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The Necessity of a Paradigm Shift Towards Alternative Energy Sources in Nigeria: An Examination of Fuel-less Generators

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A B S T R A C T

Based on a report published by the African Development Bank (AfDB), Nigeria incurs an annual economic deficit of $29 billion due to insufficiencies in its power supply infrastructure. Currently, generators serve as an alternative power source, these are predominantly reliant on fossil fuels availability and pricing (cost). This study x-rays impact of unstable power supply, the effects of using fuel generators and the necessity for the development of a fuel-less generator technology to meet demand. The data indicates that a substantial majority of respondents, comprising 89.9 percent or 414 individuals, expressed the perception that the electricity supply in their respective areas is marked by instability. According to the survey participants, the use of a fuel-powered generator as an alternative means of power provision is deemed economically disadvantageous for customers due to the overall production cost and finally, the findings revealed that 93.1 percent of the respondents held the belief that the development of fuel-less generator technology would bring about significant improvement in the society.

Keywords: Fuel-less generator, Fuelled generator, Power, Electricity, Economy

1. Introduction

Nigeria, being the foremost economy in sub-Saharan Africa, encounters growth constraints due to limitations within its power sector. Nigeria possesses substantial reserves of oil, gas, hydro, and solar resources, thereby exhibiting the capacity to generate a significant amount of electric power, estimated at 12,522 MW, through its current power plants. On the majority of occasions, the power grid is capable of dispatching approximately 4,000 MW. This capacity is deemed inadequate for a nation with a population exceeding 195 million individuals (USAID, 2019).

In 2013, the Nigerian federal government implemented a privatisation initiative involving the transfer of ownership of 11 electricity distribution companies (DISCOs) and six generating companies (GENCOs), while maintaining full ownership of the Transmission Company of Nigeria (TCN). This strategic move was undertaken as part of a broader plan to reform the sector and foster economic expansion. The ongoing comprehensive power sector reforms in the country are designed with the objectives of expanding capacity, enhancing electricity access, and upgrading transmission infrastructure (International Trade Administration, 2023).

Adequate provision of electricity is an essential requirement for the progress of any country, and the processes of generating, transmitting, and distributing electricity involve significant investments in terms of financial resources and infrastructure capacity. Given the current situation in Nigeria, where there is a gradual decline in the availability of funds, it is imperative to explore creative and innovative solutions to effectively tackle the issue of power supply (Sambo et al., 2010).

Despite years of public investment, Nigerian electricity remains unreliable. Poor electricity infrastructure has slowed progress in the real economy, education, and workforce engagement, especially for women and girls (Moyo, 2012; Oseni and Pollitt, 2012). Underperforming state utility companies NEPA and later PHCN necessitated power sector reform. The generation and distribution segments of the electricity value chain were privatised in 2014 after this reform.

The lack of progress in the Nigerian electric power sector following the reform has presented a significant obstacle for various stakeholders, including the government, private investors, electricity experts, development partners, and scholars. This persistent issue hinders the achievement of electricity goals and necessitates the exploration of inventive solutions (Onyekwena, Ishaku and Akanonu, 2017).

According to a report by the African Development Bank (AfDB), Nigeria experiences an annual economic loss of $29 billion as a result of inadequate power supply. Additionally, manufacturers within the country incur substantial expenses, amounting to N10.1 trillion, in order to meet their energy

requirements (Ogunseyin, 2023). According to Udegbunam (2021), the epileptic power supply in Nigeria imposes significant financial burdens on businesses, amounting to approximately $29 billion annually. Additionally, the International Monetary Fund (IMF) has estimated that Nigeria experiences a loss of $29 billion, equivalent to 5.8% of its annual GDP, as a result of inadequate energy infrastructure and unreliable power provisions. According to Ijaseun (2023), Nigerians allocate a substantial annual expenditure of $14 billion towards the procurement of generators and fuel.

Generators which have become the alternative power source now make use of fossil fuel. The use of fossil fuels pollutes the environment and deplete the ozone layer. Land and water pollution, noise pollution, and fossil fuel price fluctuations are other issues. The fuel-less generator is Nigeria's only solution to these disparities (Cibulka, 2009).

2. Review of Literature

Electricity plays a fundamental and indispensable role in our daily lives, as it illuminates our surroundings and provides power to various essential sectors such as residential, educational, medical, commercial, and industrial settings. The relationship between a nation's economic growth and its electrical power supply is a well-established phenomenon (Olugbenga, Jumah and Phillips, 2013).

