstration projects for Microgrids which have been, and are being, constructed.

This work by Bihari, Sadhu, Sarita, Khan, Arya, Saket, and Kothari (2021) describes a comprehensive review of microgrid control mechanism and impact assessment for hybrid grid. The work offers a critical overview of the micro grid growth, economic analysis and control strategy. [A Comprehensive Review of Microgrid Control Mechanism and Impact Assessment for Hybrid Renewable Energy Integration

Papathanassiou, Hatziargyriouand Strunz (2005) presented and discussedwhata benchmark LV network is, consisting of a LV feeder supplying a suburban residential area. A more extended version of the benchmark network is also included, suitable for the study of multi-feeder or multiple microgrids. The emphasis is placed on the network characteristics, while micro sources, representative of all currently important technologies, are connected to selected nodes. The benchmark network maintains the important technical characteristic of real-life utility grids, while dispensing with the complexity of actual networks, to permit efficient modeling and simulation of microgrid operation.

In his presentation to the International District Energy Association, Dempsey (2016) gave the common features of a microgrid such as decoupling of generators from loads, increased redundancy of generation, among others, design considerations for existing ad new systems, distribution systems, controls and costs.

The work by Pilo, Hatziargyriou, Celli, Pisano, and Tsikalakis (2006) describes the economic scheduling functions of the Microgrid Central Controller (MGCC) for the optimization of Microgrid operation. This is achieved by maximizing its value, i.e., optimizing production of the local DGs and power exchanges with the main distribution grid. In particular, the authors proposed novel MGCCs based on the application of different techniques such as Neural Networks (NN) for the NN-MGCC and Dynamic Programming with Merit Order for the MGCC. It was observed that no matter which is the adopted technique, the MGCC controls the Microgrid on the basis of a predefined Market Policy by communicating with the generators and responsive loads aiming at the maximization of the value of the Microgrid. More specific, by aggregating the power bids from generators, the MGCC can participate in the energy market maximizing the revenues for the DG owners or for the microgrid itself.

http://dx.doi.org/10.31364/SCIRJ/v12.i11.2024.P11241008

The report by Ye, Walling, Miller, Du, and Nelson (2005) investigated three key issues of facility microgrid with multiple DG units unintentional islanding protection, facility microgrid response to bulk grid disturbances andfacility microgrid intentional islanding.Active schemes were developed for single DG units, inverter- or machine-based. Previously, their performance when applied to multiple DG units was not well understood.It was recommendations that for a facility microgrid with only inverter-based DG, all DG units should be equipped with the same anti-islanding control, either active voltage scheme or active frequency scheme, or both schemes should be enabled; for a facility microgrid with only machine-based DG, all DG units should be equipped with the same anti-islanding control, either active power scheme or reactive power scheme, or both schemes should be enabled while for a facility microgrid with mixed inverter- and machine-based DG, all inverter-based DG units should be equipped with active frequency scheme, and all machine-based DG units should be equipped with reactive power scheme. Further, they noted that if the recommendations are not followed, the facility microgrid may risk unintentional islanding unless other means or design changes are provided. These results are also relevant to the performance of multiple DG units not in a planned microgrid but connected to an Area EPS. Finally, the report studied facility microgrid intentional islanding behaviors and observed that not all of the load within the facility can be served when the microgrid trips to islanded operation. In all cases, roughly half of the load in the facility tripped. Non-essential load can be disconnected to allow for secure operation of critical load. The ability to differentiate between critical and noncritical load is a major reliability consideration and potential advantage for a facility microgrid. The microgrid fails to tolerate the dynamics associated with the trip to an island for one case: the very severe fault and the machine-based DG. The faster response of the inverter-based DG with very aggressive controls and with sufficient overcurrent capability allows for a better recovery.

2.4.1 Research Gap

This research work gave birth to the amount of money people and students living in Eziobodo are spending on fussil fuel, is too much as a reason why Eziobodo is taken as a case study and as a research gap which need to be address. This research work will provide solution to the problem which will enable students living in Eziobodo to have a reduced amount of fuel to at least half of the money they spent in buying fuel.

The previous works from literature were deployed mostly in the areas of microgrid optimization, operation, control and facility management. However, they were not deployed to a rural electrification project in an area that seriously lacks adequate power supply.

http://dx.doi.org/10.31364/SCIRJ/v12.i11.2024.P11241008

3.1 MATERIALS

In the course of executing this project materials used are grouped into hardware and software materials. These are explained as follows:

3.1.1 HARDWARE MATERIALS

The following materials were used in the design and simulation of this work:

i. Photovoltaic cells
ii. Energy meter as a Data logger
iii. Battery bank
iv. Wind turbine
v. Power converters and inverters
vi. General interconnectivity and inspection

3.1.2 SOFTWARE MATERIALS

The Homer Pro and MATLAB Softwares were used in the design and simulation of this work. The Homer Pro software allows the user to key in the location of experiment or research, it automatically generates the obtainable amount renewable energies in the concerned vicinity.

3.2 METHODS

The Homer Pro software was used in the design and simulation of the proposed system. The energy resources considered at Eziobodo community for a micro grid setup included Wind energy and Hydro energy.

3.2.1 Methods of harnessing solar Energy at Eziobodo community

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The block diagram of the Micro-grid power demand optimization for an area as shown in Fig 3.1. The solar energy feeds the Photovoltaic cells which are usually connected electrically in series and/or parallel circuits to produce higher voltages, currents and power levels. Photovoltaic modules consist of PV cell circuits sealed in an environmentally protective laminate, and are the fundamental building blocks of PV systems. At the output end of system there is a smart energy meter for each building for energy distribution and consumption.

3.2.2.1 Homer Energy Software Design for Eziobodo

The proposed system was designed using the Homer Energy Software.

The following steps were meticulously adopted in the design of a microgrid system for electrification at Eziobodo.

