

Improving Power Supply Efficiency in Smart Grids Via Renewable Energy Adoption in Nigeria

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Abstract

At the moment, Nigeria is experiencing great problems within its energy sector, which is evident from the state of the socio-economic lives of its people. However, there is great room for improvement through application of innovation. Adoption of smart grid systems within Nigeria's energy sector will become imperative due to their ability to ensure efficient production, distribution, and consumption of energy in the future. The use of intelligent grids may be instrumental in overcoming persistent problems associated with poor supply of electricity, as well as reducing pressures on the national grid. Renewable energy systems, especially solar PV systems, are also innovative and sustainable energy production methods that can be adopted in Nigeria. Due to availability and reliability of solar energy, its adoption is likely to solve problems associated with grid instability and breakdowns. Notably, integration of smart energy solutions in Nigeria faces some key challenges.

Keywords: Smart Grid Technology, Power, Renewable Energy, Solar Energy, PHCN

1. INTRODUCTION

The increasing global demand for sustainable and environmentally friendly energy sources has led to a significant rise in the adoption of solar power systems, particularly in institutional settings such as universities. Solar energy offers numerous benefits, including cost savings, energy independence, and reduced carbon emissions (Ekwueme, 2025). Achieving efficiency in power supply using renewable energy for smart grid deployment in Nigeria is one of the major goals that have been set within Nigeria's electricity industry given the inefficiencies and increasing demand for energy. The power systems in Nigeria continue to be faced with difficulties like high losses and frequent disruptions despite all efforts to reform them and improve their efficiency in 2026 (Inyang, Magaji, & Ismail 2025) According to recent reports, despite the improvements in generating capacity, there is significant underutilization of energy, which suggests inefficiencies in the energy distribution network (Airoboman, Asih and Zira 2025). Electric power interruptions are common, especially after storms, prompting the search for reliable and economical backup power sources (Ekwueme, 2025). This reinforces the necessity for adopting new strategies like intelligent grids.

The smart grid is a revolutionary innovation in electricity transmission through the integration of digital communication technology and automation. Smart grids enable the reduction of loss, efficient fault detection, and effective energy flow management within the system. In Nigeria, smart grids can be used to solve several power problems (Energy Focus Report 2025). In the Nigerian context, unreliable electricity supply remains a persistent barrier to socioeconomic and institutional development. Universities, as centers of research and academic excellence, have not been spared from the detrimental effects of erratic grid power (Ekwueme & Ogbodo, 2025). Even more important, however, the smart grid technology presents a dynamic platform that can enable the seamless integration of renewables like solar, wind, and micro-hydro power in the current power grid system. This is very necessary since Nigeria has immense renewable energy potential, especially solar energy, yet most of it goes unexploited (NERC 2025). Integration of renewable energy sources into smart grids increases efficiency in

electricity distribution by allowing decentralized production and decreasing dependence on distant electricity distribution networks.

This method, which includes use of mini-grids, has already proven to be effective in increasing access to electricity in under-serviced communities (Reuters 2025). Moreover, modern technologies like artificial intelligence and smart meters allow better demand prediction, balance, and energy management in real time, resulting in less loss of energy and increased efficiency of the whole system (Reuters 2025). This is especially important for Nigeria, where the discrepancy between supply and demand is rather large. But then again, the effective implementation of smart grids and renewable energy integration in Nigeria faces a number of obstacles that include regulation issues, funding problems, and poor infrastructure (IJAEM 2025). Clearly, overcoming the stated challenges is no easy task. Nevertheless, it might well prove to be a valuable addition towards the sustainable development of Nigeria power sector. To put it briefly, it will become an avenue for improving the power supply efficiency through the implementation of smart grids and renewable sources of energy.

