Globalization of Smart Grid and Renewable Energy; Projecting the Prosumer Panacea in Nigeria Energy Sector

Philip O. Adebayo, Victoria Yemi-Peters, and Folashade O. Auru

***Abstract*— Nigeria energy situation is worrisome especially having considered the obvious fact that so much funds have been injected into the sector with no appreciable result. Many Nigerian viewed the sector as a national embarrassment. Since return to democracy in 1999, staggering allocations have been earmarked to give the power sector a face lift, but all to no avail. Economic activities cannot thrive well with the prevailing energy situation in Nigeria. Energy access, availability and affordability are critical and inextricably linked to economic activities. The government had in the past introduced a number of laws and reforms to address the plethora of issues that plague the power generation, transmission, and distribution industries. The government utilized a variety of initiatives, including supporting private sector engagement, diversifying energy generation sources, and boosting energy efficiency for long-term development. All of which have yielded extremely minimal result. In this study, questions about the problems militating against the energy sector in Nigeria shall be answered and modern solutions proffered. We suggest the smart grid as well as the prosumer system as a way out of the present energy logjam in Nigeria. The challenges associated with implementation will also be discussed.**

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I. INTRODUCTION

The energy industry is a large network of interconnected businesses that deal with the production and distribution of energy. Oil and gas, gasoline, diesel oil, and nuclear energy are examples of non-renewable energy sources. Hydropower, wind power and solar power are examples of renewable energy. The production and usage of energy contribute to the economy and the long-term survival of society. Unfortunately, energy production contributes to global warming, accounting for nearly two-thirds of worldwide greenhouse gas emissions. Many people in Nigeria, hitherto, do not have access to constant electricity, so they rely largely on charcoal and animal dung for lighting, cooking, and warmth (United Nations environment programme) [1].

The energy industry encompasses the generation of electricity from coal, oil, natural gas, biomass, nuclear power, and renewable energy sources like wind and solar. A few years ago, the Nigerian power sector was at its lowest ebb. Electricity delivery was at best erratic, leaving cities and villages in the dark all of the time. Businesses were unable to break even and eventually had to close up due to the high cost of using private generators. Today, it is no news that the prices of both generators and fuels to power them have skyrocketed. This calls for urgent attention and intervention.

It is common knowledge that energy access and affordability are directly connected to economic growth. As a result, a lack of energy, or a complete loss of energy, might bring Nigeria's already weak economy to a halt or, at the very least, damage it. Low productivity and, as a result, low cash flow are often the result of persistent and insufficient financial resources to develop energy supply. In some ways, it can be claimed firmly that there is a clear link between a lack of energy on the one hand, and people's living standards on the other. As a result, the provision and availability of power and energy will almost certainly keep economic activity afloat, reducing poverty to its barest minimum.

Energy and electricity was viewed as a yardstick for judging successive governments in Nigeria and the rest of the developing world. Lack of energy is believed to be a key impediment to the development of the 4th Industrial Revolution within the third world countries. This lackluster attitude among successive governments and their cronies, along with widespread corruption at all levels, has hampered Nigeria's quick growth and development particularly in the area of electricity.

This paper is structured as follows: Section 2 presents an overview of the literature on the history of Nigeria's energy sector and the government's role in revitalizing the sector. Global energy delivery trends, as they affect renewable energy, the smart grid, and the role of prosumers in the global energy equation, are also well addressed. A brief explanation of the methodology is given in section 3. Section 4 contains the results and discussion section, and it will propose potential solutions to Nigeria's energy problems, particular `rly in connection to modern technologies, in order to permanently solve the lingering energy problem. Section 5 of the report finishes with implications for energy strategies in smart cities, as well as limitations and further research.

II. Literature Review

Here we intend to answer some fundamental research questions as it affects Nigeria energy situation, smart grid and prosumers in the power and energy value chain. The research questions are as structured below:

RQ1: What is the current state of Nigeria energy sector?

RQ2: What are the challenges facing Nigerian government in delivering sustainable energy to consumers?

RQ3: What is the current trend in global energy delivery?

RQ4: How can prosumers be encouraged to leverage smart grid in the energy value chain?

To answer these research questions, the following research objectives were set:

i. Review the Nigeria energy ecosystem and the challenges that have hitherto defied appropriate solution.
ii. Review trends in global energy delivery and the place of prosumers in Nigeria energy value chain.
iii. Evaluate current trend vis-à-vis Nigeria energy situation.

