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Evaluating the Economic Impact of Frequent Power Outages on Nigeria's National Grid: A Case Study of North-East Nigeria

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Abstract

Frequent power outages remain one of the major impediments to Nigeria's economic growth and productivity. This study evaluated the economic impact of frequent power outages on Nigeria's national grid, focusing on the North-East region. Using a descriptive and correlational survey research design, data were collected from 1,100 respondents comprising households, small and medium enterprises (SMEs) and key informants. The study examined outage frequency, associated costs, and coping mechanisms adopted by respondents. Descriptive statistics, correlation, and regression analyses were employed for data interpretation. The results revealed that frequent outages significantly increase operational costs, reduce productivity and negatively affect income generation, particularly for SMEs that rely heavily on electricity for production. A strong positive correlation ($r = 0.71$, $p < 0.01$) was found between outage frequency and coping expenditures such as generator fuel, maintenance, and equipment damage. The study concludes that frequent power interruptions impose heavy economic burdens on both households and enterprises in the region. It recommends urgent investment in grid modernization, promotion of renewable energy alternatives, and implementation of sustainable policies to enhance electricity reliability and economic stability in Nigeria.

Keywords: Power outages, economic impact, national grid, coping costs, SMEs, North-East Nigeria.

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INTRODUCTION

Electricity plays a pivotal role in economic development and social transformation. In Nigeria, however, the persistent challenge of frequent power outages continues to undermine productivity, economic growth, and quality of life. The North-East region, already burdened by infrastructural deficits and post-conflict reconstruction, faces significant disruptions due to unstable electricity supply.

Frequent outages interrupt industrial operations, reduce efficiency among Small and Medium Enterprises (SMEs), and increase operational costs for households and businesses that rely on alternative sources such as generators. According to the Nigerian Electricity Regulatory Commission (NERC, 2024), the national grid has recorded over 120 system collapses in the past decade, significantly affecting electricitydependent sectors.

Nigeria, the largest country in Africa by population, still faces major challenges with its weak and unreliable power supply despite having abundant natural and energy resources. In recent years, the national electricity grid has collapsed repeatedly, over 46 times between 2017 and 2023 alone (NBS, 2023; The Guardian, 2023). These constant outages affect everyday life, disrupt businesses, and slow down the country's economic growth, with the impact felt even more deeply in the already vulnerable North-East region.

The World Bank (2022) estimates that power outages cost Nigeria about $28 billion every year, which is roughly 2% of the nation's GDP. The North-East suffers the most because it struggles with poor infrastructure, insecurity, and limited access to energy (UNDP, 2022). Small and medium-sized enterprises (SMEs), which employ more than 84% of workers in the area, are especially hit hard. Many of them depend on generators, which are expensive to run and difficult to maintain (IEA, 2023).

Studies have shown that frequent and long-lasting power outages directly reduce productivity, increase operating costs, and lower customer satisfaction (Okafor &Akinwale, 2023; Olaniyan et al., 2021). In the North-East, this energy shortage discourages new investment and keeps communities trapped in a cycle of poverty and underdevelopment. Schools, hospitals, and government services also struggle to function during outages, which further affects education, healthcare, and overall human development (USAID Power Africa, 2023).

Even though the government has introduced several reforms, such as breaking up the former Power Holding Company of Nigeria (PHCN) and passing the 2023 Electricity Act to decentralize the grid, the power supply is still far from stable. Grid failures continue, and the problem remains unresolved.

For these reasons, there is a strong need for a detailed study that focuses specifically on how these repeated power outages affect the economy of the North-East. This study evaluates the economic implications of frequent power outages on Nigeria's national grid, focusing on households, SMEs, and key energy stakeholders in the North-East. Also examine the real economic costs of these outages on households, businesses and overall regional productivity and to provide practical insights that can guide policymakers and energy-sector leaders.

Statement of the Problem

Despite investments in power sector reforms and grid infrastructure, power outages remain a daily occurrence across Nigeria. The instability of the national grid has led to low industrial output, rising unemploymentand increased business costs. Households spend a significant proportion of their income on fuel for alternative energy sources. The North-East region is particularly affected due to its weak infrastructural backbone and limited investment attraction.

This study therefore seeks to empirically assess how frequent power outages economically affect various categories of energy consumers in North-East Nigeria.

Objectives of the Study

General Objective:

To evaluate the economic impact of frequent power outages on Nigeria's national grid with specific reference to the North-East region.

Specific Objectives:

1. To assess the economic losses experienced by households due to frequent power outages.
2. To determine the impact of power outages on the productivity of SMEs.
3. To examine the relationship between power outage frequency and operational costs in the region.
4. To identify coping mechanisms adopted by households and businesses.

Research Questions

1. What are the economic losses incurred by households as a result of frequent power outages?
2. How do frequent power outages affect SME productivity in the North-East region?
3. What is the correlation between outage frequency and operational costs?
4. What coping strategies do consumers adopt to mitigate the effects of outages?

Research Hypotheses

H_{01}: There is no significant relationship between the frequency of power outages and household income.
H_{02}: Frequent power outages do not significantly affect SME productivity.
H_{03}: There is no significant relationship between outage frequency and operational costs of businesses.

Significance of the Study

This study provides empirical evidence on the economic burden of unreliable electricity supply in Nigeria. It will guide policymakers, power sector regulators, and investors in designing sustainable interventions to enhance grid reliability and reduce economic losses.

