Sustainability and Resilience in the Nigerian Power Sector

Justicia C. Otobo
PhD Researcher
School of the Built Environment and Architecture
London South Bank University
103 Borough Road, London, SE1 0AA, United Kingdom
otoboj@lsbu.ac.uk

Abstract

Electricity is widely used to manufacture goods and services in all sectors of the economy. While a country's standard of living and degree of economic development is primarily determined by its energy use, electricity generation and distribution influence productivity and overall economic growth. Unfortunately, many developing nations, like Nigeria, are still unable to supply their populations with enough long-term power, which is essential to enhance their standard of life and fuel economic progress.

Despite being Africa's largest economy, only around 60% of the Nigeria's 200 million residents has access to electric power. With a rapidly expanding population, it is critical to increase electrical supply to satisfy demand. The Federal Government of Nigeria (FGN) wants to boost access to power from 45 percent to 90 percent by 2030.

This paper examines policies created from 2001 to 2020 to investigate how they increased the country's generation and supply of electricity. The findings demonstrate that, because Nigeria is still in the early phases of economic development, it would be sensible to promote renewable energy to boost the economy, decrease energy poverty, and protect the environment. This may be accomplished by diversifying the country's energy mix and constructing renewable energy power plants.

Keywords
Sustainability, Renewable energy, Construction, Climate change, Energy Poverty, Nigeria

1. Introduction
Energy poverty, climate change, and energy supply security are three fundamental concerns that the world faces today in the realm of Energy (Zhao et al. 2022). As environmental concerns have grown in recent years, the problem of energy poverty has gotten much attention. Energy poverty is a multidimensional issue with many aspects. As a result, many academics approach energy poverty from different viewpoints (Igawa 2022). Energy poverty has been used to describe the absence of household energy services or fuel poverty. Research in energy poverty in high-income and low-income countries distinguishes between accessibility and cost. At the same time, energy poverty in low-income nations has received attention on developing countries' lack of access to electrical grids. Energy poverty in high-income nations has focused on the affordability component (Zhao et al. 2022).

Igawa et al. offer three ways to differentiate the accessibility and affordability at a global level. Firstly, access to electricity has increased by 10% in the previous two decades, reaching 90% in 2018. Recent research on energy

poverty in low-income countries reflects this trend, emphasising the necessity of looking beyond power connections and focusing more on dependability and price. Secondly, as scholarly emphasis has shifted to other high-income nations beyond Europe, the definition of energy poverty in high-income countries has evolved. During this procedure, various Eastern and Central European nations discovered disconnections from the energy grid, which were not identified in the first UK investigations (Igawa 2022).

Nigeria, like most sub-Saharan countries, struggles with energy poverty, with just roughly 45 percent of the population having access to power (IEA 2020). The Nigerian government has made some effort to restructure the energy industry, including deregulating and reorganising the oil and gas sectors, as well as privatising the electricity sector, in order to create cash to fund infrastructure developments. Furthermore, the FGN adopted a number of policies concerning the production, supply, and use of all energy resources in various sectors. The fundamental purpose of the policies is to provide energy security through a diverse mix of energy sources, resulting in sustainable development and environmental protection (NERC 2019).

Visible attempts are underway to implement the policies. However, the findings indicate that more has to be done and that policies must be amended on a regular basis to keep up with global, national, and local developments.
This study investigates the Nigerian electrical industry to assess the effects of electricity policies on power generation and supply from 2001 to 2020, and to provide suggestions on increasing the country's energy mix to include the development of renewable energy power plants.

2. Literature Review

Energy poverty is measured differently in developed and developing countries (Rao et al. 2022). Moreover, developing-country energy poverty differs significantly from that of developed-country energy poverty. Nevertheless, the shortage of power in underdeveloped nations and a lack of heating fuel in rich countries are energy poverty indicators with comparable social repercussions (Karmaker et al. 2022).

Zhao et al. use three alternative indicators to assess fuel poverty in Europe: Heating affordability, utility bill arrears, and the existence of moist walls, leaky roofs, or deteriorating windows. The energy poverty index, designed to measure the lack of energy services among users, is a widely used approach for assessing energy poverty. Based on this, (Zhao et al. 2022) offer an analogous definition of energy poverty appropriate for developed nations based on energy efficiency, energy income, and energy cost.

Energy poverty in developing counties is often associated with low literacy rates and inadequate health facilities (Hassan et al. 2022). In the context of socio-economic inequality, a lack of adequate energy supplies is unquestionably a limitation. Energy poverty can be influenced by various factors other than economic growth, such as education, the environment, and health. Higher energy use countries significantly impact economic development and human development (Deller et al. 2021; Akwukwuegbu et al. 2017).

