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Enhancing the Efficiency of Generating Renewable Electricity in Remote and Secluded Areas in Nigeria: A Study on the 'Renewable Energy Micro Utility' (REMU)

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ABSTRACT
Nigerians, particularly those in rural regions, have been encountering challenges in acquiring cost-effective electricity. The Renewable Energy Micro Utility (REMU) is a programme established by the Federal Ministry of Power to enable rural communities in the country to have access to power by utilising renewable energy resources that are readily available in their local areas. Most renewable electricity installations in the country have been deemed unreliable and significantly more expensive than grid electricity or conventional diesel/petrol generators. Global awareness of the necessity to produce power from renewable energy sources to mitigate the adverse effects of carbon emissions on the environment caused by fossil fuel-based energy generation is steadily growing. This has prompted the necessity to develop optimal renewable energy systems that are both efficient and cost-effective. Renewable energy recently has been proposed for decentralized energy generation for remote areas having difficult terrain This research project aims to examine and assess the different renewable energy sources available in the country and propose the most efficient setups for providing electricity to rural areas. The technology can also be utilized to supply electricity to various remote public facilities and infrastructure in the country, including schools, hospitals, marketplaces, and street lighting.
Keywords: cost-effective electricity, Renewable Energy Micro Utility

INTRODUCTION

The significance of electricity in fostering economic growth and promoting national development cannot be overstated. To mitigate the environmental damage caused by the use of conventional fuels, it is crucial to promote the adoption of renewable energy sources to create an eco-friendly environment. The progress of infrastructure development in Nigeria's hilly and riverine regions is hindered by the expensive and challenging nature of extending the grid system to these areas, which are characterised by their fragmented and rugged terrain. The energy generation capacity of a nation or culture typically serves as a key indicator of their industrial prowess. Access to affordable and dependable electricity is a measure of a community's societal and economic well and a means of attaining a satisfactory standard of living. The African Progress Report (2015) states that over 90 million Nigerians, which accounts for 45% of the population, lack electricity access. Among this population without access to electricity, 17 million reside

in urban regions, while 73 million reside in rural areas. This has impeded the country's social and industrial progress and exacerbated the people's living conditions, particularly in rural communities. The majority of the people without access to electricity in the country reside in rural locations where it is neither cost-effective nor feasible to provide grid service due to the enormous expenses associated with building transmission infrastructure. The Nigerian government has initiated the 'Operation Light-up Rural Communities' programme to expand electricity access in rural areas throughout the country without the need for grid extension. This programme showcases a novel off-grid renewable electricity generation initiative called the 'Renewable Energy Micro Utility' (REMU). The objective of this effort is to supply electricity to rural areas that are not connected to the main power grid by utilising renewable energy resources that are readily accessible in the local area. This will result in the provision of sustainable and dependable electricity, while also establishing a profitable business opportunity for investors. The generation capacity will vary between 10kW and 1MW, and the power tariff structures will be determined based on the availability of renewable energy resources in the area and the operational costs of the utility. Nigeria has a diverse distribution of renewable energy resources across several geographic places in the country. Although solar energy may be viable for generating power in certain areas, other sites may suggest wind, hydro, or biomass energies as more favourable alternatives. The few REMU projects commissioned in rural communities in the country have employed a singular method of generating electricity using photovoltaic technology. The initial two utilities established by investors in collaboration with the Federal Ministry of Power in 2015 were the 40kW facility in Gnami and the 50kW facility in Pakau, both located in Kaduna state. These utilities are autonomous solar photovoltaic smart grid systems with battery backups that have been The significance of electricity in fostering economic growth and promoting national development cannot be overstated. To mitigate the environmental damage caused by the use of conventional fuels, it is crucial to promote the adoption of renewable energy sources to create an eco-friendly environment. The progress of infrastructure development in Nigeria's hilly and riverine regions is hindered by the expensive and challenging nature of extending the grid system to these areas, which are characterised by their fragmented and rugged terrain. The energy generation capacity of a nation or culture typically serves as a key indicator of their industrial prowess. 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autonomous solar photovoltaic smart grid systems with battery backups that have been supplying continuous power to the two tiny settlements in the Northern region of the country. Nigeria possesses substantial sun, wind, hydro, and biomass renewable energy resources. However, only minimal amounts of power are currently being generated from these sources, and their use is inefficient. The initial stage in improving rural electricity availability in the country involves the development of cost-effective and high-performing renewable energy systems.

