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A REVIEW ON RENEWABLE ENERGY POWER SUPPLY SOURCES AS AN OPTION FOR POWER GENERATION

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ABSTRACT

Education is an essential tool to maintain steady development and strengthen human resources in any country. The development of any nation depends largely on her technical prowess and capabilities. The need for energy to satisfy the country technical training institution for the avoidance of unemployed graduate and unplanned production of irrelevant skilled should be a priority for effective national building as majority of the institution are having unreliable power supply. Implementing renewable energy policy intensely in this institution will aid to achieve the workforce for the purpose of initiating, facilitating and implementing technological development of a nation. The study examined opportunities associated with renewable energy resources and challenges to meet electricity demands in Nigeria technical Institution. The findings revealed that if solar, wind, biomass and small hydro power resources are integrated and fully harnessed it would help to achieve the goal of renewable energy by providing sustainable and reliable power, reduce emission and offer clean energy.

KEYWORDS: Renewable Energy, Electricity and Institution.

1.0 Introduction

Good quality electricity service is a prerequisite for advancing the prosperity of the people and alleviating poverty (Olatomiwa, 2016). Thus, a lack of access to electricity has affected the quality of critical services such as education and health (Dodo *et al.*, 2021). Education is an essential tool to maintain steady development and strengthen human resources in any country. The development of any nation depends largely on her technical prowess and capabilities (Adetola, 2021). The need for manpower development is now very important as the contest between machine and man is increasing in complexity which has led to establishment of Technical Colleges (Evans, 1978). Energy is a very important infrastructure for running the Technical Colleges in the country (Olarnle *et al.*, 2020). However, over 95% of Technical Colleges in Nigeria lament about incessant and epileptic power supply because the amount of generated energy, distributed and transmitted is grossly inadequate for technological development and these has account for the increase in unemployment, lack of trainer to tailor their training towards the manpower development needed by agencies and industries (Ochuba, 2002). There is a need for reliable energy supply which should be a priority for effective national building in our technical training institution for the avoidance of unemployed graduate and unplanned production of irrelevant skilled (Badejo and Ogunseye, 2020). Petrol and diesel generators have traditionally been used to power of these institution but due to global hike in the cost of fuel prices most of the technical school activities has been paralyzed and there have been an unendurable difficulty in the operation of the school as most of their operation demands the use of fuel due to lack of constant electricity (Kwa and Mahmud, 2018) which has brought an undesirable impact on the social-economic position of the communities (Eleri *et al.*, 2012). Nigerians spent about $14 billion on generators and fuel annually according to the Central Bank of Nigeria (CBN), (Olalekan, 2020); an evidence that power supply is not getting any better. The pollution from this fossil-based source energy such as emission of gases (CO, NO, and NO_2) are major contributor to the global worming faced in the world today,

injurious to animals and plants and also cause health problems in humans (Olatomiwa *et al.*, 2018; Yimen *et al.*, 2018), therefore this is the perfect time to implement renewable energy policy more intensely in this institution.

Renewable energy is not a new concept and there is availability of several forms of renewable energy sources in Nigeria such as solar, wind, biomass, fuel cell and geothermal energy. Among these energy sources, wind and solar have proven great abilities to contribute substantially to global climate protection effort (reduction in greenhouse gas emission) and meet the rapidly growing energy demand (Dihrab & Sopian, 2010; Dursun *et al.*, 2013). However, wind system and standalone cannot provide reliable power supply because of changes in atmospheric conditions due to the intermittent nature of the resources. Therefore, there is need for different energy sources to be integrated for extended usage.

In this paper, the review seeks to examine Nigeria's renewable energy potential for power generation in technical institution for sustainable development and adopting renewable energy to meets the electricity demands of a technical training institution, its also highlights key challenges hampering renewable energy and how a shift from fossil fuel to renewable energy is a sure way of mitigating climate change.