2. METHODS

The research design of this study is an exploratory and descriptive study, which uses a thorough systematic review of the energy situation in Nigeria as it will be in 2026. Instead of using primary field experiments, the researcher incorporates a qualitative analysis of current secondary data in order to assess the intersection of smart grid technology and adoption of renewable energy. In such a way, the multi-dimensional analysis of the technical, economic, and regulatory factors that are currently defining the evolution of the power sector becomes possible. To obtain a timely and well-founded worldview, data needed by the study were carefully collected through a diverse array of sources that are considered reliable and authoritative. These are technical reports by the Nigerian Electricity Regulatory Commission (NERC), global energy reports by the World Bank and the International Energy Agency (IEA) and real-time situational reports on the 2025 national grid collapses. The synthesis of data on these institutional publications with recent scholarly research establishes a benchmark of the average solar irradiance in Nigeria and existing capacity of Nigeria transmission infrastructure. The study has an analytical framework that is based on a functional analysis of smart grid components, including Advanced Metering Infrastructure (AMI) and Wide Area Situational Awareness (WASA). The researcher compares these technologies with the historical context of power sector reforms in Nigeria, which revolves around the period when the power sector was centralized and monopolized by the NEPA and the current privatized but struggling model of distribution. This comparison and contrast paper outlines what is lacking in current infrastructure and what will be needed to support a decentralized solar-powered network.

3. RESULTS AND DISCUSSION

Despite Nigeria's large population and early ICT adoption in parts of the economy, structural bottlenecks, limited broadband penetration, uneven digital skills, weak regulatory frameworks, and infrastructure gaps constraint the ICT sector's ability to deliver broad-based productivity gains and inclusive growth (Ekwueme, 2025). The initial characteristic of the history of the power sector in Nigeria is that of having a centralization process controlled by the government. Eventually, this sector became partially liberalized aiming to improve efficiency and reliability. Solar energy can be considered one of the most efficient energy resources which could be utilized in Nigeria owing to the availability of sunlight within the country alongside the need for continuous power. Nigeria stands

out as being among the places with abundant sunshine levels ranging from 3.5 to 7.0 kWh/m²/day; hence, it is a perfect place for solar energy generation (World Bank 2026).

The availability of solar energy in Nigeria would enable a better balance in terms of energy sources, as it will reduce the reliance on fossil fuels (NERC 2025). Electricity generation is the process of generating electric power from other source of primary energy. Energy conversion process is divided into different type such as, thermo electric (heat- electric energy), steam engine (heat – mechanical energy) (Ekwueme & Ogbodo 2025). Although NEPA enjoyed a monopoly, it was not spared from criticisms that it lacked efficiency, failed to provide good maintenance services, and was unreliable regarding electricity generation. The most important reform came about in 2005 when the EPSRA was passed by the National Assembly. This marked the unbundling of NEPA into companies that would be responsible for generation, transmission, and distribution of power, which paved the way for PHCN (World Bank 2026). Afterward, from 2013 to 2014, the Nigerian government privatized generation and distribution firms, whereas transmission was left under government control. Current efforts are being made towards enhancing performance in the sector through regulation and an increasing level of private sector participation. Decentralized renewable energy systems and the implementation of smart grids represent the dawn of a new era in the power industry that seeks to solve inherent problems and enhance electricity access (International Energy Agency 2025). Despite the presence of various challenges such as inadequate infrastructure and lack of liquidity, reforms are continuously being undertaken.

As of 2026, the present status of the power sector in Nigeria is one of continued shortages, infrastructural problems, and attempts at reforms that will enhance the efficiency of the system. Even after many years of development and reforms in the electricity sector, power generation and delivery still do not match up to the national requirement. From recent findings, Nigeria produces electricity that amounts to 4,000-4,500 megawatts against a population of more than 200 million individuals where the demand is expected to exceed 30,000 megawatts (Nigerian Energy Crisis Report 2026). This huge mismatch in supply has led to power blackouts and dependence on alternative sources such as fuel generators. Another factor that contributes to the prevailing problem is the insufficient gas supply to thermal power stations, which provide most of the country's electricity. According to reports from the first quarter of 2026, there was only 43% availability of gas supply to power stations compared to what was needed, thereby restricting generation capacity and compelling grid operators to limit electricity distribution in order to sustain the operation of the grid (Nigerian Energy Crisis Report 2026). Moreover, there is an impending economic crisis in the sector because the debts accumulated by the generation and distribution firms amount to trillions of naira, which hinders the firms' ability to make necessary investments in upgrading facilities (Reuters 2025).