Provision of electricity is an essential requirement for the progress of any country, and the processes of generating, transmitting, and distributing electricity involve significant investments in both financial resources and infrastructure capacity. Given the current situation in Nigeria, where there is a gradual decline in the availability of funds, it is imperative to explore creative and innovative approaches to tackle the issue of power supply (Sambo et al., 2010).

The primary sources of power generation in Nigeria are thermal and hydro, accounting for a significant majority of the country's installed capacity, which stands at approximately 12,522 MW. The nation is a member of the Economic Community of West African States (ECOWAS) and the West African Power Pool (WAPP), which is a specialised agency within ECOWAS comprising 14 countries within the regional economic community. The initiation of the West African Power Pool (WAPP) aimed to foster the advancement and enhancement of power generation and transmission infrastructures, while concurrently facilitating the coordination of power exchange activities among the member states of the Economic Community of West African States (ECOWAS). Nigeria presently provides electricity to the neighbouring countries of the Republic of Benin, Togo, and Niger (International Trade Administration, 2023).

The rise in population and the resulting surge in electricity demand have compelled power systems to operate at near maximum capacity (Happ, 1994; Illic et al., 1997). The electricity industry in Nigeria has undergone a process of deregulation, resulting in the restructuring of the National Electric Power Authority (NEPA), now known as the Power Holding Company of Nigeria (PHCN). Previously, NEPA held the complete responsibility for electricity generation, transmission, and distribution. However, as per the PHCN annual report of 2009-2010, this entity has been unbundled into six generating companies, eleven distribution companies, and a single transmission company.

Despite the fact that Nigeria has been producing electricity on a large scale for more than a century, the country's progress in developing electricity infrastructure has been sluggish, resulting in insufficient power supply. The Nigerian power sector faced significant challenges prior to reforms, primarily stemming from the government's vertically integrated monopoly over power generation, transmission, and distribution. Although the reforms have achieved success in privatising the generation and distribution segments of the Nigerian Electricity Supply Industry (NESI), the sector continues to face significant issues. It is important to note that privatisation has merely altered the nature of these challenges (Onyekwena, Ishaku and Akanonu, 2017).

The performance of Nigeria's Electricity Supply Industry (NESI) remains suboptimal despite the implementation of a promising reform. The participants within the NESI face a multitude of obstacles, such as an insufficiently varied energy source portfolio, financial limitations, deficiencies in infrastructure that are worsened by acts of vandalism, significant aggregate technical, commercial, and collection (ATC&C) losses, and the operation within an ineffective market governance framework. The current state of Nigeria's electricity sector positions it as a significant underperformer within the African context.

These challenges present a significant obstacle to the government's objectives of ensuring widespread and cost-effective electricity access in Nigeria. The government has set forth ambitious objectives, including the establishment of a diversified energy portfolio with a substantial share of renewable sources, the gradual elimination of individual electricity generation through personal generators, the enhancement of electricity accessibility to 90% of the populace from the existing 40%, and the advancement of energy efficiency (Onyekwena, Ishaku and Akanonu, 2017).

Proffering the solution to the Nigerian electricity challenge will need concerted efforts at exploring other means to make up the short fall from the existing system. One of such is the development of fuel-less generator. The pressing need for clean energy solutions has spurred the necessity for inventive approaches to power generation. The conceptualization, development, and implementation of a fuel-less generator that employs an electric motor and alternator as an innovative substitute for conventional generators reliant on fossil fuels (Erinle, Falana and Oladipupo, 2023).

The fuel-less generators typically operates with minimal noise and vibration, and its notable advantage lies in its absence of air pollution, as it does not emit hazardous gases such as carbon monoxide (CO) and carbon dioxide (CO2). The speed of the device can be modified or engineered to operate at a singular velocity, independent of the utilisation of petrol, oil, or other flammable fuels for its engine. The fuel-less generators have the capability to generate electrical energy at no cost, which is subsequently fed back into the motor for reuse (James, 2005). Fuelless engines offer a reliable, economically viable, and environmentally advantageous energy solution. However, additional research is required to examine alternative methodologies for mitigating carbon dioxide emissions and addressing the negative consequences of human activities (Adewumi, 2015).

2.1 The Categorization of Fuel-Less Generators

Mboko, Etim and Essien, (2019), classified the fuel-less generator into distinct categories.

1. Off-grid fuel-less generators are employed in remote systems where the inverter obtains its direct current (DC) energy from batteries that are charged by solar arrays and/or other sources, including wind turbines and hydro turbines. Typically, these systems do not establish any form of connection with the utility grid, and therefore, they are not obligated to possess anti-islanding protection.