There is a shortage of energy services in different dimensions throughout the globe. The most basic of them is a lack of access to electricity and gas, widespread in low-income nations (Hassan et al. 2022; Zhao et al. 2022). According to (Igawa 2022), 840 million people lacked access to electricity, while 3 billion people relied on conventional fuels (such as firewood) to cook in 2019. As a result, indoor air pollution generated by open cooking fires is responsible for 2.6 million fatalities. In addition, gathering firewood takes much time and deprives people of possibilities for education and work. In high-income nations, on the other hand, the affordability of household indoor heating is a severe problem with negative health consequences, such as respiratory sickness and an increase in winter fatalities (Igawa 2022).

With the growth of the renewable energy sector in recent years, academics have commenced studying the influence of renewable energy on energy poverty. For example, Obeng et al. investigated the relationship between solar PV rural electrification and poverty using data from ninety-six solar-electrified homes and one hundred and three non-electrified homes in Ghana. They concluded that solar PV rural electrification aids in the alleviation of energy poverty in rural areas (Obeng et al. 2008).

In the developed parts of the world, people experience energy poverty differently, as seen in the energy crisis that started in the UK in 2021. According to the BBC, gas prices in the EU rose by more than 70% between 2021 and 2022. Russia supplies about 40% of natural gas imported to the EU; around 5% is supplied to the United Kingdom. As a result, energy bills are going up at unprecedented levels in the UK and are predicted to double within a year. The UK appears to be more vulnerable to the energy crisis in Europe. This is because the gas storage in the United Kingdom as of February 2021 was 86%, which is much less storage than most other European countries.

One of the reasons for the increase in gas prices is that the economy is opening after the pandemic. So, there is a massive spike in demand for gas, and the UK is hit hard because it's one of Europe's most significant natural gas users. Around 85% of UK homes have central gas heating, and gas is used to generate 1/3 of the country's electricity. This reliance on natural gas has been rising as coal is being phased out of the energy mix. In 2021, the UK did not have as much wind blowing, reducing the electricity generated from wind. This meant that the UK had to increase its reliance on gas to produce electricity (BBC News 2022b).

Finally, the war between Russia and Ukraine is the most significant factor in the rise of energy costs globally.

As the world continues to feel the effects of the COVID-19, Russia's invasion of Ukraine has a severe concern for the global economy and the supply of crude oil. This is observed through the dependence of most European countries on Russia's oil and gas exports, resulting in a supply shock that raised the global price of crude oil. (Adekoya et al. 2022). However, the strains on global energy supplies through sanctions on Russian gas can incentivise more significant development of local energy sources such as green energy and coal (Boubaker et al. 2022)

Nigeria suffers from energy poverty, with around 45 percent of the population having access to power (IEA 2020). As seen in Figure 1, there is a large disparity between installed capacity, power generated and the power that is distributed to the consumers. The government intends to improve access to energy from 45 percent presently to 90 percent by 2030 (Emodi et al. 2015,; Emodi et al. 2016, Gungah et al. 2019).