Moreover, there have been issues with grid stability and the continued occurrence of periodic failures in the past few years. An example is the grid failure witnessed in the entire country at the end of 2025 which revealed the vulnerability of the transmission infrastructure and the need for its upgrading (Reuters 2025) . As a result, people receive inconsistent supply of electricity with some days having limited power supplied within a day. Economic productivity suffers because of the unavailability of consistent sources of electricity (Reuters 2026). Additionally, the distribution of electricity continues to be unequal, as quite a substantial number of the country's population have inadequate electricity supply or are entirely unconnected. Although there are continuous efforts to increase access to electricity using renewable energy and mini-grids, their contribution to the country's electricity generation process remains relatively insignificant. It should be emphasized that although there may be some deficiencies, the government continues making reforms towards diversifying the country's electricity generation process. Yet,

even with the major problems of the power industry in Nigeria still remaining in 2026, there is optimism that the sector can be better due to the developments carrying out at present. For the efficient production of electricity in the country, it will be very important to tackle some of these problems such as gas scarcity and erratic power grid networks which are major bottlenecks...

Solar Energy as Renewable Energy Resource In Nigeria

Solar energy is one of those energy resources which could be harnessed in Nigeria owing to the availability of sunshine in the country together with the need for a steady flow of energy. Nigeria is one of the places that have enough sunshine with an average daily sunshine ranging from 3.5 to 7.0 kwh/m²/day (International Energy Agency 2025). The availability of solar energy in Nigeria would enable a better balance in terms of energy sources, as it will reduce the reliance on fossil fuels. There has been an increased focus on solar energy due to the problems associated with the traditional energy sector, which continues to experience low energy production capacity and power outages. Therefore, there has been a shift from reliance on centralized power plants to decentralized power supply such as solar energy that can be used at home (World Bank 2026).. Energy provided through the use of solar energy, which can be supplemented by battery technology, is reliable and environment-friendly as opposed to the use of diesel or petrol engines, which are very costly and environmentally harmful.

In recent times, the Nigerian government and private organizations have put in place several measures aimed at encouraging the adoption of solar energy through various policy frameworks, investment programs, and international collaboration. Examples of these include the implementation of solar mini-grid and solar household installations as part of the Nigeria Electrification Project, which have greatly increased the availability of electricity (World Bank 2026). These measures have shown that there is huge potential for solar energy in meeting the energy requirements of these areas, which are critical in socio-economic development. Moreover, regulatory policies from institutions like the Nigerian Electricity Regulatory Commission have fostered private sector involvement (NERC 2025).

The development of technology has made it easier to generate solar energy in Nigeria. Through innovations that enhance efficiency in solar paneling, lowering the price of panels, and incorporating smart grid technology, the use of solar power has become more efficient and affordable (Renewable Energy Policy Network 2025). In addition, the incorporation of solar energy into smart grids makes it possible to manage and distribute energy efficiently. This is especially necessary in Nigeria considering that there are still high transmission and distribution losses in the country's energy distribution system. However, despite its enormous possibilities, the uptake of solar power in Nigeria has not been without its fair share of obstacles. Some of the challenges that have made it difficult for solar energy to be widespread include: a high cost of solar installation, lack of financial resources, lack of technical skills, and poor infrastructure (African Development Bank 2026). Contradictions within policy and uncertainty may be some other reasons for discouragement in investing in this sector. Resolving such issues is only possible if there is an involvement of the Nigerian government and its agencies, along with the cooperation of both governmental and non-governmental organizations.

Nigeria's electricity issues can find an answer in a source of energy that is very likely to be solar power. It is in fact an endless source of energy, not harmful to the environment and can be easily incorporated into decentralized energy systems these therefore make solar energy a very important element for Nigeria's energy transformation. In spite of the fact that development towards the goal of a better energy situation in Nigeria has been marked by the growth of solar energy among others, there are still some challenges or factors that hinder the deployment of solar energy in Nigeria

and the country could definitely benefit more from solar energy if these barriers were removed.