2. Grid-tied fuel-less generators refer to a type of power generation system that is connected to the electrical grid and operates without the need for traditional fuel sources. These systems synchronise their phase with a sine wave supplied by the utility. Grid-tie, also known as grid-connected or grid-interconnected, refers to a system The fuel-less generator has been engineered to possess an automatic shutdown feature in the event of a loss of utility supply, commonly known as anti-islanding protection. The provision of backup power during utility outages is not offered by them. In the province of Ontario, it is mandatory for solar arrays that supply electricity to the utility grid, such as those participating in the FIT/micro-FIT programmes, to be equipped with anti-islanding protection.

3. Battery backup systems are a type of fuel-less generator that have been specifically engineered to extract energy from a battery. These systems are equipped with an on-board charger that regulates the battery's charge, while any surplus energy is transmitted to the utility grid. The inverters possess the capability to provide alternating current (AC) energy to specific loads in the event of a disruption in the utility power supply. Additionally, it is mandatory for these inverters to incorporate anti-islanding protection.

4. The wet-type fuel-less generator, as its name suggests, is a type of generator that operates without the need for fuel. It utilises components containing liquid, such as batteries, to optimise the generation of electrical power. The primary components of this system comprise an electric direct current (DC) motor, an electric generator, couplings, and a battery.

5. The dry-type fuel-less generator is an environmentally friendly generator that operates without the need for batteries. These systems primarily comprise an alternating current (AC) electric motor, a flywheel, pulleys, belt drives, shafts, and an electric generator

3. Results of Electricity user's perception

Respondents were drawn from Edo South and Edo Central senatorial zones in Edo State. Questionnaires were administered to them. The total figure of the respondents was 466. The breakdown of the returned questionnaires.

Table 1. Gender information

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Male	94	20.2	20.2	20.2
	Female	372	79.8	79.8	100.0
	Total	466	100.0	100.0	

The gender information show that 466 respondents filled this. The number of male were 94 and females 372. This gives a percentage of 20.2 and 79.8 percent respectively. The responds rate was 100 percent (table 1).

Table 2. Location information

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Edo Central	124	26.6	26.6	26.6
	Edo South	342	73.4	73.4	100.0
	Total	466	100.0	100.0	

The location information shown in table 2 indicates that 124 respondents were from Edo Central Senatorial district and 342 were from Edo South senatorial district. 124 of respondents make up 26.6 percent of the total respondents and 73.4 percent for the Edo State Senatorial district respondents.

Table 3. Educational Background

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	None	30	6.4	6.5	6.5
	First School Leaving Certificate	46	9.9	9.9	16.4
	JSS	16	3.4	3.4	19.8
	SSS	186	39.9	40.1	59.9
	Higher Institution	186	39.9	40.1	100.0
	Total	464	99.6	100.0	
Missing	System	2	.4		
Total		466	100.0		

The educational background information from returned questionnaire show that the majority of respondents were O'Level and Graduates from tertiary institutions, they were 186 for each. This is 39.9 percent for them respectively. The others make up of JSS, Primary school leavers were a combine figure of 62 making up 13.3 percent, while 30 did not have a qualification (table 3).

Table 4. Electricity supply in my location is very stable and predictable

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	SD	248	53.2	53.2	53.2
	D	166	35.6	35.6	88.8
	U	24	5.2	5.2	94.0
	A	20	4.3	4.3	98.3
	SA	8	1.7	1.7	100.0
	Total	466	100.0	100.0	

The Likert scale used was a 5 scale Likert scale. The keys are as follows SD=Strongly Disagree, D=Disgree, U=Undicided, A=Agree and SA=Strongly Agree.

414 respondents making 88.8 percent affirms that Electricity supply in their location is very unstable and unpredictable which affect productivity. While 28 prespondents making up 6 percent are of the opinion that they usually have power in their location as shown in table 4.

Table 5. Electricity supply in my location is not stable which affects my productivity making me unable to meet up with my work demand

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	SD	8	1.7	1.7	1.7
	D	26	5.6	5.6	7.3
	U	18	3.9	3.9	11.2
	A	182	39.1	39.1	50.2
	SA	232	49.8	49.8	100.0
	Total	466	100.0	100.0	

89.9 percent corresponding to 414 respondents are of the opinion that Electricity supply in their location is not stable which affects their productivity making them unable to meet up with my work demand as presented in table 5. 34 respondents disagree making up 7.3 percent, while 18 were undecided.