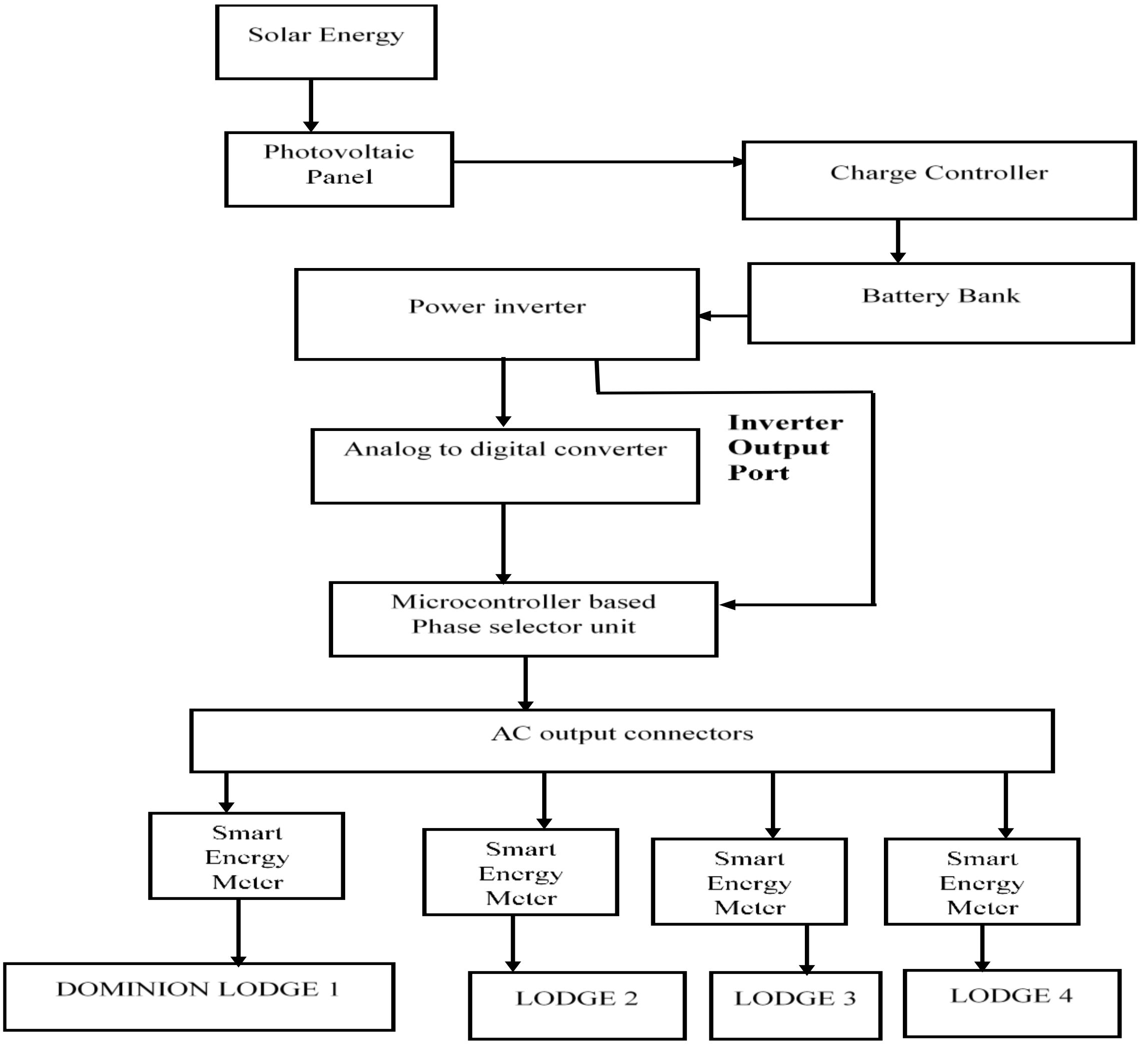

Figure 3.1: Micro-grid power demand optimization block diagram

Homer Software was launched to initiate the system design renewable energy optimization software.

i. Location of the project was entered on the Homer based Google map search box.
ii. Homer generated the mapped location which in this case was Owerri with the following details:

http://dx.doi.org/10.31364/SCIRJ/v12.i11.2024.P11241008

a. Location: Owerri

b. Zip code: 460281

c. Latitude and Longitude: 5°29.3'N, 7°1.1'E

i. The resources button was clicked in order to notify to fetch the available renewables from the National Aeronautics and Space Administration (NASA) using Homer Software.

ii. The needed components and renewables were selected accordingly.

3.2.2.2 The System Flowchart

The system flowchart shows the actually program flow internally as demonstrated in fig 3.2.

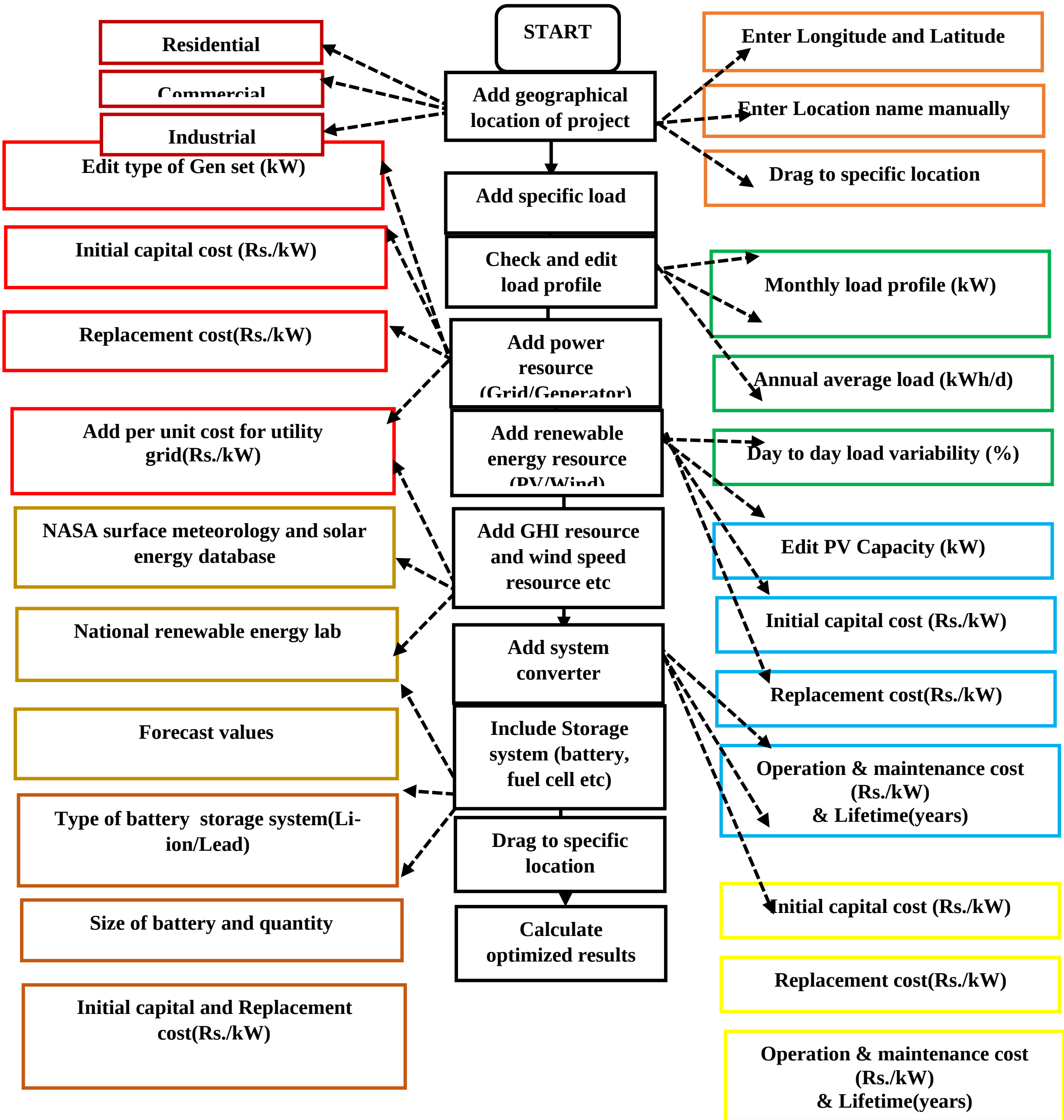

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Figure 3.2: System flowchart using HOMER PRO

3.2.2.3 11/33kV SINGLE LINE DIAGRAM IN POWER DISTRIBUTION

Location: From Ihiagwa to Eziobodo Community: The traditional power grids (as shown in Figure 3.3) are generally used to carry power from a few central generators to a large number of users or customers.