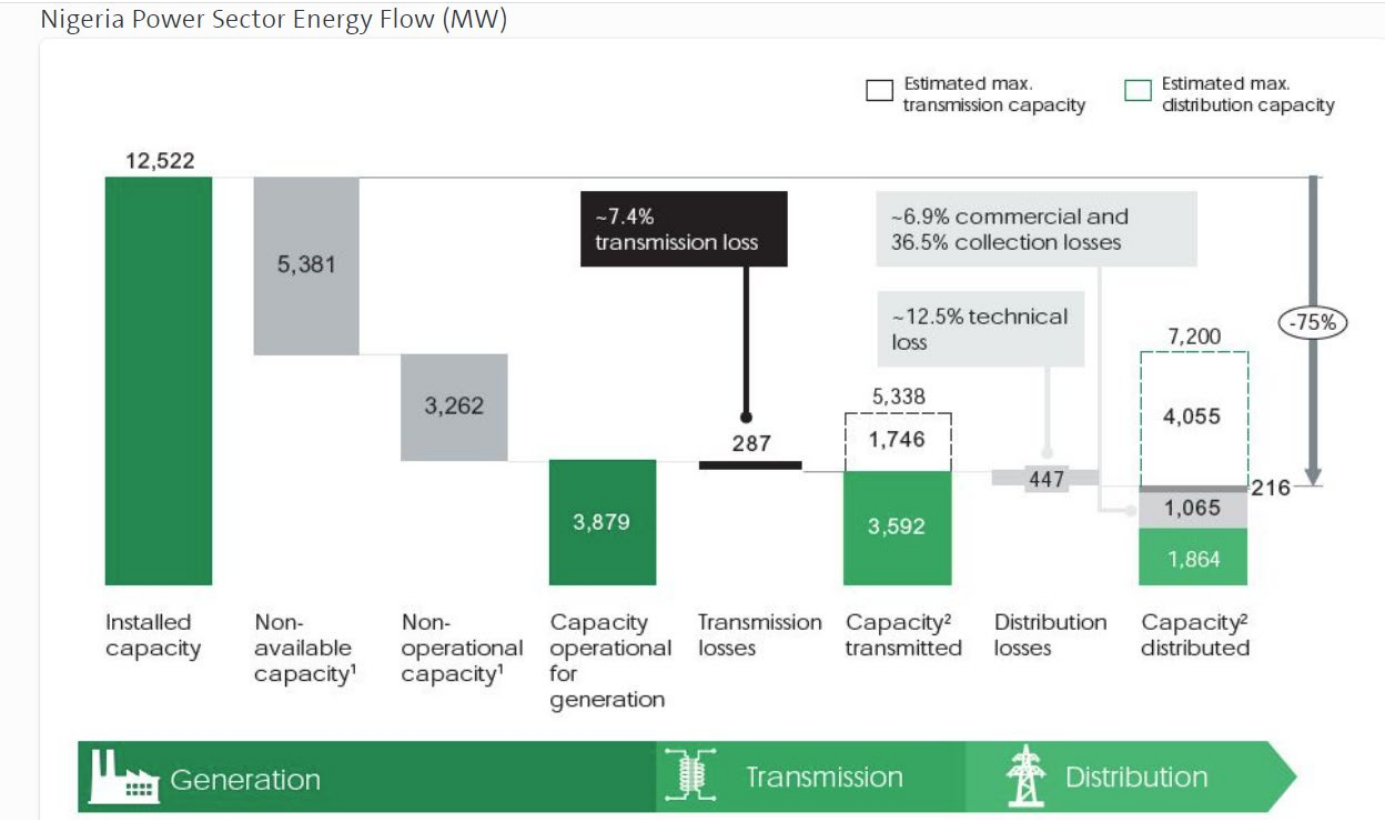

Figure 1. Nigeria's Installed capacity, supply, and losses across the Power chain

Source: (Nigeria Power Baseline Report2015)

The construction of two power plants in the Lagos colony in 1896 marked the beginning of electricity generation in the country. In 1929 the first electric utility business known as the Nigerian Electricity Supply Company was created. Hydropower, steam, and gas turbines are now the most common commercial sources of energy. As indicated in Table 1, the availability of electricity continues to be a crucial determinant in the placement of industries and a potent driver of social development (ECN 2018). Nigeria had hoped to raise its overall generating capacity to 40,000MW by 2020 by implementing changes in the ESPRA Act; unfortunately, this objective was not met (NERC 2019). The problems with electricity in Nigeria are due to lower investments in the public power industry in the 1990s, including maintenance budget cutbacks and a lack of new capacity for the national system and all power plants. As a result, by the end of the twentieth century, the gap between capacity and actual generation had increased significantly. Nigeria's reliable and steady energy supply remains a concern.

Table 1. Nigeria's population, installed and available power generation.

Year	Population (Million)	Installed capacity (MW)	Available power (MW)
1980	73.7	2507	783
1985	83.9	4192	1133
1990	95.6	4548	1537
1995	108	4548	1810
2000	122.9	5580	1738
2005	139.6	6538	2494
2010	159.7	6904	3358
2014	177	8876	3795
2018	190	12,522	4000

Source (Gatugel Usman, Abbasoglu et al. 2015): and (IEA 2019)

Table 1 shows an increase in the gap between installed capacity and available power in Nigeria as the population increases over time. This study investigates how the electricity policies can address this issue using the country's available resources.

3. Methods

A mixed-method technique was used to combine a literature review and online surveys. Mixed-method research is a philosophically based form of inquiry that combines qualitative and quantitative research methods to blend data and expand knowledge in more significant ways than every single model could do individually (Creswell 2014). Purposive sampling was used to identify various professionals from the Nigerian Power sector to participate in the survey after thoroughly examining the literature and the relevant policies.