Table 6. There is no electricity supply in my location and I depend on alternative source to meet up with my work demand

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	SD	10	2.1	2.1	2.1
	D	206	44.2	44.2	46.4
	U	62	13.3	13.3	59.7
	A	118	25.3	25.3	85.0
	SA	70	15.0	15.0	100.0
	Total	466	100.0	100.0	

216 respondents disagree with the statement that, there is no electricity supply in my location and I depend on alternative source to meet up with my work demand, this makes 46.4 percent. While 188 agrees with the statement. This makes 40 percent of respondents as shown in table 6. The inference from the result may be indicative that respondents may have alternatives in probably going to where there is power to do their job and necessarily using generators for their work.

Table 7. The frequent breakdown and cost maintenance of the conventional generator affects my productivity

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	SD	8	1.7	1.7	1.7
	D	36	7.7	7.7	9.4
	U	6	1.3	1.3	10.7
	A	202	43.3	43.3	54.1
	SA	214	45.9	45.9	100.0
	Total	466	100.0	100.0	

For respondents who use generator as alternative source to the grid electricity, they majority believes that the frequent breakdown and maintenance affect the productivity and jobs. These respondents make 99.9 percent equivalent to 406 of the respondents. While 9.4 percent were against this equivalent to 46 respondents as seen in table 7.

Table 8. The high cost of fuelling the conventional generator affects my productivity

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	D	18	3.9	3.9	3.9
	U	8	1.7	1.7	5.6
	A	148	31.8	31.8	37.3
	SA	292	62.7	62.7	100.0
	Total	466	100.0	100.0	

The issue of the high cost of fuelling the conventional generator affecting users' productivity is also an important factor. 94.5 percent agrees to the statement and 5.6 disagrees. The number of respondents with respect to the percent are 440 and 26 respectively as presented in table 8

Table 9. Developing a fuel-less generator will be a game changer

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	D	10	2.1	2.1	2.1
	U	22	4.7	4.7	6.9
	A	254	54.5	54.5	61.4
	SA	180	38.6	38.6	100.0
	Total	466	100.0	100.0	

434 respondents believe that developing a fuel-less generator technology will be a game changer, this is 93.1 percent of responses. 2.1 percent equivalent to 10 respondents disagree. While 22 were undecided in their response (table 9).

Table 10. The increase in fuel price is a serious factor as regards energy availability

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	A	212	45.5	45.5	45.5
	SA	254	54.5	54.5	100.0
	Total	466	100.0	100.0	

The increase in fuel price is a serious factor as regards energy availability. This information is presented in table 10. The table shows that a 100 percent of the respondents agree to this statement, this equals the whole 466 respondents.

Table 11. The overall cost of production is not customer friendly

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	D	14	3.0	3.0	3.0
	U	16	3.4	3.4	6.4
	A	224	48.1	48.1	54.5
	SA	212	45.5	45.5	100.0
	Total	466	100.0	100.0	

In the final analysis concerning the overall cost of using a fuelled generator as alternative to power supply, respondents are of the opinion that the overall cost of production is not customer friendly (table 11). 436 respondents agree to this statement and 14 respondents disagree and 16 were undecided in their responds. This gives a percentage of 93.6 percent, 3.4 percent, 3.0 percent respectively.

4. Conclusion

The issue of power availability in Nigeria poses a substantial barrier to the government's goals of achieving widespread and affordable electricity access in the country. The government has outlined ambitious goals, which encompass the development of a diversified energy portfolio with a significant proportion of renewable sources, the gradual phasing out of individual electricity generation through personal generators, the improvement of electricity accessibility to 90% of the population from the current 40%, and the promotion of energy efficiency. The conclusion from this research:

1. The data presented that a significant majority of respondents, specifically 89.9 percent or 414 individuals, expressed the view that the electricity supply in their respective locations is characterised by instability.

2. This lack of stability has a direct impact on their productivity, hindering their ability to meet the demands of their work.

3. In the final examination pertaining to the comprehensive expense of utilising a fuel-powered generator as a substitute for power provision, survey participants assert that the overall production cost is not economically advantageous for customers.

4. The increasing trend of fuel prices constitutes a significant determinant in relation to the accessibility of energy resources. The data presented with respect to this indicates that all 466 respondents, constituting 100 percent of the sample, agree with the given statement.

5. A total of 434 participants expressed their belief that the advancement of fuel-less generator technology would have a transformative impact, constituting 93.1 percent of the overall responses. A total of 10 respondents, constituting 2.1 percent of the sample, expressed disagreement. Among the respondents, a total of 22 individuals expressed indecision in their answers.

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