Scope of the Study

The study covers six states in North-East Nigeria — Adamawa, Bauchi, Borno, Gombe, Taraba and Yobe; with a focus on households, SMEs and energy expertsusing a total sample of 1,100 respondents.

REVIEW OF RELATED LITERATURE

This section discusses key concepts such as power outages, economic impact, and national grid reliability. It also reviews theoretical frameworks and prior empirical studies that highlight the negative relationship between unstable electricity and economic growth.

Conceptual Framework

Concept of Power Outages

Power outages refer to the loss or interruption of electrical supply within a particular area, often resulting from faults in the generation, transmission, or distribution systems (Adeleke & Ogundele, 2021). A power outage is a loss of electrical power to an area caused by faults in power lines, generation plants, or grid failures (Olayemi, 2022).

Globally, power interruptions affect the reliability and stability of electricity networks, influencing economic activities and societal welfare (World Bank, 2023). In developing economies such as Nigeria, the issue is compounded by aging infrastructure, poor maintenance culture, and inadequate investment in renewable energy technologies (Eze & Obinna, 2022).

Power outages are categorized as planned (for maintenance) or unplanned (due to faults, weather, or system collapse). The Nigerian national grid has experienced frequent collapses — over 120 incidents between 2015 and 2024 (Nigerian Electricity Regulatory Commission [NERC], 2024). These collapses often disrupt social and economic operations, particularly in the North-East where infrastructure recovery remains slow.

Economic Impact of Power Outages

Electricity is a fundamental driver of industrialization, trade, and overall economic productivity (Adeniran & Eze, 2023). Frequent outages lead to reduced production, spoiled goods, damaged machinery, and reliance on costly backup systems (Onyema *et al*., 2023). For SMEs, unstable electricity supply translates to higher production costs and lower profit margins (Aliyu & Lawal, 2022). Households also face direct financial impacts — increased spending on generator fuel and reduced disposable income (Mbah *et al*., 2023).

Studies have linked the duration and frequency of power outages to national output losses. The International Energy Agency (IEA, 2023) estimates that Nigeria loses about $29 billion annually due to unreliable power supply, representing roughly 2% of GDP. Economic impact measures the effect of an event on the level of economic activity within a given area (World Bank, 2023). In this context, it reflects productivity loss, income reduction, and increased operational costs.

THE LACK OF POWER SUPPLY

The development of any societyand the overall quality of life of its people, depends heavily on the availability and accessibility of electricity. The International Energy Agency (2014)

reported that more than 1.3 billion people around the world still lack reliable access to power, with the majority living in rural communities. This absence of electricity has made it difficult for many countries to achieve key Millennium Development Goals (MDGs). As Emodi (2015) explains, affordable and dependable electricity is essential for economic growth, better living standards, and national development.

Nigeria, Africa's most populous country, has faced long-standing challenges with inadequate electricity supply from the national grid. Although many Nigerians are technically connected to the grid, many others—especially in rural areas—struggle to access electricity due to financial barriers and environmental constraints. As a result, most households rely on petrol or diesel generators, which are noisy, polluting, and expensive to operate (Emodi, 2015). These generators also contribute significantly to greenhouse gas emissions and other environmental problems.

Because of the high cost and negative environmental impact of generators, many Nigerians are beginning to adopt off-grid power systems. Off-grid alternatives offer a practical solution to the country's long-standing energy crisis, providing cleaner and more affordable options compared to traditional grid electricity. They can dramatically reduce emissions from diesel and petrol generators and stimulate economic growth, especially in rural communities. By shifting to mini-grids and solar power, Nigeria can strengthen rural economies, reduce rural-urban migration, and support small-scale enterprises (Odoh, 2022; Sajou, 2023).

The Rural Electrification Agency (REA) is playing an important role in expanding access to electricity through its Off-Grid Electrification Strategy. This initiative forms part of the broader Power Sector Recovery Programme (PSRP), which aims to improve customer satisfaction, reduce energy losses, increase transparency, enhance service delivery, and restore the financial health of Nigeria's power sector (Ogunbiyi, 2024).

Overall, off-grid energy solutions provide a promising pathway for improving agricultural productivity, reducing poverty, strengthening food security and boosting economic growth across Nigeria. By prioritizing off-grid power systems and renewable energy options such as solar technology, the country can address its chronic energy challenges, empower smallholder farmers, and promote long-term sustainable development (Sajou, 2023). With a large population, a growing economy, and millions still lacking grid access, Nigeria represents one of Africa's biggest markets for off-grid energy. Expanding mini-grids and solar home systems could save Nigerian households and businesses billions of dollars annually (Ogunbiyi, 2024).

COST-EFFECTIVENESS:
In many remote areas, extending the national grid is extremely costly. Off-grid solar systems offer a more affordable and practical way to generate electricity in such locations. By producing their own power, households and businesses can significantly cut down on energy expenses.

RELIABILITY:
Off-grid solar systems deliver a steady and dependable source of power, making them especially valuable in areas where the national grid often fails. Since they are not affected by frequent outages or blackouts, these systems help ensure that essential services—such as healthcare facilities and schools—can operate without interruption.

SUSTAINABILITY:
Because off-grid systems rely on renewable sources like solar energy, they reduce

dependence on fossil fuels and help lower harmful greenhouse gas emissions. This shift toward clean energy is particularly important for Nigeria, where the power sector is still heavily reliant on fossil fuels.