2.0 Energy Status of Nigeria Technical Institution

Energy poverty remains a major critical problem in Nigeria technical institution and it has poses even more challenges in the institution where it has become a barrier to students learning as practical class group discussions and tutorial classes are cancelled or rescheduled due to power outbreak (Adelakun and Olanipekun, 2020). Nigerian power system that is highly unreliable both in content and in essence; the transmission and generation capacity is grossly insufficient, and the distribution network is inefficient and need upgrade (Akinloye *et al.*, 2016; Ogbuefi *et al.*, 2018). Due to this, energy losses, load shedding (planned outages) and voltage collapses (forced outages) are frequently experience (Salau, 2016) and these has grossly affected most of the technical college situated in the country (Adetola, 2021). The power supply in technical institution is also challenge with inadequacy due to weak grid network, transformers and feeder faults as well as non-payment of tariff (Uwaifo, 2010). Therefore, to achieve the applied skills in these institution like furniture making, electrical installation, woodwork GSM repair, welding catering and hotel management, clothing textiles, printing, fashion design and auto machine mechanics for the acquisition of practical as well as basic scientific knowledge in our technical schools seems to be a mirage in this part of our country due to inadequate power supply as modern technology today as emerge rendering outdated skills obsolete. Therefore, for the institution in the country to achieve her energy requirement there is urgent need to consider alternative power source, especially for the technical institutions (Mbata, 2000). If this renewable energy is harnessed, the unreliable and erratic power supply will be a history with less deteriorating environmental impact.

3.0 Potentiality of Renewable Energy Outlook in Nigeria.

Nigeria is abundantly endowed not only in Crude Oil, Coal, Natural gas, Tar Sands, Lignite and Nuclear Element but also in renewable energy resources (Igbinovia, 2014). The renewable energy resources includes biomass, solar energy, large and small hydroelectric power resources, wind, development of geothermal and ocean energy and potential for hydrogen utilization (Nwulu and Agboola, 2011). Despite these renewable energy resources, Nigeria is yet to exploit all these huge available renewable energy potentials that has less climatic and environmental impacts. Among the renewable energy resources wind and solar are accessible regardless of the location and very abundant. The following subsections review some literature on renewable energy (hydro, solar, wind and biomass) potentials in Nigeria.

3.1 Hydropower

Hydropower currently accounts for about 29% of the total electrical power supply and is derived from the potential energy available from water (Ogbuefi *et al.*, 2018). The overdependence on hydropower systems,

which rely on water levels and vary with seasons, has result in lower power supply (Aliyu *et al.*, 2015). Hydroelectricity is one of the most mature forms of renewable energy and Power is generated into electricity by the conversion of this energy using a turbine at a usually high-efficiency rate. The National Renewable Energy and Energy Efficiency Policy (NREEEP) of 2015 classified hydropower as follows: large hydropower (above 100 MW), medium hydropower (between 30 MW and 100 MW), small hydropower (between 1 MW and 30 MW), mini hydropower (between 500 kW and 1 MW), micro hydropower (between 100 kW and 500 kW) and Pico hydropower (less than 100 kW). Niger State has been identified as one of the major sources of large hydropower generation in the country till date with a combined installed capacity of 1930MW. However, there are other large hydropower potential of about 10,966MW that has been identified in various locations across the country (Ogbuefi *et al.*, 2018). Small hydropower (SHP) sites with total potentials of 734.3 MW were identified and virtually exist in all parts of Nigeria with an estimated total capacity of 3,500 MW. The total exploitable hydropower potential technically based on the country's river system is approximately estimated to be about 11,000 MW of which only 19% is currently being developed or tapped (Okafor and Uzuegbu, 2010).