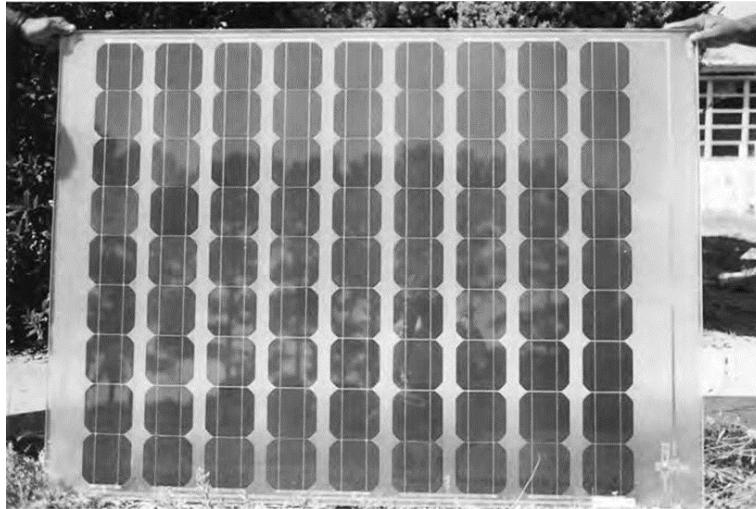


Figure 1: Solar panel

Smart Grid Technologies

Smart technologies involve the interdisciplinary and systems-based creation of intelligent and networked products, facilities, and infrastructures using information technology (IT) (Bhatt, Shah, and Jani 2014). On the other hand, the smart grid is an electric system that involves the use of digital technology to make the electrical system reliable, effective, and secure. As stated by US DOE (Gungor et al. 2011). "Smart Grid" (SG), on the other hand, is defined as a technological improvement of the current electricity supply system in order to make decisions about how and when to generate electricity, and communication between producers and users of electricity. The use of other sources of electricity generation and the capability to optimize operations at any point in time will result in lower costs and emissions (Bhatt, Shah, and Jani, 2014). Real time and two-way communication can be made possible through the implementation of SG through the use of communication technology (Gungor et al., 2011). Implementation and usage of digital electrical layer, whose effectiveness stretches from digital communication all the way up to the final mile of distribution networks, have a large effect on the improvement of the reliability, efficiency, power quality, and security of the existing electrical grid.

The implementation of these measures can be done via the complex process of prediction, control, and monitoring (Wang, Y. Xu, and M. Khanna 2011). Once more, the implementation of the smart grid technology will benefit Sub-Saharan African nations such as Nigeria, which have abundant sources of renewable energy such as wind and solar energy to export power energy to other African countries. Additionally, Saudi Arabia, being the greatest oil producer and exporter in the world, may export megawatts using the smart grid technology (Wang, Xu, and Khanna 2011).

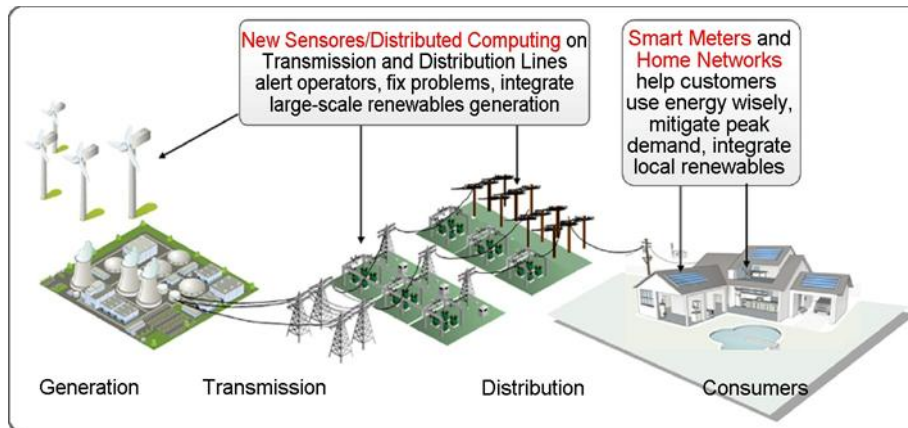


Figure 2: Smart grid technology

a) Operators of Broad-Reaching Surveillance and Management Systems have an improved understanding and capability to optimize the functioning, elements, and performance of the electricity system through real-time monitoring and visualization of data in relation to large geographical areas. State-of-the-art technologies for the operations of the system help prevent blackouts and facilitate integration of intermittent sources of power supply into the grid. Wide Area Situational Awareness (WASA), Wide Area Monitoring Systems (WAMS), and Wide Area Adaptive Protection, Control and Automation (WAAPCA) are some of the examples of sophisticated technologies used in analyzing and monitoring the system and facilitating data generation for decision making (Gungor et al. 2011).