The first step in this study was to conduct a critical literature assessment of policies on electricity to see how they influenced electrification in Nigeria. First, challenges from the past and present were identified and critically studied. Then, the survey participants were invited to determine which policies led to increasing electric power generation and supply in a study of nine electrical policies created from 2001 to 2020. The following policies are included in the study's scope:

1. National Electric Power Policy (NEPP), 2001
2. National Energy Policy (NEP), 2003
3. National Power Sector Reform Act (EPSRA), 2005
4. Renewable Energy Master Plan (REMP) 2005
5. Renewable Electricity Policy Guidelines (REPG), 2006
6. Multi-Year Tariff Order (MYTO I), 2008
7. Multi-Year Tariff Order (MYTO II), 2012
8. Nigerian Electricity Regulatory Commission Mini-Grid Regulation, 2016
9. Rural Electrification Strategy and Implementation Plan (RESIP), 2016

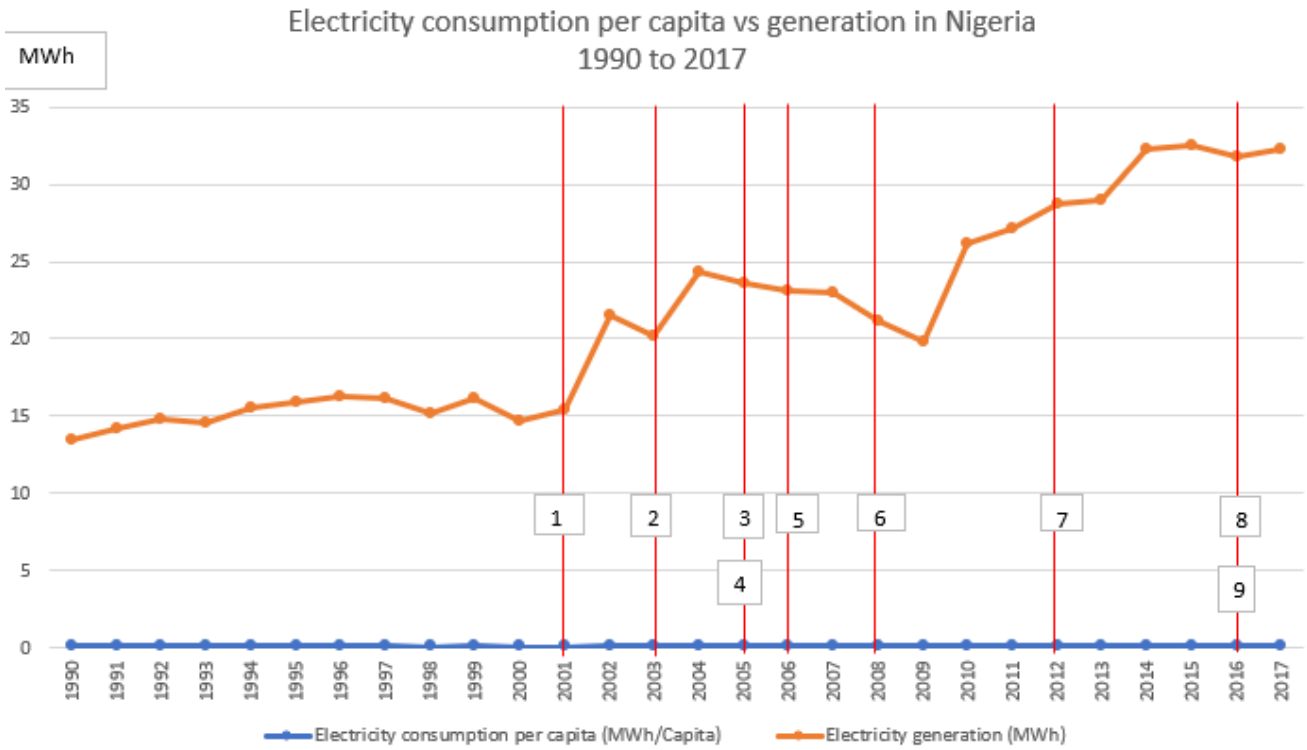

Figure 2. Electricity generation, consumption vs policy development

Source**:** Author's compilation

Figure 2 shows how the when the above stated policies were launched in relation to electricity generation between 1990 and 2017. It is noted that there was a spike in generation around 2001 which coincides with the release of the first policy within the scope of this study. The survey was designed to understand how each of the nine policies impacted the changes in terms of electricity power generation and supply in the nation.