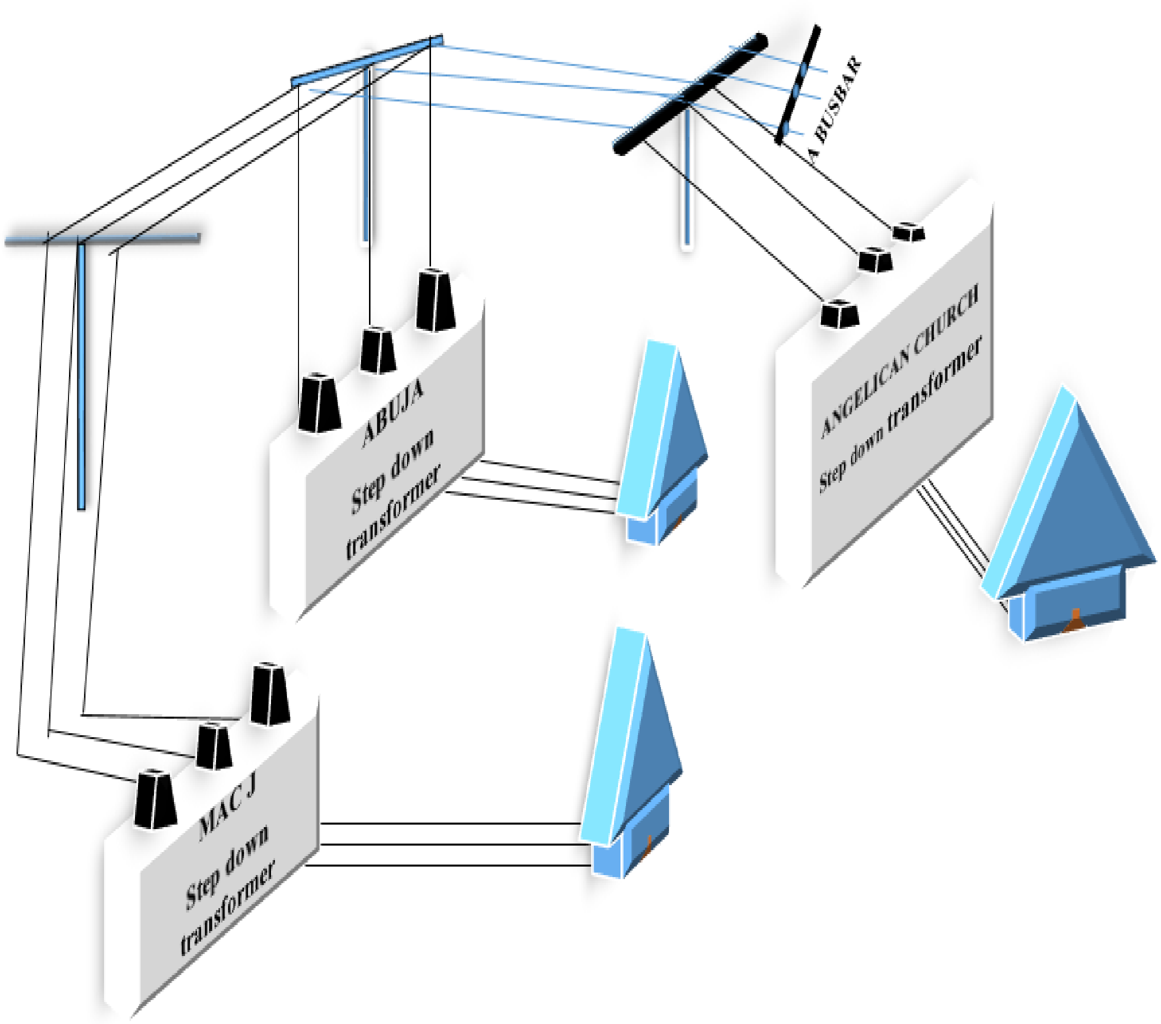

Figure 3.5: TRADITIONAL GRID

Figure 3.3: Eziobodo Traditional Grid

3.2.2 Eziobodo Modern Grid

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Smart grid is a modern electric grid which is developed by the integration of information and communication technologies into electrical transmission and distribution networks. Conventional grid provides one-way communication. Smart grid provides two-way communication. Fig 3.4 shows the architecture of the modern grid at Eziobodo.