RQ1: What is the current state of Nigeria energy sector?

To begin a discussion on smart grid, renewable energy and the Nigeria energy sector, it is expedient to first take a historical journey down memory lane.

Going Down Memory Lane

NEPA, The National Electric Power Authority was established on April 1, 1972, following the merging of the Electricity Corporation of Nigeria (ECN) and the Niger Dams Authority (NDA), with the first management appointed on January 6, 1973. The assets and liabilities of NEPA were transferred to Electricity Holding Company of Nigeria as part of the government's endeavor to reinvigorate the power sector (PHCN). As a result, in 2004, the National Integrated Power Projects (NIPP), a private initiative, was established with the goal of updating and expanding the existing capacity.

The Power Sector Reform Bill was signed into law by President Obasanjo in March 2005, letting private companies to participate in energy generation, transmission, and distribution. To ensure ultimate system reliability and maintainability, the PHCN as a company was later unbundled into 18 entities. The following are the details:

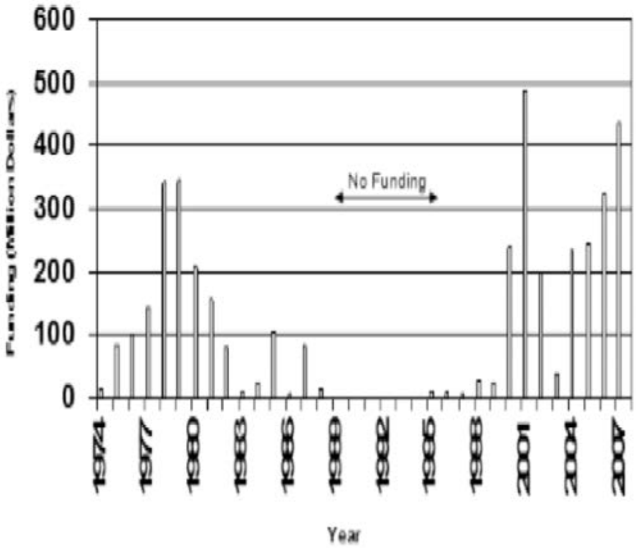
i. Six generating companies (GENCOs)
ii. One transmission company i.e. Transmission Company of Nigeria (TCN), and
iii. Eleven distribution companies (DISCOs)

This comes after the enactment of the Electric Power Sector Reform (EPSR) Act 2005, which saw Power Holding Company of Nigeria (PHCN) go from being a vertically integrated utility to an unbundled business.

In the 1970s, when the Udoji's Federal Government rewards improved the employees' economic situation, the workers increased their electricity use by purchasing a number of complex and automated machinery that used a significant amount of energy. The electricity utility industry, on the other hand, was unprepared for the spike in demand. This challenge has continued to leave a deficit in consumption and generated electricity since that time in Nigeria's energy consumption history. As a result, the demand for, and supply of electricity are always out of balance [2].

The year 1999 was a watershed moment in the history of the power industry. It marked the end of Nigeria's military interregnum and the start of a new period marked by the establishment of a civilian administration. Prior to that, finances to remodel and reinvigorate the electricity sector were always in short supply. However, much money was put into the system at the start of the new civilian administration, resulting in a minor increase in installed capacity. Between 1974 and 2007, the funding for the power industry is shown in the table below:

Table 1: Annual funding of electricity sector (Source: UNILAG fair and conference, 2007, Poster Presentation)



Today, after so much has been expended on generation, transmission and distribution infrastructures, the situation in the power sector is far from being normal as the electricity companies continue to fall short of delivering uninterrupted power to individual residential and industrial areas. After decades of massive investments in the power sector and subsequent privatization, the sector is yet to witness a significant face lift as residents and corporate organizations continue to lament the obviously worrisome situation.

Just recently on Radio Nigeria network news, residents of various states in Nigeria including the Federal Capital Territory were heard lamenting the poor state of electricity in their respective domains. The utility industries often complain of gas shortages, vandalization of power equipment, and inefficiency in generation, transmission and distribution. Although recommendations towards solving the problems of erratic electricity supply were proffered, its implementation is yet to yield meaningful result.