4. Data Collection

Purposive sampling was used to identify professionals from the Nigerian Electricity sector to take part in the survey after a thorough examination of the literature and Nigerian power policies. As a result, 78 specialists with expertise and knowledge of the industry, took part in the study. The survey findings were validated and prioritised using quantitative analysis. JISC surveys were used to disseminate the Likert-scale questions on a survey of multiple-choice questions to the participants.

5. Results and Discussion

In Nigeria, the provision of reliable and long-lasting electricity remains a problem. Between 1999 and 2017, the FGN is reported to have invested USD16 billion to restore the electrical industry (Akuru et al. 2017). Furthermore, various attempts to enhance Nigeria's energy generation and enlarge the national grid are underway. Despite having a variety of energy sources, Nigeria produces power mostly from petroleum resources, with natural gas being the most common. Table 2 depicts the various electrical production options accessible in Nigeria.

Table 3. Nigeria Renewable Energy Sources

Resource	**Energy Potentials**
Hydropower (large scale)	11,000 MW
Hydropower (small scale)	3500 MW
Wood fuel	43.1 billion tons/year
Animal waste	61 million tons/year
Crop residue	83 million tons/year
Solar radiation	3.5–7.0 kWh/m2/day
Wind speed	2–4 m/s (annual average) at 10 m height

Source: (Gatugel Usman, Abbasoglu et al. 2015b)

The survey showed that the RESIP and Mini-Grid Regulation policies provided the most contribution within the relevant timeframe, as shown in Figure 3. The Pareto chart shows that more than 80% of the improvements were associated with the development of these policies.

The Mini-Grid policy was passed in the year 2016 to govern a sector of mini-grids and provide a favourable setting for future investments to accelerate the nation's electrification roadmap. A mini-grid is defined in this article as a structure able to generate electric power ranging from 0 kW to 1MW and delivers electricity to two or more consumers. The RESIP establishes a road plan for promptly and cost-effectively increasing access to electricity in rural sections of Nigeria. It recommends employing off-grid, on-grid, and independent power delivery techniques with incentives to boost access rather than consumption (Emodi 2016; Otobo 22 Nov 2021).

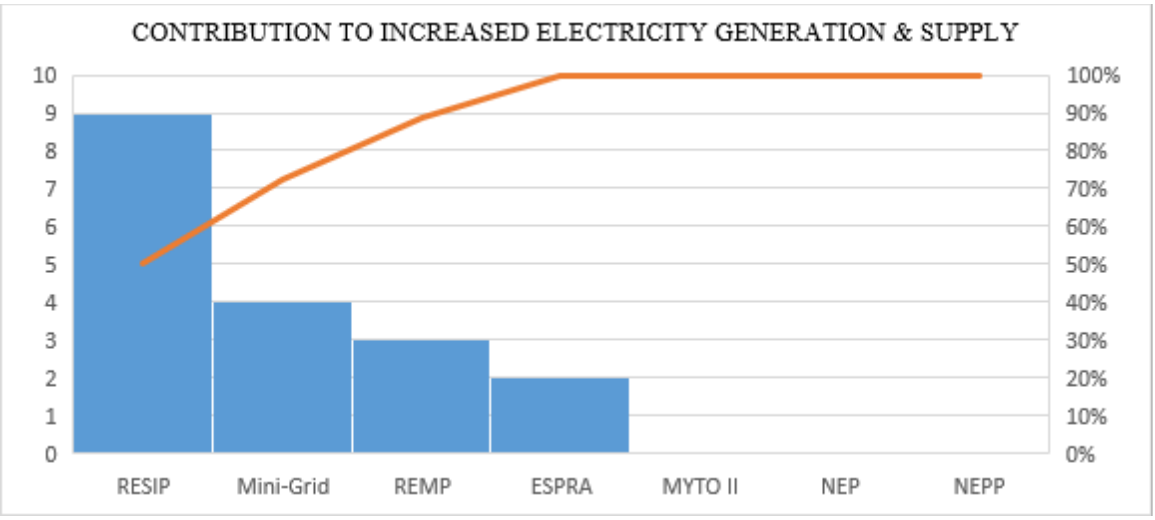

Figure 3. Policy contribution to increasing generation and supply (Quantitative data)

In this study, researchers looked at how each policy affected electricity generation and supply in Nigeria based on five factors: i) Expand electrification of off-grid and rural areas, ii) Create and regulate a competitive electricity sector, iii) Provide good investment opportunities, iv) Increase the energy mix, and v) Encourage more involvement from the complete value chain. Figure 4 shows that policies that performed best were the ones that addressed an expansion in off-grid and rural electrification. As a result, future policies should favour rural and off-grid electrification, particularly in places that are not linked to the national grid.