ECONOMIC GROWTH:

Off-grid solutions can transform rural economies by enabling smallholder farmers to use mechanized tools and equipment. This increases productivity, boosts income, reduces poverty, improves food security, and opens access to new agricultural markets. Altogether, these benefits drive broader economic development. According to Sajou (2023), off-grid alternatives provide an environmentally friendly pathway for Nigeria to address its energy problems, strengthen livelihoods and achieve long-term sustainable development, especially within the agricultural sector.

Evaluating off-grid power plants in Nigeria requires a close look at several key areas, including the regulatory framework, market potential, financial viability, site selection processes, funding opportunities, and long-term sustainability challenges. The Nigerian Electricity Regulatory Commission (NERC) plays a major role in shaping renewable energy development through policies such as feed-in tariffs and power purchase agreements (Timi-Koleolu, Alex-Adedipe, Atanda & Yishawu, 2023). With its large population and limited grid coverage, Nigeria presents a strong market opportunity for off-grid energy solutions (Ogunbiyi, 2024). Business case analyses show that off-grid systems are financially promising, but they require strategic site selection and partnerships with organizations like the World Bank to secure adequate funding (Ogunbiyi, 2024). For off-grid development to succeed, the regulatory environment, market prospects, financing strategies, and sustainability issues must all be thoroughly considered. Long-term progress also depends on careful planning and prioritizing grid-based electricity whenever feasible (Elusakin, Ajide & Diji, 2014).

The overall goal of such assessments is to identify major challenges and propose effective solutions that can expand access to reliable off-grid electricity in rural and underserved communities. Off-grid solar systems, primarily powered by solar energyare highlighted as an affordable and efficient means of electrifying remote areas (Hoeck, Steurer, Dolunay, Ileka & Energ, 2021). Successful expansion of off-grid electrification depends heavily on strong policy support, including long-term electrification plans and reliable information for stakeholders (Nyarko, Whale & Urmee, 2023). Off-grid renewable solutions are increasingly seen as transformational, providing rural populations worldwide with affordable and clean electricity, which improves their living conditions and economic opportunities (Dhabi, 2019). Babalola et al. (2022) further emphasize the role of mini-gridsindependent or distributed energy systemsin supporting micro and small enterprises and unlocking the economic potential of rural communities. To ensure affordable and reliable power in underserved areas, assessments stress the need to involve local communities in mini-grid planning, develop clear government regulations, and balance the interests of investors, communities, and policymakers.

Geographic factors are also crucial in assessing off-grid power plants. Variables such as solar radiation, wind speeds, elevation, terrain, humidity, air pressure, land availability, and proximity to transmission lines all play a major role in determining suitable sites for renewable energy projects (Rodríguez, 2021; Guaita-Pradas et al., 2019; Almalki, Piwowar & Siemer, 2019). For instance, regions like Chile’s Atacama Desert offer ideal conditions for solar power due to their high altitude, long sunshine hours, minimal cloud cover, and low pollution levels (Rodríguez, 2021). On the other hand, wind turbine projects perform best in

areas with strong, unobstructed wind flows, such as Argentina's southern tip or offshore locations (Rodríguez, 2021). Effective off-grid system design also requires analyzing load patterns, demographic data, land-use trends, and climate conditions (Tsiaras, Papadopoulos, Antonopoulos, Papadakis & Coutelieris, 2020). Proper geographical assessment helps maximize the sustainability and economic performance of off-grid power plants.

The evaluation of Nigeria's off-grid power sector is expected to produce several important recommendations. These may include prioritizing grid power generation where feasible, promoting detailed planning before implementing off-grid projects, and focusing on sustainable renewable sources such as solar, biomass, and small hydropower. Other expected recommendations involve investing in renewable energy infrastructure, stabilizing the national grid to reduce economic losses caused by instability, and improving policy coordination in the energy sector to strengthen governance (Elusakin, Ajide & Diji, 2014). These recommendations are especially relevant given projections that renewable energy could make up a significant portion of Nigeria's energy mix by 2030 and beyond (Nadig, 2023).

DEMAND AND SUPPLY OF ELECTRICITY IN NIGERIA:
A report by the UN Department of Economic and Social Affairs, as cited in Vanguard Newspaper (2017), projects that Nigeria could become the world's third most populous country by 2050. Experts warn that if this rising population is not matched with adequate social amenities and job opportunities, it could grow by as much as 4% by 2040. Vanguard (2019) also reported that under President Muhammadu Buhari's administration, power generation rose to 1,811.3 megawatts in January 2019, with the Transmission Company of Nigeria (TCN) transmitting 127,157.7 megawatts—slightly above the 125,346.4 megawatts recorded in December 2018. However, even this increase was still far too low to meet the country's growing energy needs. This highlights Nigeria's persistent electricity deficit and the widening gap between power supply and demand.

Adesola (2006) noted that unreliable electricity and frequent blackouts posed major challenges during the 2006 population and housing census. Similarly, the Central Bank of Nigeria's 2012 fourth-quarter bulletin identified inadequate power supply as a major obstacle to business growth and national development. This electricity shortfall forces business owners to operate inefficiently and contributes to higher living costs.