b) Integration of Information and Communication Technology The transfer of data in deferral or in real time, and during disruptions, is made possible through the basic communication technology used, regardless of whether the communication is being achieved using the company's internal network such as radio networks, metre mesh networks or external carriers and networks like the Internet, cellular technology, cable, and phone network. Apart from facilitating communication between communicating devices, there is two-way exchange of information between all parties that is accomplished through intensive computation, control software, and enterprise resource planning software (Bhatt, Shah, and Jani 2014).

c.) Renewable and Distributed Energy Sources The dispatch and control of energy sources from renewable and distributed energy sources, which include large-scale energy sources at the transmission stage, medium-scale sources at the transmission and distribution stages, and small-scale sources at residential or business structures, may be difficult in running the electricity network. Through the distinction between the production and delivery of energy, energy storage units such as electrical or thermal energy sources can help overcome such difficulties. Through automation control of energy production and use, smart grid networks can guarantee balance between demand and supply, among other demand responses (Renewable Energy Policy Network 2025).

d) Applications in Transmission and Enhancement There are various technologies and applications applied in the gearbox system. Flexible AC transmission systems (FACTS) are deployed for enhancing the power transfer capability and control of transmission networks. The application of such a technology on existing lines can help in improving efficiency and delay further investment needs. The high voltage DC (HVDC) technologies are used for connecting offshore wind and solar plants to the grid. As a result, there is improved controllability of the system as well as reduced system losses, helping to exploit efficiently the distant energy resources. Dynamic line rating (DLR) is used for optimizing the use of existing transmission infrastructure without the risk of

overloading. Sensors are used to calculate the current capacity of a section of the network. The market viability of high-temperature superconductors (HTS) is under discussion although they could significantly improve the efficiency of gearbox systems. They would be able to limit the fault currents more efficiently (Wang, Xu, and M. Khanna 2011).

d) The following is the way that can be done through the Management of the Distribution Grid Automation and the sensing of distribution and substations, which will improve asset management, keep voltages high, and decrease outages and repairs time. The data received from sensors and meters is analyzed using advanced distribution automation, which is responsible for controlling the distribution generation, optimizing voltages and reactive power, and feeder reconfiguration. The use of sensor technology will enable the optimization of the efficiency of equipment and therefore asset utilization (Gungor et al 2011).

e) Advance Metering Infrastructure The advanced metering infrastructure (AMI) refers to the use of several technologies, apart from the application of sophisticated meters that help in exchanging data in two directions, thus making it possible for the utility companies and customers to have information on how much energy they have consumed, the period and volume of power consumed. With the assistance of the metering function that detects when there is a power failure and restoration respectively, the AMI would be able to determine the cause, severity and location of the outage remotely, as well as offer several other capabilities such as remote customer price signaling, data gathering and analysis on consumption levels at different periods or real time basis, energy diagnostics through detailed load profiles, and retail energy (Wang, Xu, and M. Khanna 2011).

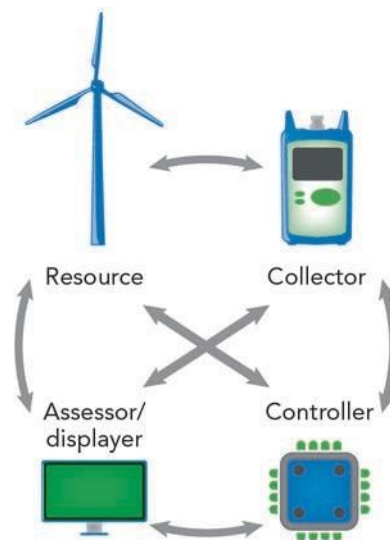


Figure 3: The four functions of smart grid technologies

Integration Of Solar Energy as A Form Smart Grid Technology Integration Into The Nigerian Grid Network

The inclusion of solar energy, which forms part of the smart grid technology, in Nigeria’s electricity grid system is a revolutionary way of dealing with the electricity problems in Nigeria. The power system in Nigeria has always faced problems relating to insufficient capacity for generation of power, inadequate transmission networks, and considerable loss of electricity during distribution, among other factors that have made the electricity supply unpredictable and inefficient. Thus, solar PV combined with smart

grids can be a solution towards achieving efficiency, resilience, and sustainability of the electricity system.