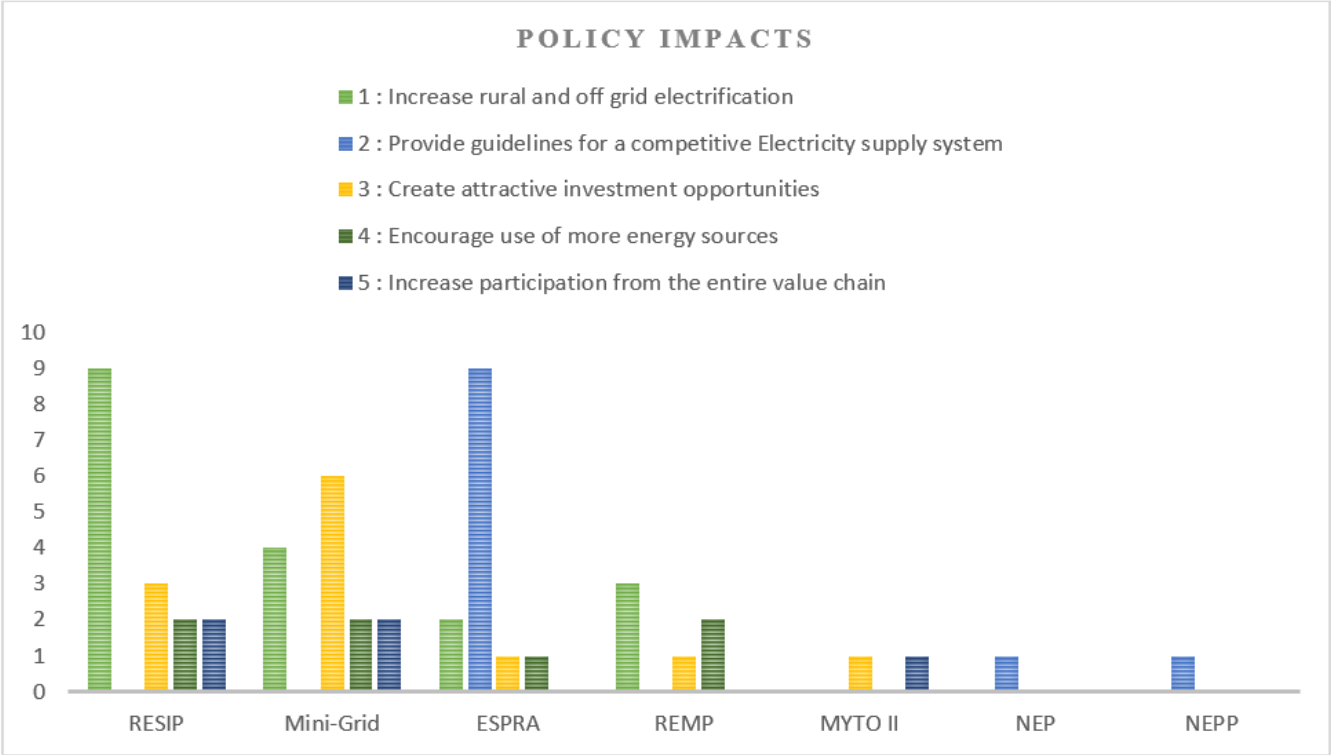

Figure 4. Policy contribution to increasing generation and supply (Qualitative data)

The survey participants were asked to comment on steps that could be taken to ensure that the current and future electricity policies in Nigeria effectively reduce and eventually eliminate energy poverty in the country. The responses were coded using Nvivo, and the tree diagram in Figure 5 shows a frequency chart that we created based on the study results. It can be seen that 21 percent of the participants proposed creating attractive investment opportunities and involving subject matter experts and participants from the entire value chain, 15 percent suggested encouraging the implementation of existing policies, 13 percent posited supporting the enhancement of the regulation of the power sector, 10 percent asked to increase rural and off-grid electrification, 8 percent proposed localising future policy designs, 5 percent suggested utilising more energy sources than is present in the current energy mix, and to encourage the political will to implement the existing policies, finally, 3 percent recommended the development of the relevant skills to the people that are resident in the affected regions (Otobo 22 Nov 2021).