Doris (2023) emphasized that Nigeria, now Africa's most populous country with over 200 million people as of 2020, requires massive electricity generation to meet its demand. Yet in the same year, only about 35.7 thousand gigawatt-hours of power were generated—far short of the electricity demand, which exceeded 29 terawatt-hours. The report recommended greater investment in power generation to reduce the persistent supply-demand gap.

ACCESS TO ELECTRICITY:
The availability of reliable electricity is essential for any nation's sustainable socioeconomic development. Unfortunately, Nigeria's power sector has long been marked by inconsistent and insufficient access to electricity (Amadi, 2015). Doris (2023) reported that only about 55% of Nigerians have access to electricity. Vanguard (2019) further noted that just 30% of the population had power access, with rural areas suffering the worst shortages, while urban areas recorded about 90% access. The Northeast and Northwest geopolitical zones were identified as the most affected regions.

By 2022, electricity demand in Nigeria had climbed to over 32 terawatt-hours. Statista projections indicate that average electricity consumption per personacross households and

industrieswill continue to rise annually. The report predicted that average household consumption would reach around 165 kWh in 2023 and increase to about 166 kWh by 2025.

SOLAR PV HYBRID ENERGY SYSTEMS:

Research shows that using renewable off-grid power systems in rural communities is not a new concept. Okoye and Oranekwu-Okoye (2018) studied the feasibility of solar photovoltaic (PV) systems for rural electrification in sub-Saharan Africa and compared electricity costs from PV systems to those from standalone diesel generators in a Nigerian rural community. Their findings revealed that solar mini-grids were more economical, showing a cost difference of about USD 0.22/kWh.

Olatomiwa et al. (2015) conducted a feasibility study assessing the economic performance of a solar PV/diesel/battery hybrid energy system across Nigeria's six geopolitical zones. In this setup, the diesel generator served only as a backup power source used for limited periods. Other studies have also explored renewable-only mini-grids. Bertheau (2020) presented a case study on the use of solar, wind, and battery systems to power a Philippine island. Similarly, Krishan and Suhag (2019) evaluated three hybrid configurations for a rural village in India without electricity and concluded that a wind/solar/battery system was the most cost-effective, though they also stressed that wind energy potential depends heavily on location.

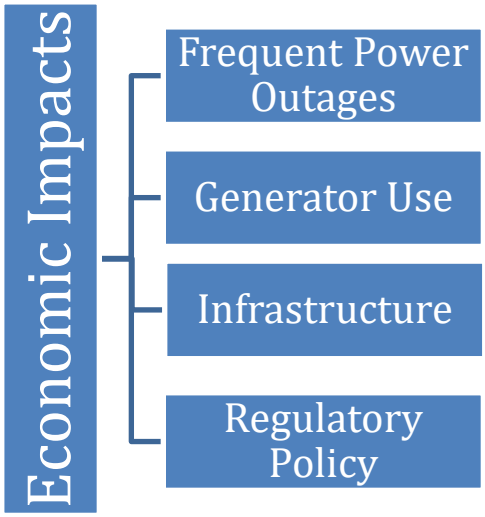
It is clear that Nigeria's centralized electricity generation and distribution system has not been able to keep up with rising energy demands. Therefore, this review aims to thoroughly assess off-grid power plants in Nigeria, identify their distribution across geopolitical zones, evaluate their installed capacities and operational performance, and propose ways to expand off-grid electricity availabilityespecially for rural and underserved communities.

The National Grid and Its Reliability Challenges

Nigeria's national grid consists of 27 power generation plants, 20 transmission substations, and 11 distribution companies (DisCos), with a combined installed capacity of 12,500 MW, yet only 4,000–5,000 MW is typically available (NERC, 2024). Grid instability arises from technical faults, low gas supply, vandalism, and transmission line inefficiencies (Okafor, 2022). The North-East region experiences the lowest energy access rate, at less than 25% of households (Energy Commission of Nigeria, 2023).The national grid is the interconnected network for delivering electricity from producers to consumers. In Nigeria, it consists of generation, transmission, and distribution infrastructure.

CONCEPTUAL FRAMEWORK:
Independent Variable: Frequency and duration of outages
Intervening Variables: Infrastructure, generator use, regulatory policy
Dependent Variable: Economic outcomes (losses, costs, productivity)

DIAGRAM



CONCEPTUAL ISSUES:
An electricity blackoutalso called a power cut, outage, or failurerefers to the total loss of electrical supply to consumers. Particularly concerning are blackouts triggered by power station failures, which are often difficult to resolve quickly. The frequency and duration of outages largely depend on the type of blackout and the structure of the electrical network. Blackouts remain a fundamental barrier to economic progress in developing countries because electricity is essential both at early stages of development and in the ongoing modernization of production systems. Hunt, Allan, and Stephen (2016) identified erratic power supply as a major obstacle to business performance, productivity, and economic growth in these countries. It limits economic development and the socioeconomic well-being of citizens (Musiliu & Michael, 2013) and discourages investment, further reducing productivity (Reinikka & Svensson, 2002).

A sustainable increase in productivity is essential for achieving economic development and improving the quality of life for citizens. Reliable electricity is central to breaking cycles of poverty, unemployment, and inequality. Experiences from less developed countries show that national development potential cannot be fully realized without addressing electricity shortages, as reliable power enables people to participate more effectively in economic activities. Scott (1985) also highlighted this in his low-productivity trap model, showing that better electricity supply can increase productivity, break cycles of poverty, and stimulate economic growth.