The use of solar energy in smart grids is based on the adoption of distributed photovoltaic energy sources within a sophisticated electric power grid system that monitors, controls, and optimizes energy flow in real-time. Solar energy is very appropriate to generate energy on both large scale and decentralized bases due to high levels of solar irradiance in Nigeria ranging between 3.5 and 7.0 kWh/m²/day (Reuters 2025). The use of solar energy generation within the electric grid would reduce dependence on centralized fossil fuel power plants and provide a better access to electricity. One of the biggest benefits of using solar power in smart grids is that the distribution of electricity becomes much more efficient. Moreover, With the implementation of smart grids, not only would it be possible for the utilities to communicate with their customers, but the customers would also be able to communicate back to the utilities. The current electrical grid system in Nigeria experiences substantial technical losses attributed to the distance of the electricity transmission process, as well as inefficient facilities. The use of distributed generation through solar power eliminates the necessity for long-distance electricity transmission, as electricity is produced near where it is consumed, increasing efficiency and voltage stability in the process (Reuters 2026).

Energy Storage Systems Are Key To The Reliability Of Solar-Fed Smart Grids, As we have mentioned above, solar energy is intermittent and depends on climatic factors; hence, storage technologies are crucial in this case to ensure balanced consumption. For example, in Nigeria, increased use of lithium-ion batteries in mini-grid systems and hybrid solar plants made it possible to improve the reliability of the power supply in remote areas that are not connected to the grid (International Energy Agency 2025). The energy accumulated at times of intensive production will be utilized when there is a lack of sunlight or when energy consumption is high. Regulatory mechanisms and frameworks are equally important to the effective incorporation of solar energy into smart grids. The Nigerian Electricity Regulatory Commission have developed regulations that seeks to encourage embedded generation and the use of renewable energy, thereby attracting private sector investment in solar energy technology (International Energy Agency 2025). Through this, a suitable environment for innovations will be provided and that solar energy systems will be efficiently integrated into the national grid. International development programmes have assisted in the installation of solar-powered mini-grids in remote areas with the major focus on the social-economic development there.

Technology has also been influential in making the process faster. The technologies like smart inverters, artificial intelligence energy management, and communication networks enable the grid operators to control the solar energy systems in real-time mode (World Bank 2026). The pilot study on smart grids along with solar energy in Nigeria has shown that technology can enhance the reliability of the grid if it is integrated with solar energy. However, there are a number of barriers that need to be overcome to ensure successful adoption on a wider scale. First, the installation of photovoltaic cells and the building of smart grid technology are extremely expensive, especially for poorer communities and small businesses. Second, the current electrical grid system does not have the ability to accommodate renewable energy sources at an extensive level, and therefore requires extensive modification. Finally, lack of technical knowledge and inadequate capacity for production also act as obstacles to the growth of the industry.

To sum up, the integration of solar energy within the smart grid system will serve as a viable option to solve the issues related to power supply in Nigeria. This is because Nigeria has the opportunity to utilize renewable sources of energy together with an efficient grid technology system. Although there exist several hurdles, the country is

expected to overcome them in order to realize its goal of adopting sustainable energy sources.

Problems Associated with Smart Grid Integration in Nigeria

Smart grids carry a potential of numerous benefits to ramp up the reliability, efficiency, and sustainability of the power supply in Nigeria. However, adequate implementation is hindered by a range of obstacles. Such barriers stem from the technical financial institutional, and socio-economic constraints of Nigerian power sector. Even though smart grids rely on new technologies for communication, automation, and data processing, the prevailing conditions of the power network in Nigeria make the smart grids deployment very difficult. Among the most important problems is the inadequate state of the transmission and distribution infrastructure in the country. Most parts of Nigeria's power grid are archaic and suffer from poor transmission lines, overstressed substations, and system failures. Such shortcomings hamper the capability of the grid to handle the sophisticated technology that makes it possible for the implementation of smart grids. Thus, despite improvements in generation facilities, the inability of the power grid to transmit power effectively limits the efficacy of the entire system (International Energy Agency 2025).

Another significant challenge is the very high expense of rolling out smart grids. The deployment of smart meters, communication networks, automation control systems, and energy storage technologies necessitates a huge amount of capital investment. In a country like Nigeria, where the electricity sector is already experiencing very serious liquidity problems, it is very difficult to get funding for modernization projects on such a large scale. Distribution companies are frequently faced with the problem of inefficient revenue collection as well as disputes related to tariffs, which further limit their ability to invest in smart grid technologies (International Energy Agency 2025). The financial burden is also increased by the fact that smart grids require constant maintenance and system upgrades, which makes the long-term sustainability doubtful unless there is strong financial support.