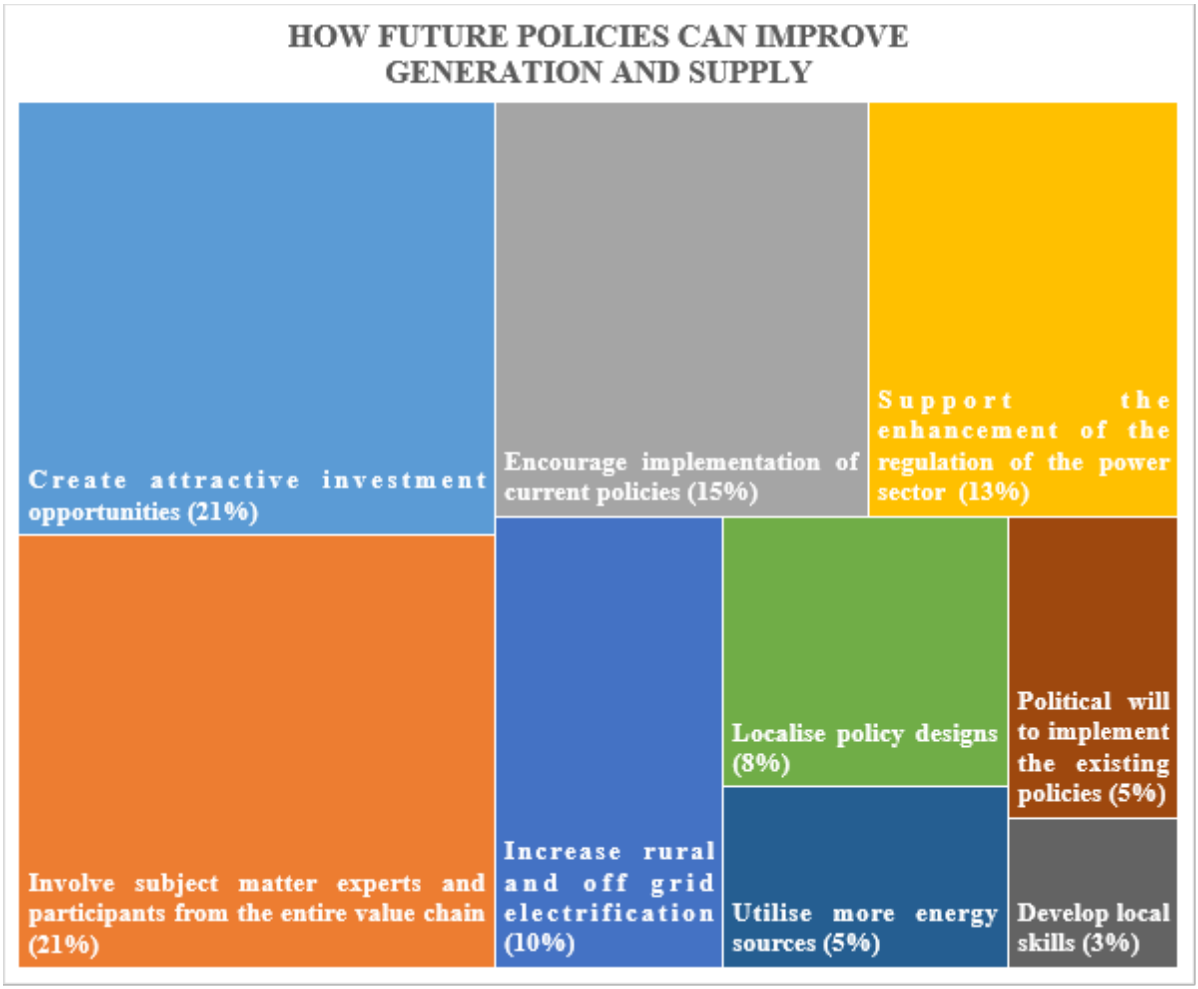

Figure 5. Proposed improvements to future policies

6. Conclusion

Nigeria's electrical infrastructure serves around 60% of its population; however, the power is unreliable and insufficient. As a result, most Nigerian families produce power using generators or solar panels (Elegbede, Kerr et al. 2021). They do, however, demand more stable, economic, and long-term electrical sources.

According to this analysis, Nigeria's power sector challenges may be remedied if appropriate regulations are put in place to encourage renewable energy investors. For example, households with direct electrical connections might employ off-grid solar to transition to cleaner, renewable energy sources. This opens the possibility of building additional power plants to generate and distribute electricity to areas and consumers who are not currently serviced by the national grid. This calls for cleaner and more sustainable power to be generated by utilising the country's untapped natural resources, such as wind, biomass, and tidal.