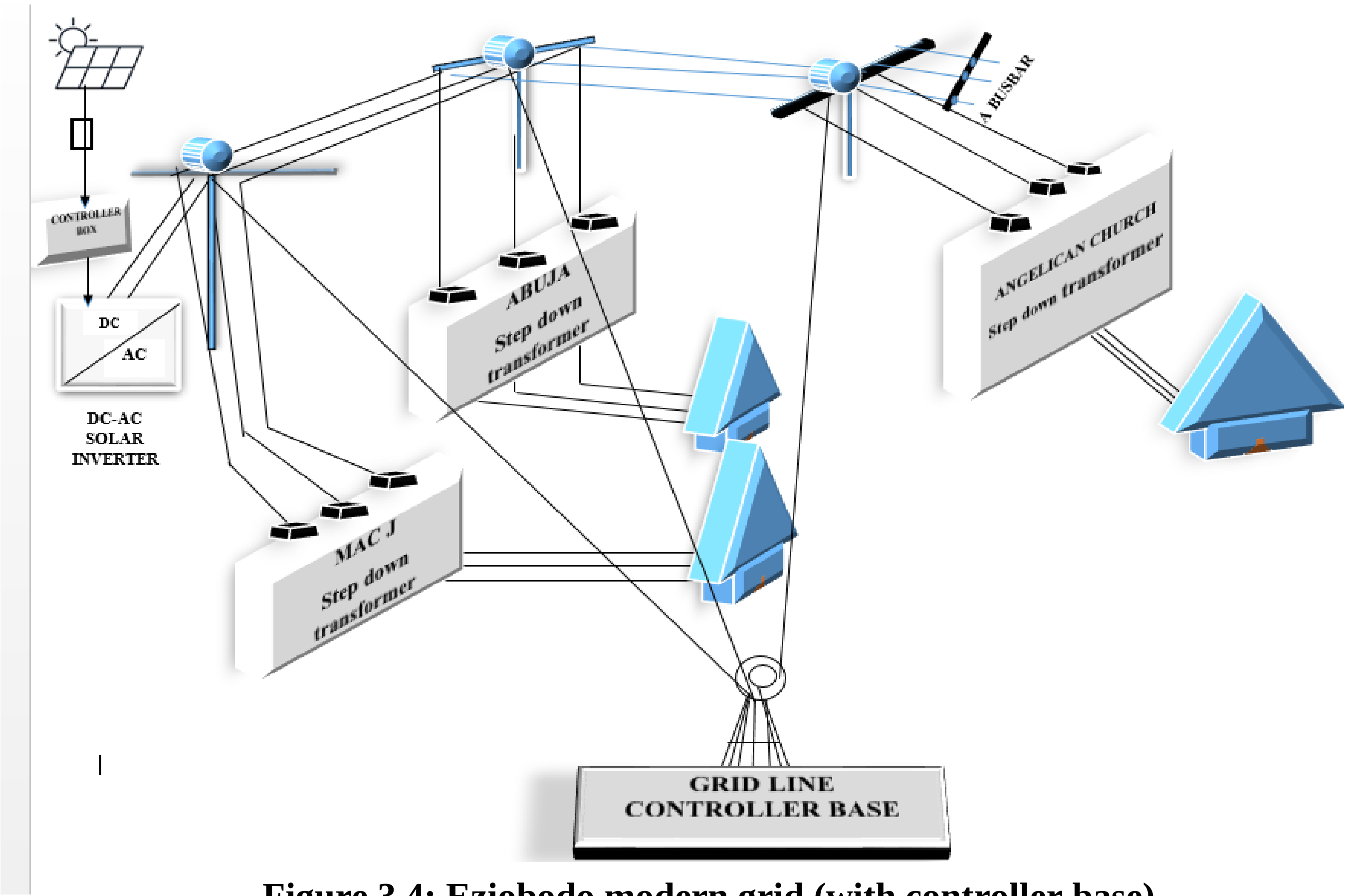

Figure 3.4: Eziobodo modern grid (with controller base)

3.3 LOAD PROFILE

Tables 3.1 to 3.19 show the load profile of the proposed system to be optimized using Homer Pro software according to the data gathered from the respective firms.

Table 3.1: GRAND HOTEL

	QUANTITY	RATING FOR EACH (KW)	DURATION (hr)	ENERGY CONSUMED (KWHr)
LIGHTING POINT	340	0.1	24	1.4167
FAN	120	0.075	24	0.3750
LG A/C	10	1.119	24	0.4663
TOTAL				**2.258.0**

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Table 3.2: COALESCENT HOTEL

	QUANTITY	RATING FOR EACH (KW)	POWER CONSUMED (KW)	DURATION (hr)	ENERGY CONSUMED (KWHr)
LIGHTING POINT	70	0.1	7	24	0.2917
FAN	20	0.075	1.5	24	0.0625
LG A/C	4	1.119	4.476	24	0.1865
TOTAL					**0.5407**

Table 3.3: WISDOM VILLA

	QUANTITY	RATING FOR EACH (KW)	POWER CONSUMED (KW)	DURATION (hr)	ENERGY CONSUMED (KWHr)
LIGHTING POINT	128	0.1	12.8	8	1.6000
FAN	40	0.075	3	8	0.375
LG A/C	3	1.119	3.357	8	0.4196
TOTAL					**2.3946**

Table 3.4: MAC JAY

	QUANTITY	RATING FOR EACH (KW)	POWER CONSUMED (KW)	DURATION (hr)	ENERGY CONSUMED (KWHr)
LIGHTING POINT	80	0.1	8	8	1
FAN	30	0.075	2.25	8	0.2812
LG A/C	2	1.119	2.238	8	0.2798
TOTAL					**1.561**

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Table 3.5: BTL HOSTEL

	QUANTITY	RATING FOR EACH (KW)	POWER CONSUMED (KW)	DURATION (hr)	ENERGY CONSUMED (KWHr)
LIGHTING POINT	60	0.1	6	8	0.75
FAN	52	0.075	3.9	8	0.4875
LG A/C	-				-
TOTAL					**1.2375**

Table 3.6: IFEANYI VILLA

	QUANTITY	RATING FOR EACH (KW)	POWER CONSUMED (KW)	DURATION (hr)	ENERGY CONSUMED (KWHr)
LIGHTING POINT	120	0.1	12	8	1.5
FAN	40	0.075	3	8	0.375
LG A/C	-				-
TOTAL					**1.875**

Table 3.7: JESSICA VILLA

	QUANTITY	RATING FOR EACH (KW)	POWER CONSUMED (KW)	DURATION (hr)	ENERGY CONSUMED (KWHr)
LIGHTING POINT	200	0.1	20	8	2.5
FAN	42	0.075	3.15	8	0.3938
LG A/C	4	1.119	4.476	8	0.5595
TOTAL					**3.4533**

Table 3.8: MUZZY VILLA

	QUANTITY	RATING FOR EACH (KW)	POWER CONSUMED (KW)	DURATION (hr)	ENERGY CONSUMED (KWHr)

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LIGHTING POINT	122	0.1	12.2	8	1.525
FAN	40	0.075	3	8	0.375
LG A/C	-				-
TOTAL					**1.9**

Table 3.9: ABUJA VILLA

	QUANTITY	**RATING FOR EACH (KW)**	**POWER CONSUMED (KW)**	**DURATION (hr)**	**ENERGY CONSUMED (KWHr)**
LIGHTING POINT	170	0.1	17	8	2.125
FAN	60	0.075	4.5	8	0.5625
LG A/C	8	1.119	8.952	8	1.119
TOTAL					**3.8065**

Table 3.10: ROYAL VILLA

	QUANTITY	**RATING FOR EACH (KW)**	**POWER CONSUMED (KW)**	**DURATION (hr)**	**ENERGY CONSUMED (KWHr)**
LIGHTING POINT	120	0.1	12	8	1.5
FAN	50	0.075	3.75	8	0.4688
LG A/C	3	1.119	3.357	8	0.4196
TOTAL					**2.3884**

Table 3.11: MATUDA LODGE

	QUANTITY	**RATING FOR EACH (KW)**	**POWER CONSUMED (KW)**	**DURATION (hr)**	**ENERGY CONSUMED (KWHr)**
LIGHTING POINT	110	0.1	11	8	1.375
FAN	30	0.075	2.25	8	0.2813

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LG A/C	2	1.119	2.238	8	0.2798
TOTAL					**1.9361**

Table 3.12: PRESIDENTIAL VILLA

	QUANTITY	**RATING FOR EACH (KW)**	**POWER CONSUMED (KW)**	**DURATION (hr)**	**ENERGY CONSUMED (KWHr)**
LIGHTING POINT	220	0.1	22	8	2.75
FAN	65	0.075	4.875	8	0.6094
LG A/C	6	1.119	6.714	8	0.8393
TOTAL					**4.1987**