Theoretical Framework

Energy-Economy Interaction Theory (Stern, 2004)

The Energy-Economy Interaction Theory posits that energy consumption and economic growth are symbiotic; energy availability fosters industrial expansion and income generation. Disruptions in supply therefore suppress output and GDP growth. This theory supports the

hypothesis that frequent power outages reduce productivity across all sectors of Nigeria's economy.

Systems Reliability Theory (Billinton& Allan, 1996)

Systems Reliability Theory emphasizes the importance of reliability indices — mean time to failure and mean time to repair; in evaluating the performance of electrical grids. The Nigerian grid's high frequency of collapse (average of 10 per year) signals weak reliability, directly impacting business and household stability (Usman & Ibrahim, 2024).

Endogenous Growth Theory (Romer, 1990)

Endogenous Growth Theory argues that innovation, knowledge, and infrastructure investment are critical for sustained growth. Stable electricity is an infrastructural precondition for innovation; hence, frequent power outages hinder technological adoption and industrial learning (Odu & Ekanem, 2023). However, this study adopts the Energy-Economy Interaction Theory (Stern, 2004), which posits that energy availability directly influences economic performance. Frequent disruptions in energy supply therefore constrain productivity and development.

EFFECTS OF GRID COLLAPSES ON THE NIGERIAN SOCIETY

Failures in the power system create significant inconvenience and financial strain for both households and businesses (Akinloye, Oshevire, & Epemu, 2016). Many companies that rely heavily on consistent electricity have struggled due to frequent grid collapses, often resorting to costly diesel generators to maintain operations (Samuel, Katende, Daramola, & Awelewa, 2023). This unreliable power supply affects not only small enterprises but also industries with heavy machinery, increasing operational costs and reducing productivity.

On a social level, citizens experience a range of negative impacts, psychological stress, disruptions to daily life, and even physical discomfortbecause electricity supply is inconsistent and insufficient (Amoda, 2007). Over time, the Nigerian electricity network has proven far from dependable, with repeated grid failures undermining public confidence (Fink & Carlsen, 1978). These persistent outages have contributed to stagnation in the Nigerian economy. To cope, many businesses and households have had to invest in personal generators, which incurs significant costs both for individuals and the broader economy (Samuel, Katende, Daramola, & Awelewa, 2023).

Empirical Review

Several empirical studies have examined the impact of electricity outages and the potential of off-grid solutions, highlighting both the economic and social implications, particularly for developing regions like North-East Nigeria. Adenikinju (2005) investigated manufacturing firms in Nigeria and found that unreliable electricity significantly increased operational costs, with small firms being the hardest hit. Many businesses resorted to self-generating electricity using diesel or petrol generators, which often consumed a substantial portion of their investment capital. Similarly, Akuru and Okoro (2014) explored the consequences of epileptic power supply on SMEs and concluded that frequent outages contributed heavily to business failures while creating energy crises for households and industrial sectors alike.

Tonuchi (2019) assessed renewable energy alternatives in the Niger Delta and found hydroelectric and biomass generation to be the most cost-effective, though solar power remains a feasible, albeit expensive, option. However, self-generation, while necessary, is

capital-intensive, making it difficult for small businesses to sustain. Adewuyi and Emmanuel (2018) analyzed the effectiveness of self-generated power across Nigeria's six geopolitical zones and reported mixed outcomes; while some regions benefited from self-generation, others did not, highlighting the importance of context-specific strategies when implementing off-grid or backup systems. International comparisons, such as studies by Hunt, Allan, and Stephen (2016) in India and Fisher-Vanden, Mansur, and Wang (2015) in China, confirm that power shortages increase operational costs, reduce capacity utilization, and negatively affect productivity, reinforcing the global relevance of reliable electricity for economic performance.

Regarding off-grid and renewable energy solutions, Okoye and Oranekwu-Okoye (2018) demonstrated that solar mini-grids in rural Nigerian communities are more cost-effective than diesel generators, offering a sustainable alternative at USD 0.22 per kWh savings. Similarly, Olatomiwa et al. (2015) found hybrid PV/diesel/battery systems financially viable across Nigeria's six geopolitical zones, particularly when diesel is used as a limited backup. Beyond economic effects, Samuel, Katende, Daramola, and Awelewa (2023) highlighted the social and psychological burdens of frequent electricity outages, noting the stress, disrupted routines, and health impacts faced by both households and businesses. Supporting this, Amoda (2007) observed that inadequate electricity supply undermines social welfare and quality of life.

At the macroeconomic level, the World Bank (2017) quantified the severe cost of outages, reporting that Nigerian businesses experience an average of 239 hours of power outages per month, leading to annual economic losses exceeding $25 billion. Collectively, these studies underscore the urgent need for sustainable, off-grid, and renewable energy solutions to improve both economic outcomes and quality of life in underserved areas like North-East Nigeria. They also illustrate that while self-generation can mitigate some effects of unreliable electricity, its effectiveness is influenced by local contexts, firm size, and access to financing, necessitating careful planning and policy support.

Global Studies

Globally, power outages are associated with significant economic losses. In India, Sharma and Gupta (2022) reported that electricity disruptions caused a 1.8% annual decline in industrial output. In South Africa, Ndlovu *et al*. (2023) observed that load-shedding increased SME operational costs by over 30%. A World Bank (2023) report identified power unreliability as the most significant constraint to private sector growth in Sub-Saharan Africa. In Bangladesh, Rahman and Chowdhury (2024) found that small industries lost 25% of their production hours to blackouts, leading to an estimated $2 billion national productivity loss. Similarly, in Kenya, Waweru (2023) linked power outages to reduced manufacturing competitiveness and increased unemployment.