References

ADEKOYA, O.B., OLIYIDE, J.A., YAYA, O.S. and AL-FARYAN, M.A.S., Does oil connect differently with prominent assets during war? Analysis of intra-day data during the Russia-Ukraine saga. Resources Policy, 77, pp. 102728, 2022.

AKWUKWUEGBU, I., NOSIRI, O., AGUBOR, C. and OLUBIWE, M.,. Comparative Power Flow Analysis of 28 and 52 Buses for 330KV Power Grid Networks in Nigeria Using Newton-Raphson Method. International Journal of Recent Engineering Research and Development (IJRERD), 2, pp. 1-23, 2017

BOUBAKER, S., GOODELL, J.W., PANDEY, D.K. and KUMARI, V., Heterogeneous impacts of wars on global equity markets: Evidence from the invasion of Ukraine. Finance Research Letters, 48, pp. 102934. 2022.

CRESWELL, J.W., Research design : qualitative, quantitative, and mixed methods approaches / John W. Creswell. Fourth edn. Los Angeles, California: SAGE,2014.

DELLER, D., TURNER, G. and WADDAMS PRICE, C., Energy poverty indicators: Inconsistencies, implications and where next? Energy Economics, 103, pp. 105551, 2021.

ELEGBEDE, O., KERR, J., RICHARDSON, R. and SANOU, A.,. Using a choice experiment to understand preferences in off-grid solar electricity attributes: The case of Nigerian households. Energy for Sustainable Development, 60, pp. 33-39., 2021

EMODI, N.V. and BOO, K., 2015. Sustainable energy development in Nigeria: Current status and policy options.

EMODI, N. and EBELE, N., Policies Promoting Renewable Energy Development and Implications for Nigeria. British Journal of Environment and Climate Change, 6(1), pp. 1-17., 2016.

GATUGEL USMAN, Z., ABBASOGLU, S., TEKBIYIK ERSOY, N. and FAHRIOGLU, M., Transforming the Nigerian power sector for sustainable development, 2015

GUNGAH, A., EMODI, N.V. and DIOHA, M.O., Improving Nigeria's renewable energy policy design: A case study approach, 2019.

HASSAN, S.T., BATOOL, B., ZHU, B. and KHAN, I., Environmental complexity of globalization, education, and income inequalities: New insights of energy poverty. Journal of Cleaner Production, 340, pp. 130735.2022.

IEA, 2020-last update, IEA Country Information. Available: https://www.iea.org/countries/Nigeria/ [06 Apr, 2021].

IGAWA, M. and MANAGI, S., Energy poverty and income inequality: An economic analysis of 37 countries. Applied Energy, 306, pp. 118076, 2022

KARMAKER, S.C., SEN, K.K., SINGHA, B., HOSAN, S., CHAPMAN, A.J. and SAHA, B.B.,The mediating effect of energy poverty on child development: Empirical evidence from energy poor countries. Energy, 243, pp. 123093, 2022

NERC, 2019-last update, Nigerian Electricity Supply Industry (NESI). Available: https://www.nercng.org/index.php/home/nesi [18 May, 2019].

Nigeria Power Baseline Report July, 2015-last update. Available: https://mypower.ng/wp-content/uploads/2018/01/Baseline-Report.pdf

OBENG, G.Y., EVERS, H., AKUFFO, F.O., BRAIMAH, I. and BREW-HAMMOND, A., Solar photovoltaic electrification and rural energy-poverty in Ghana. Energy for Sustainable Development, 12(1), pp. 43-54.2008.

OTOBO, J.C., 22 Nov 2021. Building Sustainability and Resilience in the Nigerian Power sector – A case study of the Rural Electrification Agency (REA), 22 Nov 2021, London South Bank University.

RAO, F., TANG, Y.M., CHAU, K.Y., IQBAL, W. and ABBAS, M., Assessment of energy poverty and key influencing factors in N11 countries. Sustainable Production and Consumption, 30, pp. 1-15.2022.

ZHAO, J., DONG, K., DONG, X. and SHAHBAZ, M., How renewable energy alleviate energy poverty? A global analysis. Renewable Energy, stylefix 2022.

Biography

Justicia Otobo is an Engineering Program Manager at Anaplan Inc, a planning software company. Over the past 15 years, she has led large scale programs in IT, financial services, manufacturing and engineering sectors and managed virtual teams located in Europe, Asia, and the US. She is currently a part-time research student at the London South

Bank University, studying a PhD in Engineering and the Built Environment. Justicia has a passion for learning, coaching, and working with young people, and is a School Governor at West Town primary school. Her hobbies include swimming, running, travelling, and reading.