3.2 Solar Energy Resources

The sun energy is the source of life on the planet. Solar energy is abundant, clean renewable and sustainable energy resources which reach the earth in the form of radiation (Ndaceko *et al.*, 2014). Nigeria has enormous solar energy potentials because it lies within a high sunshine belt and thus solar radiation is fairly well distributed with average sunshine hours of 6 hrs per day and average solar radiation of about 19.8 MJm^{-2} day^{-1} (Ahmadi *et al.*, 2018). If 1% of Nigeria's land area were cover by solar modules, 1850 $x10^3$GWh of solar electricity can be generated per year which is over one hundred times the current grid electricity consumption level (Sambo, 2009). The net amount of the sun's energy received on the average in a day varies significantly with geographical locations and weather patterns between 3.7 kWh/$m^2$and 7.0 kWh/m^2 from the coastal regions to the Northern regions and the country's mean solar radiation to be 5.25 kWh/m^2 (Giwa *et al.*, 2017). Emodi (2016) carried out the average monthly solar radiation of 28 sites across Nigeria and found the South-South location to have the minimum mean solar radiation of about 3.748 kWh/m^2-day while the North-Eastern location have the highest solar radiation of 6.966 Wh/m^2-day. Solar energy has been used in Nigeria in various forms namely as solar manure dryer, solar PV for rural electrification, solar water heaters, solar cooker, solar crop dryer, solar water pump and solar chick brooder. Figure 1 shows a map of solar radiation distribution across Nigeria and the States in Zone I have the highest solar radiation potentials followed by those in Zone II and Zone III respectively

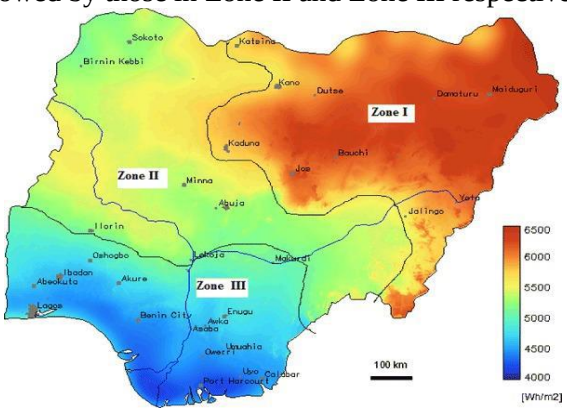

Figure 1: Solar Radiation Map of Nigeria (Abam *et al.*, 2014)

3.3 Wind Energy Resources

Wind energy can be defined as the indirect form of solar energy which is always being replenished by the sun. The energy conversion occurs when electricity or electrical power is generated using the abundant natural resource (Okedu, 2018). Wind energy has virtual benefits of saving 23 billion tonnes of carbon dioxide and the prospects of new jobs creation (Diogenes *et al.*, 2020). Wind energy in Nigeria is available at annual average speeds of about 4.0-7.5 m/s respectively at 10 m above the ground using Weibull distribution (Ajayi, 2010) at the far northern region of the country and between 2.0-3.5 m/s at the coastal region with an air density of 1.1 kg/m^3, the wind energy intensity perpendicular to the wind direction ranges between 35.2 W/m^2 at the far northern region and 4.4 W/m^2 at the coastal areas (Sambo, 2009). 75% of Nigeria's land area are suitable areas for the siting of wind farms with Jigawa and Bauchi States taking the lead in potentials. Various attempts are being made in Abubakar Tafawa Balewa University, Bauchi and Sokoto Energy Research Centre (SERC) to develop capability for the production of wind energy technologies (Ayodele *et al.*, 2018). 23% are very suitable and 2% is seen to be extremely suitable for the siting of wind farms in Nigeria's land area. Figure 2 shows the wind speed value for different location in Nigeria.

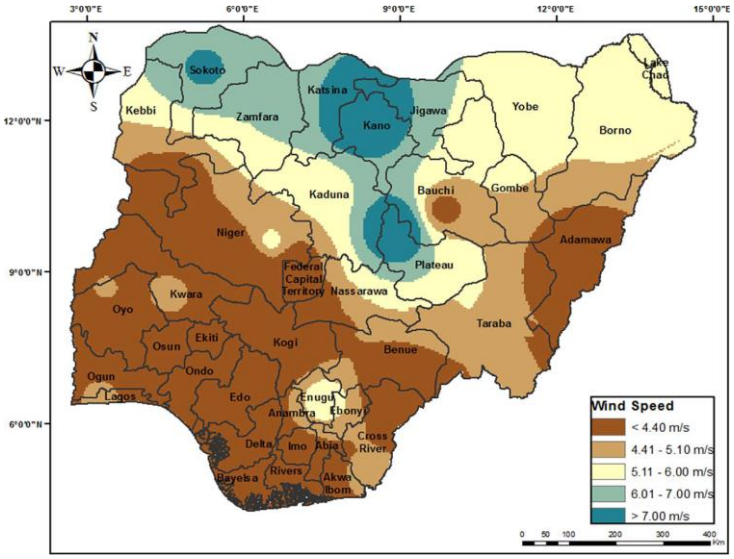

Figure 2: Wind Speed Map of Nigeria (Ayodele *et al.*, 2018).

