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Towards an Energy Sustainable Nigeria

Collins Iyaminapu Iyoloma[1], Tamunotonye Sotonye Ibanibo[2]
[1, 2]Dept. of Electrical Engineering, Rivers State University, Port Harcourt, Nigeria

Abstract— *The major objectives of the Nigerian use of renewable energy are to slow down global warming, promote economic growth, and improve energy accessibility and security. Utilizing sustainable energy and ensuring that all residents have access to modern, affordable, dependable, and sustainable energy are necessary for sustainable development. Over the coming years, it is projected that the renewable energy industry can provide a significant number of jobs in the country. The projections of Nigeria's total energy consumption, global primary energy consumption, and renewable green energy sources in Nigeria are presented in this study along with their future possibilities. the significance of Nigeria's shift to sustainable energy techniques in order to address present issues and further international environmental goals. The focus is on investing in renewable energy sources, enhancing energy efficiency, and adopting innovative technologies. The shift towards sustainability is seen as a pathway to economic growth, job creation, and improved environmental well-being. this paper has identified the various obstacles and challenges faced and Recommendations for Renewable Energy Employment*

Keywords— Nigeria, Sustainable, Renewable, energy sources, Barriers, Recommendations, Employment, government.

I. INTRODUCTION

Global greenhouse gas emissions from electricity producing sources such coal, oil, and natural gas account for one third of the emissions. Increasing the quality of life requires supplying cleaner, more dependable electricity [1]. Nigeria's need for energy is rising in order to meet the goals set forth for its economic development. A country's ability to develop economically depends on its ability to supply more energy [2]. Energy sustainability is the delivery of energy services in a way that is economical, acceptable to communities and individuals, and not harmful to the environment. It guarantees that energy services are available to everyone in a way that is sufficient to meet their fundamental needs [3][4]. The fact that energy resources power a large portion of global economic activity and have a substantial environmental impact underscores the need of attaining energy sustainability in the current global setting. Since energy sustainability refers to the sustainable use of energy throughout the entire energy system, it is regarded as a crucial component of attaining sustainable development. This involves gathering energy resources, transforming them into usable forms, moving and storing energy, and using energy to deliver energy services. In order to minimize the impact on the environment, guarantee that energy supplies are available for future generations, and encourage equal access to energy opportunities for developed and developing nations, energy sustainability must be achieved.[3]

Projection of Global Primary Energy Consumption: For socioeconomic progress to occur, an energy supply is required. The current rapid growth in the economy of nations that are developing has led to a faster rise in energy demand. This trend is expected to continue growing [5]. Forecast power consumption estimates are needed for looking into the best economic and environmental solutions [6]. Similar to this, future electricity consumption forecasts influence the decisions made on renewable energy investments. Energy security and availability are becoming more and more crucial issues for the development of human society as well as for global political and economic trends [7]. Global comparisons are helpful in determining electricity usage in the past, present, and future. Drawing on the articles of BP Energy Outlook 2018. Table 1 shows the amount of primary energy consumed worldwide.

TABLE 1: Global primary energy consumption estimates for the years 1990 to 2040[8].

Region	Consumption (million tones oil equivalent)											Change (percentage per annum)	
	1990	1995	2000	2005	2010	2016	2020	2025	2030	2035	2040	1990–2016	2016–2040
United States	1966	2119	2310	2349	2284	2273	2334	2344	2341	2325	2299	0.6%	0.0%
Brazil	126	158	188	211	268	298	330	378	419	451	477	3.4%	2.0%
EU	1672	1661	1732	1819	1754	1642	1667	1623	1570	1513	1460	- 0.1%	- 0.5%
Russia	865	662	620	647	673	674	711	720	723	722	716	- 1.0%	0.3%
MiddleEast	264	351	423	565	734	895	980	1085	1189	1287	1382	4.8%	1.8%
Africa	222	244	274	327	389	440	509	603	710	840	1002	2.7%	3.5%
China	683	889	1008	1800	2491	3053	3387	3753	4017	4207	4319	5.9%	1.5%
India	195	251	316	394	537	724	880	1118	1365	1624	1921	5.2%	4.2%

According to predicted estimates of global energy consumption, Nigeria and other countries in Africa have consistently high energy consumption, which is expected to continue until 2035 or 2040 [8]. The continent's portion of the world energy demand will rise as a result of the increased energy use Emerging economies like China, India, and Brazil have been able to increase their economic share of the global market and export vast quantities of produced goods to more affluent countries due to rapid industrialization. [9].

Nigeria Total Energy Consumption: Compared to neighbouring countries, with an average per capita power use of 140 kWh/hab in 2021, it is almost three times lower than the norm for Sub-Saharan Africa. Since 2012, the total amount consumed has increased by 2.3% annually on average, reaching 167 Mtoe in 2021.