Table 3.13: PRINCE VILLA

	QUANTITY	**RATING FOR EACH (KW)**	**POWER CONSUMED (KW)**	**DURATION (hr)**	**ENERGY CONSUMED (KWHr)**
LIGHTING POINT	200	0.1	20	8	2.5
FAN	60	0.075	4.5	8	0.5625
LG A/C	8	1.119	8.952	8	1.119
TOTAL					**4.1815**

Table 3.14: DE ARIZON VILLA

	QUANTITY	**RATING FOR EACH (KW)**	**POWER CONSUMED (KW)**	**DURATION (hr)**	**ENERGY CONSUMED (KWHr)**
LIGHTING POINT	98	0.1	9.8	8	1.225
FAN	30	0.075	2.25	8	0.2813
LG A/C	-				-
TOTAL					**1.5063**

Table 3.15: OSLO VILLA

	QUANTITY	**RATING FOR EACH**	**POWER CONSUMED**	**DURATION (hr)**	**ENERGY CONSUMED**

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		(KW)	(KW)		(KWHr)
LIGHTING POINT	190	0.1	19	8	2.375
FAN	40	0.075	3	8	0.375
LG A/C	4	1.119	4.476	8	0.5595
TOTAL					**3.3095**

Table 3.16: CITY-GLOBAL LODGE

	QUANTITY	RATING FOR EACH (KW)	POWER CONSUMED (KW)	DURATION (hr)	ENERGY CONSUMED (KW/hr)
LIGHTING POINT	120	0.1	12	8	1.5
FAN	36	0.075	2.7	8	0.3375
LG A/C	-				-
TOTAL					**1.8375**

Table 3.17: NATHSON VILLA

	QUANTITY	RATING FOR EACH (KW)	POWER CONSUMED (KW)	DURATION (Hr)	ENERGY CONSUMED (KWHr)
LIGHTING POINT	120	0.1	12	8	1.5
FAN	32	0.075	2.4	8	0.3
LG A/C	-				-
TOTAL					**1.8**

Table 3.18: DE-PEDRO FILLING STATION

	QUANTITY	RATING FOR EACH (KW)	POWER CONSUMED (KW)	DURATION (hr)	ENERGY CONSUMED (KWHr)
LIGHTING POINT	12	0.1	1.2	8	0.15
FAN	4	0.075	0.3	8	0.0375

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LG A/C	-				-
TOTAL					**0.1875**

Table 3.19: UNIQUE FILLING STATION

	QUANTITY	RATING FOR EACH (KW)	POWER CONSUMED (KW)	DURATION (hr)	ENERGY CONSUMED (KWHr)
LIGHTING POINT	20	0.1	2	8	0.25
FAN	2	0.075	0.15	8	0.0188
LG A/C	-				-
TOTAL					**0.2688**

3.4 ELECTRIC LOAD SETUP

The resources were chosen based on the location (Owerri) of this design. The peak load monthly consumption was taken in July since this is when second semester exams are usually taken. By summing the individual load profile of each building, a total of 40.6409kW was realized. This simply means that the energy resources available in the location of this design must produce enough energy to run the available loads seamlessly.

3.5 SYSTEM CONVERTER

Table 3.20: System Electric Parameters

S/N	Parameters	(kW)	Cost($)
1	Capacity of the system converter	600	-
2	Capital cost	-	2200
3	Replacement cost	-	2200
4	Operation and Maintenance cost	-	440
5	Lifetime period(years)	15	
6	Efficiency (%)	95	

3.6 WIND TURBINE

On this platform, the peak load was selected accordingly with the load survey carried out at the respective residential buildings.

3.10 CANADIAN SOLAR PHOTOVOLTAIC PANEL SPECIFICATIONS

i. **Higher Energy Yield**- Excellent module efficiency up to 16.68%. Positive power tolerance up to 5W. Outstanding performance at low irradiance (96.0%). High PTC rating of up to 91.97%.

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ii. **Increased System Reliability & Secure Investment** - Enhanced system performance stability with PID resistant technology. Long term system reliability with IP67 Junction Box. Robust frame to hold 5400 Pa load. Salt Mist, ammonia and blowing sand resistance, apply to seaside, farm and desert environment. Automotive industry quality management system (ISO16949) to our module MFG process to ensure product quality.

iii. **Extra Value to Customers** - A global bankable brand, top ranking amongst module manufacturers by industry analysts. Anti-glare project evaluation (e.g., Airport installations). 25 Year linear performance warranty. 25 year performance warranty insurance. 10 Year product warranty on materials and workmanship.

iv. Capital cost =$185 (₦106,375.00)

v. Replacement cost =$185 (₦106,375.00)

vi. Capital cost =$84 (₦48,300.00)

vii. Lifetime is 25 years

viii. Operation and maintenance cost=₦21,275.00

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4.1 SEASONAL LOAD PROFILE

Figure 4.1 shows the initial homer pro optimization page where the daily load profile, monthly load profile, seasonal load profile and yearly load profile were successfully simulated. It was observed that at every 18 hours (6pm) gap, the daily load consumption was usually the highest (with a value of 0.985). For seasonal load consumption, it was noticed that July was the peak load month (with a value of 13.88). Fig 4.1 shows Homer Pro optimizer dashboard for the daily average load consumption. It could be deduced that the average daily load of the building was optimized by the software as 31.71kWh/day.

Figure 4.1: Homer Pro Optimization home page (optimization in progress)

Figure 4.2 is the graph of the simulated results on the monthly average electrical loads consumption. Observations from the graph show that July was the peak load month, that's the month with the highest load consumption. The peak load monthly consumption was taken to be July since the weather conditions especially temperature and wind tend to be more stable in this month than others. This is usually calculated by the Homer Pro Software using the NASA data as reference. It is therefore advisable for the Enugu Electricity Distribution Company (EEDC) to supply more energy to Eziobodo Community in the month of July.

http://dx.doi.org/10.31364/SCIRJ/v12.i11.2024.P11241008

Table 4.1: Components selection on Homer environment

COMPONENT	NAME	SIZE	UNIT
PV	Kyocera KU325-8BCA	34.6	kW
Storage (Lead Battery)	EnerSys PowerSafe SBS 480	18	strings
Wind turbine	Bergey Excel 10-R	3	ea.
System converter	System Converter	11.6	kW
Dispatch strategy	HOMER Cycle Charging		

4.2 HOMER PRO SYSTEM SCHEMATIC

The system architecture comprises electrical loads, generator, wind turbine, PV panel, Energy Storage (battery) and system