3.4 Biomass Resources

Agricultural and forestry residues offer much potential for renewable energy sources in form of biomass (Ben-Iwo *et al.*, 2016). The energy generated through them is friendly to both human and ecology (Mckendry, 2002). In most countries like Nigeria recycling of waste products (agricultural waste) into useful product is rarely practice, this has led to environmental problems such as pollution resulting from refuse heap on our streets, drainage system and water ways. This has also brought about flooding in rainy days and outbreak of epidemic in our society today (Yahaya, 2012). Proper recycling of this biomass into useful products will make more renewable source of energy into our society as the resources are abundantly available in Nigeria, thus reducing environmental pollution and disease attack. Solid fuel from agricultural product waste can serve as an alternative energy source especially to the rural dwellers if properly processed (Grover and Mishra, 1996). It is estimated that in Nigeria about 227,500 tons of fresh animal waste is produced daily and since 1 kg of fresh animal waste produces about 0.03 m^{3}biogas, then Nigeria has the potential to produce about 6.8 million m^{3}of biogas every day from animal waste only. A lot of research works on the policy aspects and technology of biogas production has been carried by various researchers

in the country such as in Ibadan (Ayodele *et al.*, 2018), Ebonyi State (Nwofe & Ekpe, 2014) and Ilorin (Ibikunle *et al.*, 2019) respectively.

4.0 Renewable Energy Hybridization Research Trend for Power Generation.

Various development and efforts have been channeled into the Utilization of renewable energy technologies alongside energy storage devices and this has encouraged their entry to the electricity market and with the approval of the National Renewable Energy and Energy Efficiency Policy (NREEEP) it will gain more momentum and these technologies can function as part of hybrid systems, stand-alone sources or distributed generation (DG) connected to a national grid/microgrid. Hybrid renewable energy system integrates two or more energy sources and the combination of the different energy sources has led to improvement on the system efficiency, reduction of the energy storage needs and consistency of the energy supply compared to systems with single-source RE supply (Nandi and Ghosh, 2010). Table 1 present different article on optimal system configurations and feasibility evaluations of hybrid renewable power supply in Nigeria in terms of hybrid system configuration and study location.

Table 1: Research Trends on Hybrid Power Sources in Nigeria.

S/N	Hybrid System Configuration	Case Study	Reference
1	PV-WT-BESS-DG	Rural area	Muleta and Badar (2023)
2	PV-WT-BESS-DG	Rural area	Ganjei *et al.*(2022)
3	PV-DG-BESS	Rural area	Afrouzi *et al.* (2021)
4	PV-WT-BESS-FC	Base Transceiver station	Ramunenyiwa *et al.* (2020)
5	PV-DG-BESS	Base Transceiver station	Babatunde *et al.* (2019)
6	PV-DG-BESS	Industry	Bappy *et al.* (2019)
7	PV-DG-BESS	Rural area	Esan *et al.* (2019)
8	PV-DG-BESS	Rural area	Oladigbolu *et al.* (2019)
9	PV-WT-BESS-DG	Rural area	Salisu *et al.* (2019)
10	PV-DG-BESS	Bank	Ayodele *et al.* (2019)
11	PV-WT-BESS-DG	University	Shuaibu *et al.* (2019)
12	PV-DG-BESS	Base Transceiver station	Oviroh and Jen (2018)
13	PV-WT-BESS-DG	Rural area	Yusuf and Mustafi(2018)
14	PV-WT-BESS-DG	Rural Health centre	Olatomiwa *et al.* (2018)
15	PV-DG-BESS	Rural area	Bukar *et al.* (2017)
16	PV-DG-BESS	Rural area	Ani(2016)
17	PV-WT-BESS-DG	Rural area	Iosr et al.(2015)
18	PV-BG-BESS	Rural area	Eziyi and Krothapalli (2014)
19	PV-Grid-BESS	Rural area	Adaramola (2014)
20	PV-DG-BESS	Rural Health centre	Acharya and Animesh(2013)