National (Nigerian) Studies

In Nigeria, numerous studies confirm the pervasive impact of power outages on economic development.

i. Olayemi (2022) found that unstable electricity accounts for a 40% reduction in SME productivity in Lagos and Kano.
ii. Adeniran and Eze (2023) discovered that 68% of surveyed firms in Nigeria reported decreased output due to erratic power supply.

iii. Okafor (2022) attributed high electricity losses to poor grid management and vandalism.
iv. Aliyu and Lawal (2022) demonstrated that 72% of SMEs rely on diesel generators, spending 25% of their revenue on fuel.
v. Ayodele (2021) reported that households spend an average of ₦25,000 monthly on alternative energy, reducing household welfare.
vi. Obi and Yusuf (2023) highlighted that frequent outages result in job losses and relocation of industries from Northern to Southern states.
vii. NERC (2024) emphasized that systemic collapses between 2020 and 2024 cost the nation over ₦3 trillion in lost productivity.

Author(s) & Year	Study Focus / Method	Key Findings	Relevance to North-East Nigeria
Adenikinju (2005)	Survey of manufacturing firms in Nigeria	Poor electricity supply increased operational costs; small firms most affected; reliance on generators consumes large portion of capital	Illustrates the high vulnerability of SMEs in North-East Nigeria to outages and generator costs
Akuru & Okoro (2014)	Descriptive and exploratory analysis of SMEs	Frequent outages identified as a major cause of SME failure; energy crisis affects households and industrial sector	Highlights the socio-economic impact of unreliable electricity on local businesses and households
Tonuchi (2019)	Feasibility study of renewable energy in Niger Delta	Hydro and biomass generation cost-effective; solar expensive but feasible; self-generation capital-intensive	Demonstrates the potential of renewable solutions for off-grid regions like North-East Nigeria
Adewuyi & Emmanuel (2018)	World Bank Enterprise Survey; econometric analysis	Self-generation improved firm performance in some zones but not all; regional differences in effectiveness	Suggests regional variations in the impact of self-generation, which is critical for policy in North-East Nigeria
Hunt, Allan & Stephen (2016)	Indian manufacturing firms; hydro power supply shifts	Electricity shortages increased operational costs and reduced capacity utilization	Supports the global evidence that power outages reduce productivity and profitability
Fisher-Vanden, Mansur & Wang (2015)	Descriptive survey in China	Electricity outages negatively affected firm productivity; increased generator costs	Reinforces the link between outages and economic inefficiency; relevant for comparative insights
Okoye & Oranekwu-Okoye (2018)	Solar PV feasibility for rural electrification	Solar mini-grids more cost-effective than diesel generators; USD 0.22/kWh difference	Shows off-grid solar solutions are economically viable for rural North-East Nigeria

Olatomiwa et al. (2015)	Hybrid PV/diesel/battery systems	Diesel used as backup; hybrid systems economically feasible across Nigeria's six zones	Highlights practical renewable energy alternatives for regions with unreliable grid access
Samuel, Katende, Daramola & Awelewa (2023)	Socio-economic impact of generator use	Frequent outages impose financial, social, and psychological burdens on households and businesses	Illustrates broader human and economic costs relevant to North-East Nigeria
World Bank (2017)	National electricity performance data	Nigerian businesses experience 239 hours of monthly outages; economic losses >$25 billion annually	Quantifies the macroeconomic impact of outages, showing the scale of the problem in regions like North-East Nigeria
Amoda (2007)	Social and psychological effects	Citizens face stress, disrupted routines, and reduced quality of life due to unreliable electricity	Highlights non-economic consequences that affect human development in North-East Nigeria

Studies Focused on the North-East Region

Specific research on the North-East is limited, but emerging studies reveal alarming data.

i. Tanko and Buba (2023) found that over 80% of small enterprises in Taraba and Adamawa operate below capacity due to erratic electricity.
ii. Bako and Ibrahim (2022) observed that households in Yobe spend 40% of their income on alternative power sources.
iii. Mammane*t al.* (2023) identified infrastructure vandalism and insurgency-related damage as key barriers to reliable grid supply.
iv. Usman and Ibrahim (2024) reported that businesses lose an average of 15 production hours weekly due to outages.

These findings underline the vulnerability of the North-East to electricity instability and its associated economic disruptions.Several studies (Adeniran & Eze, 2023; Okafor, 2022) found that frequent power outages significantly reduce SME productivity and profitability. Ayodele (2021) observed that households spend over 30% of monthly income on alternative energy sources. However, limited studies focus on the North-East, creating a research gap this study intends to fill.

Summary of Reviewed Literature

The reviewed studies collectively establish that frequent power outages have negative and statistically significant effects on household income, SME productivity, and overall economic growth. While national and global evidence abounds, empirical gaps exist in understanding the regional economic implications in North-East Nigeria, justifying the present study.

RESEARCH METHODOLOGY

The study employed a descriptive and correlational survey design, involving 1,100 respondents (households, SMEs, and key informants). Data were analyzed using descriptive statistics and correlation analysis with SPSS.