Power Consumption: The demand for electricity fell by 4.3% in 2022. Before the economy began to grow less quickly, growing by 3% year between 2013 and 2021, power consumption has grown at a significantly slower rate than before, compared to roughly 9% annual increase between 2000 and 2012[10].

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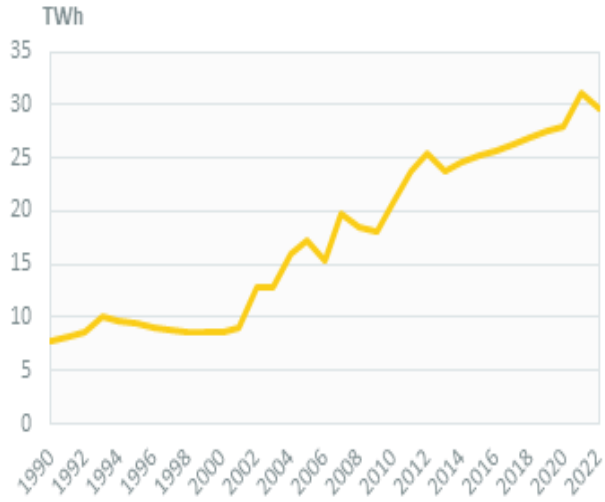

Figure 1: Electricity Consumption (TWh) [10]

II. Nigeria Renewable Energy Sources

Renewable energy sources sustainable as it is obtained from sources that are inexhaustible, can be relied on for the long-term. contribute to achieving energy sustainability by reducing reliance on fossil fuels, which are finite and contribute to environmental pollution. sources of renewable energy, including hydropower, wind, and solar, are abundant and can be harnessed without depleting natural resources. They contribute to slowing down climate change by emitting little to no greenhouse gases. By converting to renewable energy, Nigeria can achieve a more sustainable and ecologically friendly energy system [11].[12]. Renewable energy sources such as light, water, and wind can be transformed into electrical energy. Renewable energy sources include biological fuel, wind, solar, and water energy. Non-renewable energy sources include coal, oil, natural gas, nuclear power, and hydrogen power. Nigeria now uses a shockingly little amount of its plentiful natural renewable energy resources, which are essential for the country's sustainable growth.

Solar: Solar cells convert light from the surrounding environment instantly into electrical energy through the process of photovoltaics. When electricity is generated from solar energy, less fossil fuels are used, which lowers pollution. Although solar energy is a renewable, clean, and non-degradable natural resource that is free of cost, its drawbacks include its reliance on sunlight and weather, as well as the high cost and wide area required for site development and production. The average annual global horizontal radiation in Nigeria is between 1600 and 2200 kWh/m^2, with the highest values (more than 2000 kWh/m^2) found in the northern part of the country. This indicates Nigeria's enormous potential for solar energy resources.

IRENA calculates that the country has a technical solar photovoltaic (PV) potential of 210 gigawatts (GW), given that only 1% of the land is viable for project development [14]. With a potential of about 88.7 GW, concentrated solar power (CSP) has great promise. Its principal site is in northern Nigeria, where direct normal irradiance is at its highest [15].

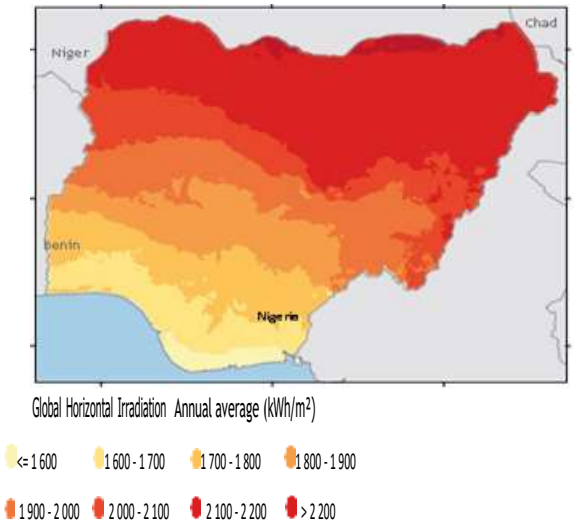

Figure 2: Nigeria's average yearly exposure to global horizontal radiation [13].

Wind: The kinetic energy of the wind powers electric turbines and windmills. However, a neighbourhood cannot employ windmills. Offshore wind turbines provide steady, dependable green electricity to many countries. Wind energy is inexpensive, non-biodegradable, a free natural resource, and environmentally friendly. Its drawbacks include its reliance on wind and weather, its inability to be used in residential areas, its enormous area consumption, and the high cost of developing and producing wind energy sites (land is expensive). noisy and harmful to animals and birds. Nigeria has a modest wind capacity; average wind speeds at a height of 10 meters (m) range from 2.1 to 8 m/s, with the greatest values (more than 7 m/s) found in the northern part of the nation. IRENA calculates that the technical potential for wind generation is 3.2 GW, taking into account that only 1% of the suitable land may be exploited for project development [14]. Southern Nigeria receives.