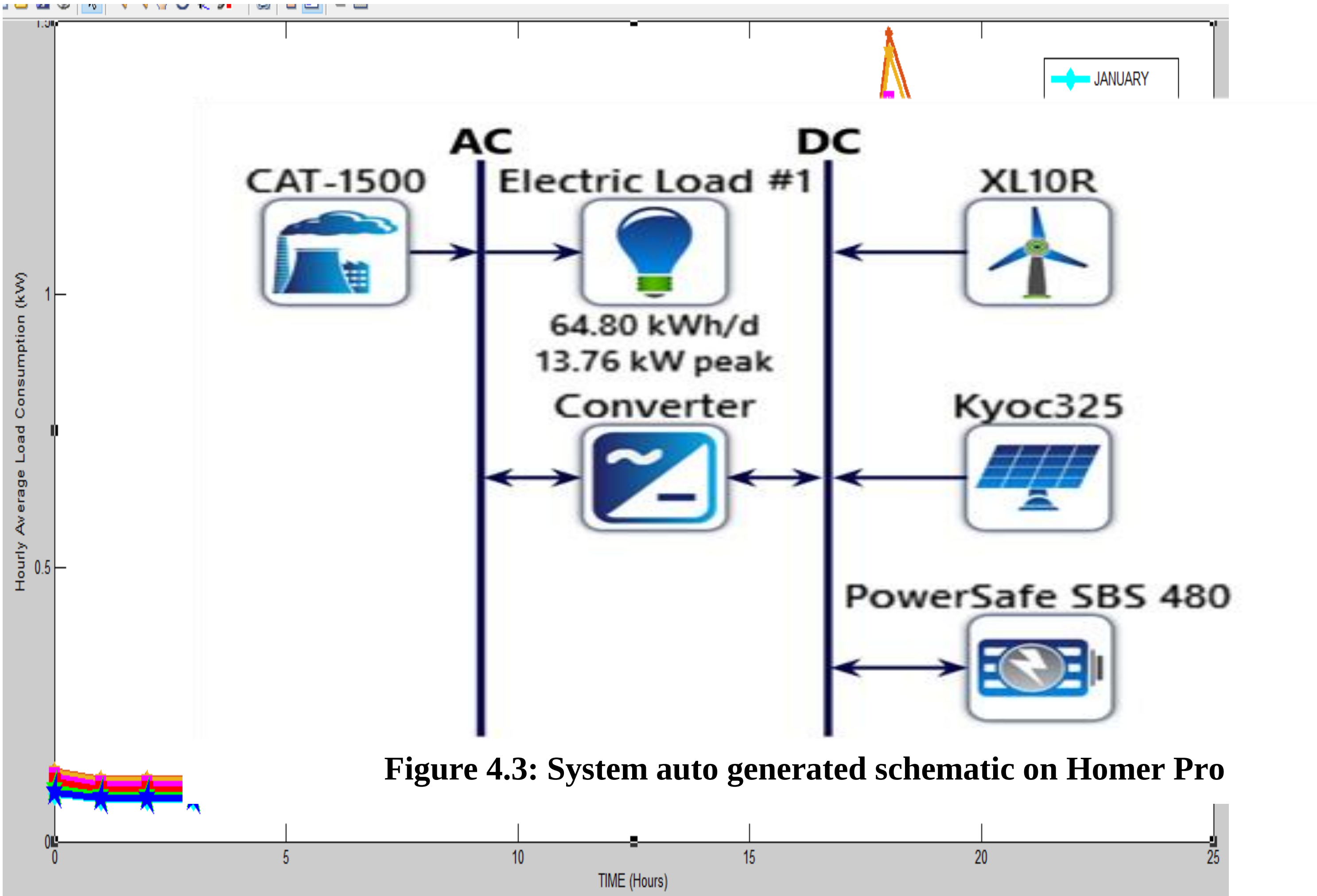

Figure 4.3: System auto generated schematic on Homer Pro

Figure 4.2: Monthly Average Load consumption for 12 months (year)

converter. The homer optimizer calculated the actual number of each renewable resource. This feature makes the Homer pro software unique and effective. This is shown in fig 4.3.

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Results obtained from the simulation shows that converter was the most expensive with the capital cost of about $200, 000. This also had relative influence on the replacement and maintenance costs. Fig 4.2 shows the graphical representation of the cash flow of the entire system.

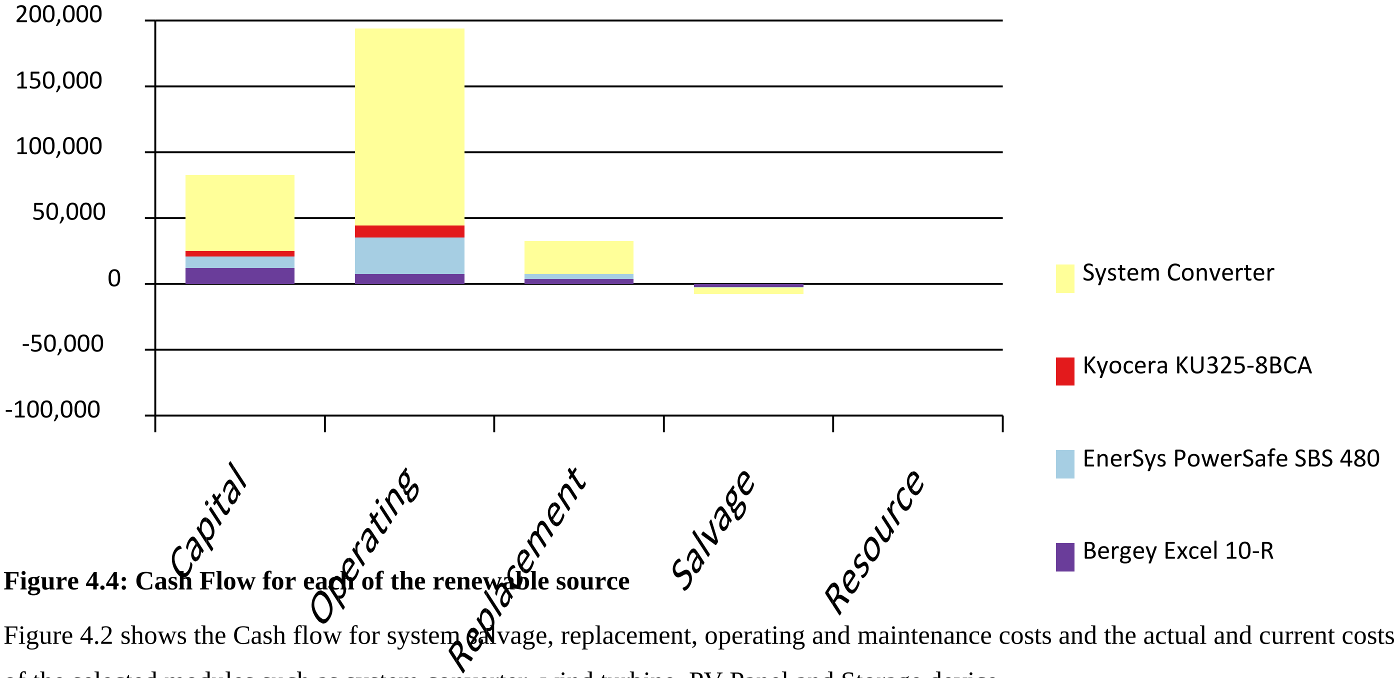

Figure 4.4: Cash Flow for each of the renewable source

Figure 4.2 shows the Cash flow for system salvage, replacement, operating and maintenance costs and the actual and current costs of the selected modules such as system converter, wind turbine, PV Panel and Storage device.