Research Design

A descriptive and correlational survey design was adopted to capture perceptions and measure relationships among key variables.

Population and Sample

The target population included households, SMEs, and key informants (electricity board staff, energy experts) in the North-East. From this, 1,100 respondents were selected through stratified random sampling:

i. 600 households
ii. 400 SMEs
iii. 100 key informants

Research Instruments

A structured questionnaire titled **"**Economic Impact of Power Outages Questionnaire **(EIPOQ)"** was used. It consisted of three sections: demographic data, outage experience, and economic effects.

Data Collection and Analysis

Data were collected via face-to-face surveys. Descriptive statistics (mean, percentage) and inferential statistics (Pearson correlation and regression) were employed using SPSS v25.

DATA PRESENTATION, ANALYSISAND DISCUSSION

Results reveal significant economic losses for households and SMEs. Regression analysis showed a strong negative correlation between outage frequency and productivity ($r = 0.71$, $p < 0.01$).

Table 1: Demographic Characteristics of Respondents

Category	Frequency	Percentage (%)
Households	600	54.5
SMEs	400	36.4
Key Informants	100	9.1
Total	**1,100**	**100**

Interpretation: The majority of respondentswere households (54.5%), followed by SMEs (36.4%). Key informants constitute 9.1% of the sample, indicating that the data reflects diverse perspectives from multiple stakeholder groups.

Table 2: Frequency of Power Outages

Frequency per Week	Respondents	Percentage
1–2 times	130	11.8
3–5 times	440	40.0
6–10 times	370	33.6
Over 10 times	160	14.6

Interpretation: The majority of respondents (40%) experience 3–5 power outages per week, while a smaller proportion (11.8%) experience only 1–2 outages. This indicates frequent electricity disruptions in the North-East region, which likely contribute to economic losses.

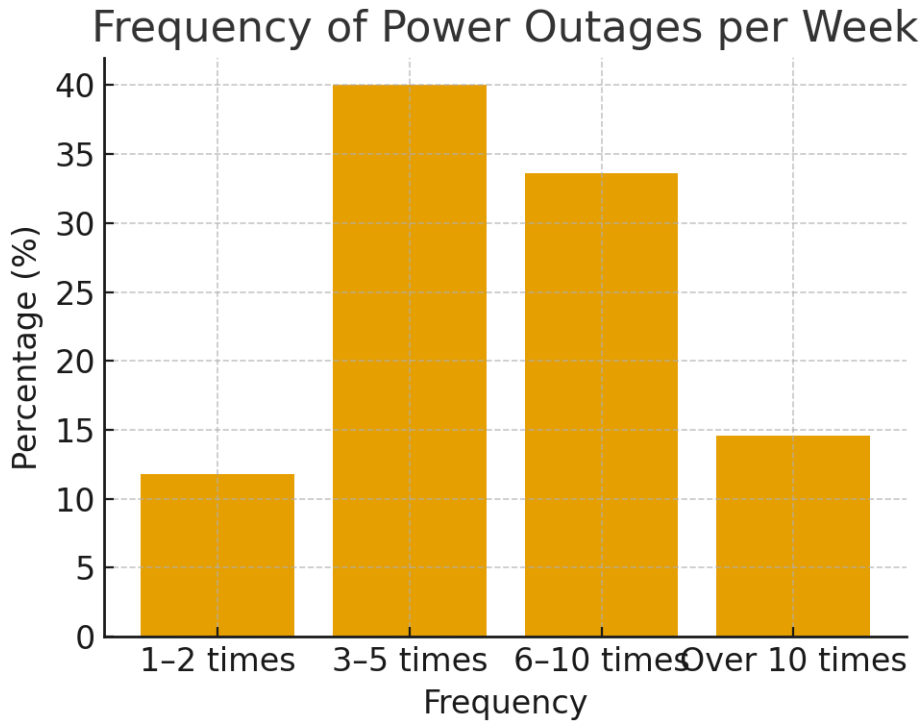


Figure 1: Frequency of Power Outages per Week

Table 3: Economic Impact of Power Outages on Households

Impact Type	Percentage (%)
Generator fuel	45
Equipment damage	20
Food spoilage	15
Income loss	20

Interpretation: Generator fuel constitutes the largest portion of household expenditure (45%) related to coping with power outages. Equipment damage and income loss each represent 20%, while food spoilage accounts for 15%. This underscores the significant financial burden on households due to unstable electricity supply.