Problem Statement/Justification

The Nigerian ministry of power has transformed the Operation Light-Up Rural Nigeria initiative by replacing the traditional Micro-grids without payment systems with off-grid Micro Utilities that have pre-payment and power management systems. These integrated systems allow for the collection of revenue from the project and the management of load demands. This transformation has led to the creation of the Renewable Energy Micro Utility (REMU) Concept (SE4ALL-AA, 2016). The objective of this research project is to discover a sustainable solution to Nigeria's electricity deficiency, particularly in rural areas. The objective of this study is to examine and evaluate several renewable energy systems that can achieve the goals of the REMU project. This will be done by conducting tests at a specific area in Nigeria. The purpose of this research project is to inform policy makers, investors, development partners, and the public on the feasibility and long-term viability of renewable electricity initiatives. This will enable the implementation of effective planning and the development of proactive strategies in advanceo mitigate any adverse outcomes during the project's execution.

Objectives of the Research

The research objectives are

To investigate the patterns and obstacles in the development of renewable electricity in Nigeria.

To ascertain and assess the parties involved in the REMU initiative.

To examine and evaluate the social, economic, and environmental sustainability of the REMU project in rural regions of the country.

To investigate and comprehend the capacity for renewable energy in the chosen. area.

To demonstrate the economic feasibility and energy efficiency of generating renewable electricity in the chosen area.

LITERATURE REVIEW

Nigeria has the biggest economy in Africa and the most people (186 million as of 2016). It has an abundance of renewable energy resources (hydro, wind, sun, biomass, geothermal, and tidal) that can meet all the nation's energy needs, both residential and industrial. Nigeria is still trailing behind in achieving a balance between its electricity generation and consumption, despite these potentials. In Nigeria, an estimated 90 million people do not have access to electricity, according to the African Progress Report (2015). Of these non-electrified people, 73 million reside in rural areas and 17 million in urban areas. According to SE4ALL-AA (2016), the bulk of the population that is not electrified lives in off-grid locations where grid supply is not cost-effective and may not be sustainable due to the high cost of building transmission infrastructure. People in rural areas may be more inclined to engage in productive and income-generating activities if they have access to clean, reasonably priced, and dependable power (Wang et al., 2013). This could enhance their standard of living. Numerous initiatives have been started in the nation to produce electricity from wind and solar energies, but to no effect due to recent improvements in technologies that may create a respectable amount of electricity from readily available renewable resources. According to Cheng et al. (2013), comprehensive policy and financial measures have a significant impact on hastening the development and uptake of renewable energy generation in China. In Nigeria, the growth of renewable energy has stagnated mostly due to inefficiency and unreliability. Because renewable energy has benefits for the environment, several studies have been conducted on how to enhance Nigeria's power industry through its generation, but little progress has been made. While the country's Levelized Cost of Energy (LCOE) per kWh is greater than that of grid energy, individuals and business entities create their own electricity using solar photovoltaic panels with battery

storage. However, during periods of low sun irradiation, these systems also have poor generating capabilities. In order to secure a market share, renewable energy sources, according to Cheng et al. (2013), must be able to provide electricity at prices that are competitive with those of conventional power generation, in addition to being a key component of environmental benefits.