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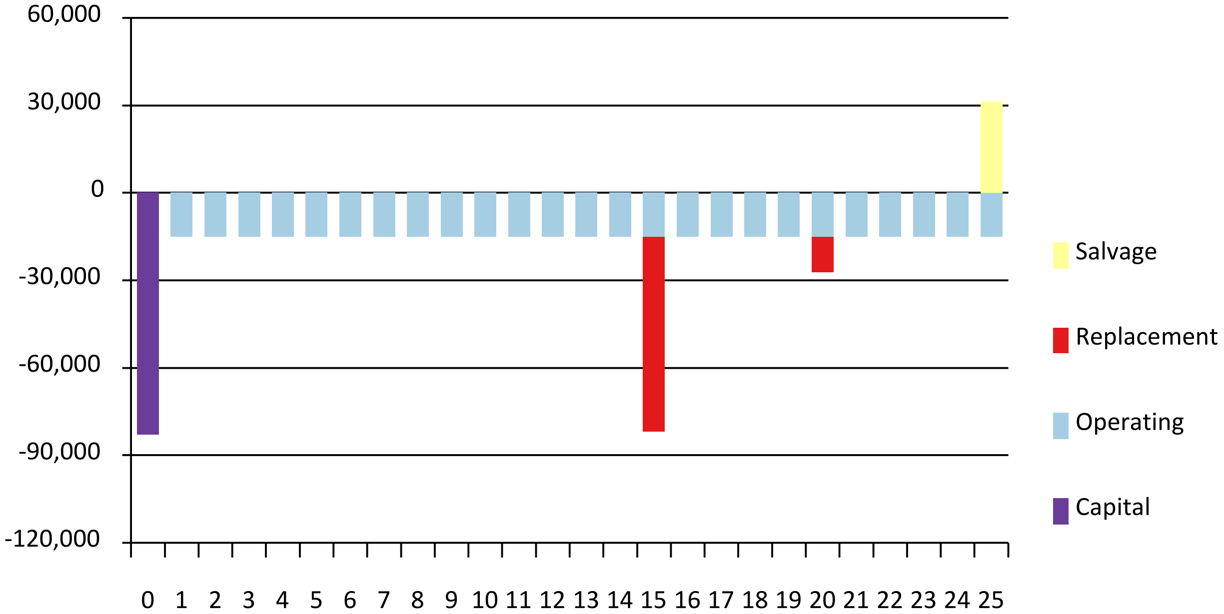

Figure 4.5: Cash flow for system salvage, replacement, operation and maintenance costs

Another cash flow generated by the homer pro software was the net present costs.

Table 4.2: Net Present Costs

Name	Capital	Operating	Replacement	Salvage	Resource	Total
Bergey Excel						
10-R	$12,000	$7,757	$3,826	-$2,156	$0.00	$21,426
EnerSys PowerSafe						
SBS 480	$9,000	$27,923	$3,818	-$718.67	$0.00	$40,023
Kyocera						
KU325-8BCA	$4,149	$8,940	$0.00	$0.00	$0.00	$13,089
System						
Converter	$57,834	$149,531	$24,538	-$4,618	$0.00	$227,285
System	$82,984	$194,151	$32,182	-$7,493	$0.00	$301,823

Table 4.3 indicated the annualized cost of each renewable and the respective manufacturers.

Table 4.3: Annualized Costs

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Name	Capital	Operating	Replacement	Salvage	Resource	Total
Bergey Excel						
10-R	$928.25	$600.00	$295.93	-$166.78	$0.00	$1,657
EnerSys PowerSafe						
SBS 480	$696.19	$2,160	$295.37	-$55.59	$0.00	$3,096
Kyocera						
KU325-8BCA	$320.95	$691.51	$0.00	$0.00	$0.00	$1,012
System						
Converter	$4,474	$11,567	$1,898	-$357.24	$0.00	$17,582
System	$6,419	$15,018	$2,489	-$579.61	$0.00	$23,347

4.2 DISCUSSIONS

Location: 25 Concorde Ave, New Owerri 460281, Owerri, Nigeria (5°29.3'N, 7°1.1'E): this is where the latitude and longitude of the location is identified by the Homer pro.

Total Net Present Cost: $301,823.20: This is estimated initial capital or amount needed to harness the renewable energies in Eziobodo community.

Levelized Cost of Energy ($/kWh): $0.987

DESIGN Title: DESIGN AND ANALYSIS OF A MICROGRID SYSTEM FOR A RELIABLE ELECTRIFICATION IN EZIOBODO

4.2.3 Homer Pro Components selection

Table 4.1 shows the resources selection and manufacturers. This makes the bill of engineering materials easier since it paves ways to involve the manufacturer’s standard selling prices of each module.

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5.1 CONCLUSION

In this research work on design and simulation of a Microgrid using Eziobodo as a case study has been successfully carried out with the aid of Homer Pro Renewable energy powerful simulation tool. Matlab was used to simulate the values obtained during Homer Pro Energy optimization. The resources were downloaded based on the location (Owerri) of this design. It was observed from the simulation result that the peak load monthly consumption was July. By summing the individual load profile of each building in chapter 3, a total of 40.6409kW/day was realized. This simply means that the energy resources available in the location of this design must produce enough energy to run the available loads seamlessly. And from the Homer pro design schematic, 64.80kWh/d was realized which was more than enough to power buildings having a total load consumption of 40.6409kW/day.

5.2 RECOMENDATIONS

Homer Pro is a versatile software for renewable energy simulation and optimization of load consumption. This software needs to be improved upon by including some locations that were not mapped yet to achieve better results in the deployment of renewable energy to homes and offices.

5.3 CONTRIBUTIONS TO KNWLEGDE

HOMER Pro is a powerful software tool that is widely used in the field of solar energy and renewable energy systems. It allows users to model and analyze various energy systems, including solar photovoltaic (PV) systems, to optimize design, operation, and cost.

i. One of the key contributions of HOMER Pro to knowledge on this thesis is the ability to perform techno-economic analysis of the availability renewable energy resources in Eziobodo community.

ii. The software enables users to evaluate the economic feasibility of solar energy projects by considering various factors such as system performance, costs, and financial metrics. This capability has helped the Eziobodo dwellers to understand the financial implications of deploying solar energy systems in different settings and has facilitated the comparison of solar energy with other conventional energy sources.

iii. Another significant contribution of HOMER Pro to knowledge on using solar energy is its role in supporting energy access and electrification efforts. The software has been used on thesis which focused on bringing electricity to remote and off-grid communities through solar PV systems.

iv. By simulating the performance and costs of off-grid solar energy systems, HOMER Pro has helped to identify viable solutions for increasing energy access in underserved areas and has contributed to the understanding of the technical and financial requirements of off-grid solar electrification.

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REFERENCES

P. Asmus, A. Lauderbaugh, K. Adamson (2012). Executive Summary: Microgrid Deployment Tracker 4Q12. Pike Research Report.

R. Bayindir, E, Hossain, E. Kabalci and R. Perez (2014). A Comprehensive Study on Microgrid Technology. International Journal of Renewable Energy Research. Vol. 4, No. 4.