Extremely low wind speeds, while northern Nigeria sees higher wind speeds, with the exception of coastal and offshore places [16].

Hydro: Electric energy is produced from the kinetic energy of water flow. Water energy has several benefits, including being inexpensive, renewable, and non-biodegradable. It is also a free natural resource. Wind energy's drawbacks include its reliance on the weather and water flow, its inability to be used in residential areas, its restriction to areas with waterfalls, its huge area use, and the high cost of developing and producing water energy sites. Nigeria has a hydro potential that ranges from 3.5 GW to 24 GW, which is both enormous and little. Most of its potential remains unrealized. In 2015, Nigeria had constructed big hydropower capacity of 1.9 GW and developed small hydropower capacity of about 60 megawatts [18].

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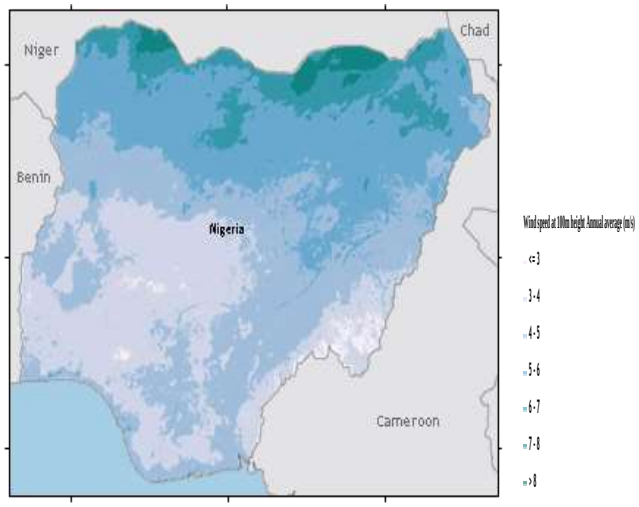

Figure 3: Average annual wind speed in Nigeria *[17].*

Biomass: Utilizing the enormous potential of biomass resources that Nigeria has access to, particularly in the form of agricultural waste for power production, will substantially mitigate the country's current energy crisis [19]. Although there are other options for producing biomass power, this study only looks at agricultural leftovers as a feedstock for biomass power plants [20].

Renewable in Percentage of Power Generation

The percentage of capacity expected to be made up of renewable energy is expected to be 40% by 2030, or 17 GW (2022: 2.1 GW), and 96% by 2050, or 248 GW. Carbon neutrality should be achieved by the power sector by 2050. The nation unveiled its National Renewable Energy and Energy Efficiency Policy in December 2022. A portion of it is the "30:30:30" plan, which intends to add 30 GW of electric power capacity by 2030 with 30% of the country's energy coming from renewable sources [10].

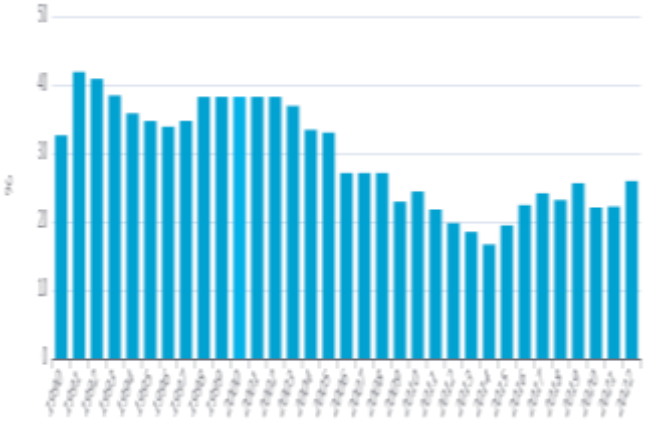

Figure 4: Nigeria Share of Renewables in Electricity Production [10]

It has been noted that feed-in-tariff (FiT) programs are one method for incorporating renewable energy sources into the current energy infrastructure. By ensuring grid access, granting long-term contracts, and setting cost-based purchase rates for the extra electricity generated, Feed-in Tariffs (FiTs) encourage the production of renewable electricity. This promotes the integration of various renewable technologies into the current electricity infrastructure and fosters their growth [11].

Energy Harvesting: During the past 10 years, it has grown more feasible and appealing to use free space energy in the form of electromagnetic waves, heat, light, vibration, muscle motion, and other energy kinds. There are numerous ways to generate electricity using these various sources of energy [21][22].

The need of power connections and the daily requirement to change batteries may be eliminated with energy harvesting systems. Utilizing as much free space energy as possible requires combining the electromagnetic power from several wireless communication systems [23].