DG = Diesel Generator, WT = Wind Turbine, PV = Photovoltaic, BESS = battery energy storage systems, BG = Biogas Generator

As seen from the table from the list of the review presented 70% of the papers focused on rural areas while 15% of the papers delved into base transceiver station. University, Bank and industry has each 5% respectively and this has shown that there is more concentration on renewable-based rural electrification while other areas are lagging and few or no research yet conducted in Nigeria technical institution and this is due to government's lack of critical mass concerning electricity generation from renewable energy

sources for these institutions. It is also clear from the table presented among the various options for supplying electricity to a geographic location (PV) systems, distributed generation (DG), and battery-based hybrid systems are the most common and the PV systems in the configuration has help to reduce the DG operation and reduce energy consumption from grid and other hybrid system solution commonly considered for powering a geographic location are PV-WT-battery, WT-DG-battery, PV-WT-DG-battery and PV-BG-battery systems (Acharya & Animesh, 2013; Yeshalem & Khan, 2017) and the selection and design of hybrid power systems for geographic location would depend on location-specific characteristics such as available resources, ambient condition, load and other factors. It is evident that among these energy sources, wind and solar have proven great abilities and harnessing this renewable source of energy makes considerable sense and provide reliable electricity as best alternative source of energy for a Nigeria Technical Institution.

5.0 Key Benefits and Challenges of Renewable Energy Utilization in Nigeria

The demand of energy is growing day by day as Nigerian population keeps increasing at a faster rate resulting in inadequate, unreliable and unsustainable power supply to satisfy these increasing demands. The use of fossil-based generators are destructive to the environment and this has been one of the main reasons for the vast amount of research currently on-going in renewable energy sources and the adoption of Renewable energy technologies offer clean, environmentally friendly, sustainable reliable as well as low operating and maintenance cost of power supply. It's also serving as energy security, Job creation, improved grid stability, reducing dependence on fossil fuels, reduce emission and other harmful gases associated with the use of fossil-based generators. However, Renewable energy adoption for power generation in Nigeria also faces several challenges, variable resource and its availability as energy source fluctuates, upfront costs, lack of a framework for sustainability, Government policy and incentives, storage technology, lack of awareness and information, high and exorbitant import rates, Ineffective quality control of products, insecurity of renewable plant infrastructure, operation and maintenance costs, lack of support for local manufacturing, geographic limitations, Grid unreliability, financial corruption, bureaucratic ineffectiveness and competition with land uses. These challenges can be overcome by favorable policies and strong political will from the government, mitigate economic, political and regulatory investment risk, increase consistent awareness creation and enforce and establish quality standards for energy equipment (Adedipe *et al.*, 2018 Ajayi, 2010).

6.0 Conclusion

This paper examines the potential of renewable energy resources in Nigeria for power generation and how it helps to mitigate the climatic consequences such as global warming and environmental pollution. Renewable energy resources has help in reducing dependency on fossil fuels and attaining sustainable energy production due to the fact that the use of renewable energy sources like solar, wind, biomass and other sources has grown significantly overtime. A qualitative published papers were reviewed to establish the research direction for the viability assessment of adopting hybrid renewable energy systems to serve the electricity demand of technical institution in Nigeria and the study has successfully revealed that Nigeria possesses vast renewable energy resource and if fully harnessed it can satisfy the electricity demands of technical institution in the country by providing lighting and extended studying hours, facilitation of ICT, enhanced staff retention and teacher training, better school performance, enablement of community co-benefits and competency in our industry and agencies, mitigate the climatic consequences and as well as giving a safer and healthier environment.

The trends of research have shown that the attention of authors is more on rural electrification with very little research efforts on industry and technical institution with an emphasis on hybrid solar PV-diesel generator and hybrid solar PV-wind-diesel generator due to ease of access of the wind and solar resources at the study locations. The study brought to light the opportunities associated with the adoption of renewable

energy sources and the challenges that tend to hinder the sustainability of renewable energy resources and suggestion are made that can improve the concerns of renewable energy being sustainable.

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