M. Barnes, J. Kondoh, J. Oyarzabal, G. Ventakaramanan, R. Lasseter and N. Hatziargyriou (2007). Real-World MicroGrids-An Overview. *2007 IEEE International Conference on System of Systems Engineering*. pp. 1-8, doi: 10.1109/SYSOSE.2007.4304255.

S.P. Bihari, P.K. Sadhu, K. Sarita, B. Khan, L.D. Arya, R.K. Saket, and D.P. Kothari (2021). A Comprehensive Review of Microgrid Control Mechanism and Impact Assessment for Hybrid Renewable Energy Integration. *IEEE Access*, vol. 9, pp. 88942-88958, 2021, doi: 10.1109/ACCESS.2021.3090266.

P. de Boer and J. Raadschelders. Flow batteries. [Assessed from: http://www.leonardoenergy.org/sites/leonardoenergy/files/root/pdf/2007/Briefing%20paper%20%20Flow%20batteries.pdf]

C. Cho; J. Jeon; J. Kim; S. Kwon; K. Park; S. Kim (2011). Active Synchronizing Control of a Microgrid. IEEE Transactions on Power Electronics, vol.26, no.12, pp.3707,3719.

M. Ding, Y. Zhang, and M. Mao (2009). Key technologies for microgrids-a review. International Conference on Sustainable Power Generation and Supply, 2009. SUPERGEN '09., pp.1,5, 6-7 April 2009 , Nanjing China.

M. Dempsey (2016). Designing Microgrids. International District Energy Association. June 20, 2016.

Eto, J.; Lasseter, R.; Schenkman, B.; Stevens, J.; Klapp, D.; Volkommer, H.; Linton, E.; Hurtado, H.; Roy, J. (2009). Overview of the CERTS Microgrid laboratory Test Bed. PES Joint Symposium Integration of Wide-Scale Renewable Resources into the Power Delivery System, pp.1,1, 29-31 July 2009

Fast Market Research (2013). Microgrid Market, Global Forecast & Analysis (2012 - 2022) - Focus on Renewable Power Generation, Solar Photo-voltaics, Wind Micro-Turbines, Battery, Energy Storage & Control Systems, By Types, Components & Technologies. [Assessed from: http://www.fastmr.com/prod/531733_microgrid_market_global_forecast_analysis_2012.aspx?dt=s]

M. I. Henderson, D.Novosel, and M. L. Crow (2017). Electric Power Grid Modernization Trends, Challenges, and Opportunities. November 2017.[Accessed from: https://www.cmu.edu/epp/irle/readings/henderson-novosel-crow-electric-power-grid-modernization.pdf]

E. Hossain, E. Kabalci, R. Bayindir, R. Perez (2014). Microgrid testbeds around the world: State of art. Energy Conversion and Management, vol. 86, pp. 132-153.

T. Ise (2006). Advantages and Circuit Configuration of a DC Microgrid. Symposium on Microgrids, pp.1-5, Montreal 2006.

A. Larson (2020).Electric Transmission Grid Problems and Solutions. Power Magazine [Accessed from: https://www.powermag.com/electric-transmission-grid-problems-and-solutions/].

S. Laval (2021). Duke Energy One. Duke Energy Sustainable Solutions [accessed from: https://sustainablesolutions.duke-energy.com/resources/three-types-of-microgrids/]

http://dx.doi.org/10.31364/SCIRJ/v12.i11.2024.P11241008

N.W.A. Lidula and A.D. Rajapakse (2011). Microgrids research: A review of experimental microgrids and test systems. Renewable and Sustainable Energy Reviews, vol. 15, no. 1, pp. 186-202, January 2011.

C. Ma and Y. Hous (2012). Classified Overview of Microgrids and Developments in China. Energy Tech 2012, Ohio, pp. 1-6, 29-31.

R. Majumder (2013). Some Aspects of Stability in Microgrids. IEEE Transactions on Power Systems. vol. 28, no. 3, pp.3243,3252.

Marnay C. and Venkataramanan G. (2006). Microgrids in the evolving electricity generation and delivery infrastructure. In: IEEE power engineering society general meeting. p. 5.

L. Mariam, M.Basu, and M.F. Conlon (2013). A Review of Existing Microgrid Architectures. Journal of Engineering, pp.1-8, doi:10.1155/2013/937614.

Oak Ridge National Laboratory. Grid Modernization: Resilient, Secure, More Sustainable Electricity [Accessed from:https://www.ornl.gov/sites/default/files/Grid%20Modernization.pdf

S. Papathanassiou, N. Hatziargyriou and K. Strunz (2005). A Benchmark Low Voltage Microgrid Network. CIGRE Symposium on Power systems with dispersed generation: technologies impact on development, operation and performances", April 2005, Athens, Greece.

Peças Lopes J.A., Moreira C.L., and Resende F.O. (2005). Microgrids black start and islanded operation. In: Proc 15th power system computation conference (PSCC), Liege, 22–26 August 2005. p. 1–7. [Assessed from: http://www.montefiore.ulg.ac.be/services/stochastic /pscc05/papers/fp69.pdf]

F. Pilo, N. Hatziargyriou, G. Celli, G. Pisano and A. Tsikalakis (2006). Economic Scheduling Functions to Operate Microgrids in Liberalized Energy Markets. CIGRE C6-303 (http: //www.cigre.org)

E.Planas, A. Gil-de-Muro, J. Andreu, I. Kortabarria, and I. Martínez de Alegría (2013). General aspects, hierarchical controls and droop methods in microgrids: A review. Renewable and Sustainable Energy Reviews, vol. 17, pp. 147-159.

S.Ula, T. S. Kalkur, M. S. Mattmuller, R. J. Hofinger, A. K. S. Bhat, B.H. Chowdhury, J. C. Whitaker, and I. Buchmann (2005). The Electronics Handbook, Second Edition, pp. 1033 -1257.

T. S.Ustun, C. Ozansoy, A. Zayegh (2011). Recent developments in microgrids and example cases around the world—A review. Renewable and Sustainable Energy Reviews, vol. 15, no. 8, Pages 4030-4041.

S. Wang, Z. Li, Q. Xu and Z.Li (2011).Reliability analysis of distributed system with DGs. 2011 4th International Conference on Electric Utility Deregulation and Restructuring and Power Technologies (DRPT), pp.14-17, 6-9 July 2011.

Z. Ye, R. Walling, N. Miller, P. Du, and K. Nelson (2005). Facility Microgrids. Subcontract Report NREL/SR-560-38019. General Electric Global Research Center Niskayuna, New York. May 2005.

D. Yu (2014). From "Cool" to "Cool and Connected": Why the smart home movement toward connected solutions will accelerate enterprise smart building adoption. [Assessed from: http://www.daintree.net/blog/index.php]

http://dx.doi.org/10.31364/SCIRJ/v12.i11.2024.P11241008