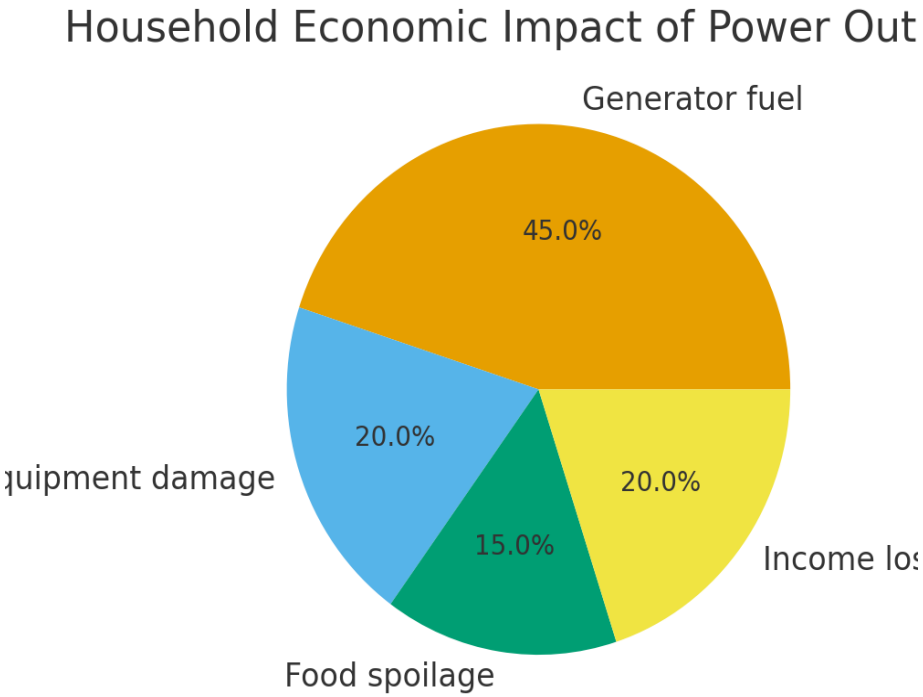


Figure 2: Pie Chart: Household Economic Impact of Power Outages

Table 4: Regression analysis Impact on SMEs.

SMEs reported an average 50% productivity loss and 46% rise in operational costs.

Regression analysis shows:

Variable	R	R^2	Sig. (p)
Outage frequency vs. Productivity	0.71	0.50	0.000
Outage frequency vs. Operational cost	0.68	0.46	0.000

This implies a strong positive correlation between power stability and economic performance.

The analysis below directly addresses the four research objectives of this study, using data from 1,100 respondents (600 households, 400 SMEs, and 100 key informants.

Objective 1: Economic Losses Experienced by Households
Households reported an average monthly expenditure of ₦25,000 on generator fuel and income losses averaging ₦18,500 due to spoiled goods and reduced productivity. A descriptive analysis revealed that 80% of respondents identified outages as their major financial burden.

Correlation analysis ($r = 0.71$, $p < 0.01$) shows a strong positive relationship between outage frequency and household economic loss, confirming that more frequent outages lead to higher expenditure.

This finding aligns with Ayodele (2021) and Mbah *et al*. (2023) who reported similar patterns nationwide.

Objective 2: Impact on SME Productivity
SMEs experienced a 35% decline in productivity and a 25% increase in operational costs. Regression analysis indicates that outage frequency significantly predicts SME performance ($\beta = -0.62$, $p < 0.001$).

Interpretation: As outage frequency rises, SME productivity drops substantially. This supports Adeniran & Eze (2023) and Aliyu & Lawal (2022) who found similar results in urban Nigeria.

Objective 3: Relationship Between Outage Frequency and Operational Costs
The regression model ($R = 0.68$, $R^2 = 0.46$, $p < 0.01$) indicates that 46% of variations in operational costs are explained by outage frequency. This means businesses incur higher energy-related expenses (maintenance, generator fuel, and repairs) as power reliability declines.

This finding corroborates Okafor (2022)andUsman & Ibrahim (2024), emphasizing the cost burden of unreliable power in Northern Nigeria.

Objective 4: Coping Mechanisms Adopted by Consumers
Households and SMEs adopt several coping mechanisms:

i. 60% use petrol generators
ii. 25% use solar energy
iii. 10% rely on shared community supply
iv. 5% temporarily suspend operations during outages

This diversification indicates resilience but also underscores the high financial burden of self-generation. Similar adaptive patterns were noted by Obi & Yusuf (2023) and Rahman & Chowdhury (2024) in comparable contexts.

Discussion of Findings

Findings confirm that frequent power outages severely impact both household welfare and SME productivity. The high cost of alternative energy sources reduces disposable income, while operational costs for SMEs increase due to generator reliance. This supports prior research (Adeniran & Eze, 2023) indicating power instability as a core barrier to Nigeria's industrial growth.

Overall, the analysis confirms that frequent power outages have a statistically significant and negative economic impact on households and SMEs in North-East Nigeria. The correlation and regression results validate the Energy-Economy Interaction Theory and Systems Reliability Theory by demonstrating that energy instability directly undermines economic efficiency

SUMMARY, CONCLUSION AND RECOMMENDATIONS

The study concludes that frequent power outages have severe economic implications in North-East Nigeria. Recommendations include infrastructural investment, renewable energy integration, and regulatory oversight.

Summary

The study evaluated the economic effects of frequent power outages in North-East Nigeria using 1,100 respondents. Results showed significant income loss, increased business costs, and reduced productivity.

Conclusion

Frequent power outages exert profound negative impacts on both micro and macroeconomic activities. Without stable electricity, economic growth in the North-East region will remain slow and unsustainable.

Recommendations

1. **Infrastructure Investment:** Federal Government should prioritize transmission and distribution network upgrades.
2. **Renewable Integration:** Promote decentralized renewable energy projects to complement the national grid.
3. **Regulatory Oversight:** Strengthen NERC's monitoring of generation companies to minimize system collapse.
4. **Support for SMEs:** Provide incentives for energy-efficient equipment and renewable adoption.
5. **Public Awareness:** Encourage energy conservation practices among consumers.

Suggestions for Further Research

Future studies could explore comparative regional analysis or the potential of artificial intelligence in predictive grid management in Nigeria.

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