The primary goals in constructing a renewable energy system are ensuring reliability and achieving cost-effectiveness (Bhandari et al, 2014). In order to accomplish these goals, power systems must be optimised to facilitate the highest possible integration of renewable resources. Various forms of renewable energy systems can be implemented based on the specific requirements and the accessibility of resources in a given area (Lee et al, 2017). The 'Renewables-Battery-Diesel' system is currently the most dependable but inefficient hybrid system. However, the Renewables-Battery system has proven to be both reliable and cost-effective, particularly when the load demand is moderate. The primary aspect that ensures reliability in a hybrid system is energy storage for backup, which becomes crucial when renewable resources are unavailable or unable to satisfy the load demands. Lithium-ion batteries (LIBs) are considered one of the most promising electrical energy storage technologies for Hybrid systems (Abruna et al 2017). Additional study should be conducted to identify more viable storage facilities that have increased durability and can minimise the expenses associated with frequent battery changes. Zomers et al (2011) highlighted four primary factors for decision making in rural electrification projects in their study on 'The problems of rural electrification'.

The need: what is necessary?

The environment: what is acceptable?

The economy: what is affordable?

The technology: what is feasible?

The environment encompasses the natural, societal, and human dimensions. The affordability of electricity in rural areas in most developing countries is supported by practical government initiatives aimed at improving the well-being of the population. Hence, it is imperative to make decisions regarding rural electrification projects based on economically viable methods that can ensure the uninterrupted functioning of the electricity utilities. According to Palit et al (2017), in their study on 'Rural electricity access in India', it was emphasized that rural electricity should be utilised to improve the local economy and generate sufficient income for rural households. This enable them to allocate a portion of their earnings towards purchasing electricity.

RESEARCH METHODOLOGY

Research Location

The inquiry will be carried out in 2 specifically chosen Schools in Abdu Gusau polytechnic Talata Mafara i.e. School of Science and School of Information and communication technology. Alternatively, if there are any hindrances to the functioning of the systems, other adjacent areas can be utilized instead.

Research design

The primary renewable energy sources present in the vicinity of the research site include solar power, wind energy, and dry biomass derived from agricultural and forestry waste. The renewable energy technologies chosen for this study are Solar Photovoltaic, wind turbine, and biomass direct combustion technologies. The inquiry will span a duration of 12 months, encompassing all seasons, due to the reliance of renewable energy supplies on seasonal variations. Conversely, the report will be completed and made available for publication within a period of 1 month.

Sampling, Data collection and Energy analysis

A variety of solar photovoltaic (PV) technologies, including monocrystalline and polycrystalline modules, will be tested in isolation with battery storage to determine which is most suited to the site. During the examination, we will study and record data related to variables that impact the functioning of the PV system, including temperature and insolation. An anemometer and a vertical-axis wind turbine will be set up on the wind technology to track the location's energy performance and wind characteristics. This study will use the following biomass feedstock samples:

a. Rice straw
b. Wheat straw
c. Sugarcane bagasse
d. Corn stover
e. Mixed forest residue

Using "Bomb Calorimetry," the calorific values (LHV) of the feedstock will be determined at various moisture contents and meteorological conditions. The System Advisor Model (SAM) programme will be used to model a biomass combustion facility with a cyclone furnace using the results.

Two distinct Renewable Energy analysis methods will be used to conduct the performance and feasibility analyses for this study.

i. System Advisor Model (SAM) 2018 version developed by NREL United States
ii. RETScreen Expert developed by Natural Resources Canada

The findings derived from the examined systems will also serve as inputs in the analysis tools for designing optimal renewable energy systems on a bigger magnitude.

RESULTS

Upon successful completion of this research, the results will be able to give an account of the renewable energy performance and feasibility of the investigated systems in the location. This will ease the design of an optimum renewable energy system either stand-alone or hybrid that is both reliable and affordable for similar locations on a large scale. The research will also suggest ways of improving renewable electricity efficiency and affordability, especially for rural villages in the country.

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