Electromagnetic waves that are traveling through empty space are caught, stored, and used for battery charging and other purposes in RF energy harvesting devices. The level of electromagnetic energy in the atmosphere has significantly increased. In 2013, 1.5 exabytes of radio waves were anticipated to be in the atmosphere per month. 11 exabytes per month of radio waves were anticipated to be in the atmosphere in 2017 [23].

Below is table 1 showing energy sources used in harvesting systems.

TABLE 2: Energy Sources Used in Harvesting Systems [23].

Energy Source	Type	Efficiency	Estimated Harvested Power
Light	Outdoor / Indoor	10~25%	100 mW/cm^2
Thermal	Human Industrial	~0.1% ~3%	60 µW/cm^2 ~1-10 mW/cm^2
Vibration	~Hz–human ~kHz–machines	20~50%	~4 µW/cm^3 ~800 µW/cm^3
Electromagnetic	900 - 2700MHz WiFi, WLAN	~50%	0.1 µW/cm^2 0.001 µW/cm^2

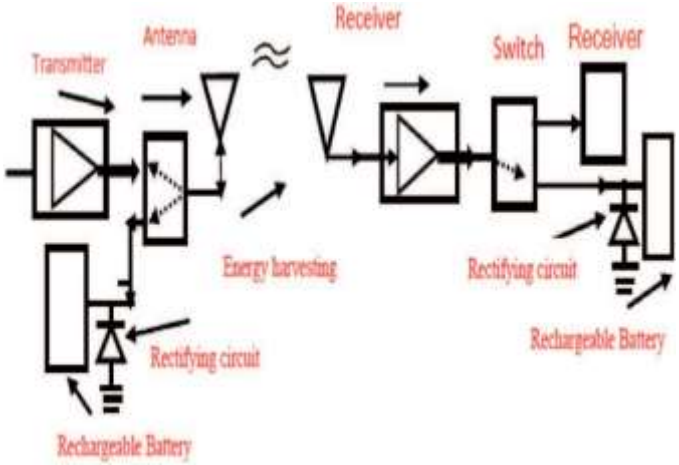

Figure 5. Dual-Mode Energy Harvesting Concept [23].

Figure illustrates the notion of harvesting energy. An antenna, a rectifying circuit, and a rechargeable battery make up the RF energy harvesting system. The energy collecting system is capable of functioning in two modes.

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The low-noise amplifier is part of the receiving system. The LNA DC bias voltages are supplied by the receiving system [23].

The key strategies that can contribute to building an energy-sustainable nation include [24]:

- Speeding up the Retirement of Non-Renewable Energy Plants;
- Limiting Sales of Fossil Fuel-Driven Transport Systems;
- Investigating Circular Economy Concepts;
- Investing in Sustainable Energy Use and Energy Efficiency Measures;
- Enacting High Carbon Pricing and Clean Electricity Standards;
- Introducing Policies Like Fossil Fuel Taxing and Renewable Energy Subsidies
- Utilizing promising energy storage solutions
- Encouraging the electricity industry and other sectors to become carbon neutral.

Development of national energy plans and policies

The background gives details on China's national initiatives for the advancement and application of renewable energy. China's renewable energy policy and legal framework are shaped by these national plans, which also establish goals and objectives. Their goals are to increase investment in renewable energy, enhance market mechanisms, and allocate resources as efficiently as possible. (11)

Challenges and Barriers

• Inaccessible financial packages
• Huge upfront and technological costs
• Non-competitiveness
• No viable markets;
• Popularity

The government should pass historic laws to remove these obstacles and hastened the development of the nation's renewable energy resources.

Recommendations for Renewable Energy Employment

- Increasing capability and concentrating on providing training in operation and maintenance to underprivileged groups and individuals.
- Create and make available training programs for citizens who lack formal education or training and who are ineligible for existing programs that prevent them from working in the renewable energy sector.
- Create links between training facilities and renewable energy enterprises to ensure that: (a) skilled people are put in suitable roles both during and after the program, and (b) training curricula align with the needs of the renewable energy industry.
- Promote a sense of ownership among the public in renewable energy initiatives, as this may help the industry expand.
- Investigate the effects of jobs and the deployment of renewable energy on reducing poverty and varying living standards with the help of field surveys.

III. CONCLUSION

The long-term development and environmental sustainability of Nigeria depend on the pursuit of an energy-sustainable nation. It is crucial to switch to greener, more sustainable energy sources as the country struggles with energy security. Nigeria can address its existing energy shortages and support international efforts to prevent climate change by investing in renewable energy sources, enhancing energy efficiency, and implementing cutting-edge technologies. Nigerians may look forward to increased economic prosperity, the development of jobs, and improved environmental conditions with a sustainable energy future. To pave the path for a better and more environmentally friendly future, embracing these changes will require cooperation from the public sector, private sector, and citizens.

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