Another reason why the integration of smart grids into the system is difficult is the inconsistency in regulatory and policy frameworks. Despite the reforms in Nigeria aimed at improving the electricity industry, the sector still faces certain regulatory issue (World Bank 2026). Policy changes are common, and institutions responsible for certain areas overlap in their jurisdiction, and some mechanisms are inadequate when enforcing regulations. This poses uncertainty for both private investors and developers, thus making it challenging to incorporate smart grid technology in the industry. The lack of technical capability is another key limitation. The implementation of smart grids involves the need for very highly skilled workers in fields like data analysis, IT, electrical engineering, and cyber security. Unfortunately, Nigeria does not have enough well-trained people who can design, run, and maintain these complex systems. This limits the rate at which smart grids can be adopted and leads to reliance on overseas expertise, which tends to be costly and unavailable (Nigerian Energy Crisis Report 2026).

Cybersecurity threats are another emerging threat that could impede the adoption of smart grids. As a result of their extensive dependence on electronic communication channels, smart grids can be susceptible to hacking, data theft, and manipulation by attackers. In Nigeria, where there are relatively nascent cybersecurity measures, such threats to energy facilities can pose a real danger. The occurrence of a cyber attack against the country's power supply network may trigger massive power failures and other adverse consequences. The problem of the unstable supply of power and dependence on diesel and petrol generators is another factor that hinders the implementation of smart grids. In many parts of Nigeria where diesel and petrol generators are being used due to the deterioration of the electrical grid infrastructure, the notion of smart grid introduction

may not be practically relevant because such systems rely heavily on optimal interaction inside an energy system. Currently, the use and integration of renewable energy sources like solar panels and wind farms into the system is quite limited.

The power crisis in Nigeria requires a paradigm shift of the country towards using smart grids rather than petrol generators, but this can only be achieved after addressing the systemic level of antagonism within the national infrastructure (Ilukwe & Ume, 2025). This can be achieved through strong human capital development to drive productivity (Mbuba, 2022) and by adhering to the federal character principle so as to ensure equitable energy distribution (Mbuba, 2021). Nonetheless, the psychosocial burdens due to economic crises are to be rightly navigated by the media (Onyemaechi et al., 2025), particularly as workers in institutions such as Nnamdi Azikiwe University adapt to diverse coping mechanisms in the face of industrial uncertainties (Onwuka et al., 2022). The multifaceted national development is reflected not only by the fact that the other industries are key driver of growth (Ilukwe, 2025), but also by the regulatory challenges inherent in the country, such as piracy and copyright infringement (Nwadike and Ilukwe, 2023). The same applies to the energy industry, where ethical governance is necessary to prevent any conflict of interest (Okosa et al., 2025) and should not be compelled to impose restrictive and unconstitutional requirements similar to those of mandatory attire (Okosa, 2022). Social order must also be taken into consideration during technical advancement; it is as crucial to address criminal behaviors related to neurological deficits as it is to provide physical grids (Achebe et al., 2024). Finally, the empowerment of institutions and standardized approach to stakeholders are also important to the sustainable energy future in Nigeria.

CONCLUSION

The integration of renewable energy into the smart grid with the intention of improving efficiency in electricity distribution in Nigeria is an extremely ambitious concept that could potentially completely transform the energy industry in Nigeria. Substitution of the conventional power sources with renewables like solar, wind, and mini hydro plants through smart grids will not only help the country to cut down the power losses during transmission but also will increase the overall reliability of the power system and be able to align energy supplies in the most efficient way with demand patterns. Smart grid technology facilitates the effective management and control of energy delivery, thus playing a key role in elevating the performance and sustainability of renewable energy integration. Using different kinds of renewable energy can reduce reliance on fossil fuels, lower the harmful effects on nature, and even provide energy security especially in remote areas. Although it might be a challenge to implement and get used to new technologies, the benefits like saving money, easy accessibility, and being able to withstand power failures make the use of renewables in smart grids a very good and wise move for Nigeria's energy sector.

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