RQ2: What are the challenges facing Nigerian government in delivering sustainable energy to consumers?

Despite several problems relating to technical, environmental, political, economic, and social concerns, the greatest stumbling block to the electrical industry's success is money. There is no doubting that investing in the electricity business requires a significant amount of capital. It became necessary to build more transmission lines and substations to facilitate energy evacuation, but the existing transmission line capacities were woefully inadequate. There was also the issue of insufficient technical or experienced staff to efficiently and effectively handle and maintain electrical machines.

The electrical sector was on the verge of collapse due to insufficient investment in the energy sector. As a result of these worries, Nigerians have switched to alternative sources of power, ranging from basic candles to fuels such as diesel and gasoline. Expensive diesel generators are a popular choice for those who can afford them, with Nigerians spending more than twice as much on self-generation as they do on grid-based power. In 2009, it was predicted that 60 million Nigerians would own electricity-generating sets. According to the Manufacturers Association of Nigeria (MAN), this figure rose to 100 million by 2016 [3].

The author also stated that over 50 million households spent at least N30,000 ($72) per month on fuel for their generators, and that the President and Vice President's offices spent N32.9

million ($79,277) on fuel in 2016, while government ministries spent approximately N55.4 billion ($133,494 million).

Newer power stations were built by GENCOS and IPPs in order to meet the demand for electricity by consumers. New power plants are expensive to build, and extensive maintenance of existing units that aren't working costs a lot of money. There is always a cost associated with maintaining a consistent electricity supply in our houses. Because the primary objective will be to generate a profit, this will very certainly result in more money being handed to utility corporations by end customers. This is obvious from Hall's (2000) research on a privatization program in the United Kingdom [4].

Ethnic, linguistic, religious, and other emotive considerations have impeded the seamless development of the electricity sector in the past. Without resorting to salient concerns of proximity to raw supplies and various other factors, the place where the current political gladiators came from has always been a crucial predictor of who gets what. The thought of keeping the Kaduna refinery at its current location, thousands of kilometers from the source of raw materials, comes to mind immediately.

The release of hazardous gases into the host environment also makes citing a power station in a specific region difficult. There is no denying that carbon monoxide is a harmful gas that may pose unnecessary threat to local residents. Another issue is paying the exorbitant compensation requested by the residents. Vanderlization of power equipment such as overhead cables, generators, and transformer parts, as well as insufficient gas to power producing sets, are all issues worth considering. Regrettably, much of the gas that could be used to power plants is flared.

Despite the many issues that the power sector faces, there are still opportunities for potential investors. Investment opportunities, job chances, and technical manpower transfer are among them. The constant rise in distribution power demand has produced a significant transmission capacity gap at the various transmission stations and distribution lines, resulting in local load shedding. For a long time, the persistent issue of inadequate system maintainability has also been a big blight on the system. Some power transformers in the distribution network are malfunctioning, requiring repairs and/or replacement, while many transformers are overloaded, resulting in regular load shedding. This is made worse by the unethical practice of connecting multiple electrical loads without the knowledge of utility personnel.

Insufficient supply of power was a key hindrance to Nigeria's growth and development. Nigeria's transmission infrastructure does not reach every part of the country. Nigeria has a total installed capacity of 12,522 MW of electric power from existing plants due to its endowment with large oil, gas, hydro, and solar resources, but on most days, it can only generate a maximum of 9MW and then struggle to transmit and distribute 5,000 MW, which is insufficient to meet the increasing demands of the growing population and gadgets. As a result, the country is subjected to enormous load shedding.

The biggest difficulty preventing electricity from reaching the end-users, according to [5], is structural inefficiencies across the power value chain. The Nigerian electrical industry has been beset by a series of issues that defy fast resolution. This is despite the government's numerous interventions through her agencies. Energy access is the bedrock of wealth, health, liberty, and human dignity.

Nigeria's economy is Africa's largest, with a predicted GDP of $445 billion in 2022 and $450.00 billion in 2023. Nigeria's economy increased by 3.4 percent year-on-year in 2021, according to the National Bureau of Statistics (NBS), with a real value of N72.39 trillion. Nigeria's GDP per capita is predicted to rise to $2,400 in 2022 and $2,500 in 2023. Nigeria's GDP per capita would have doubled over time but for the ongoing power problem and other challenges.

According to a report by the Organization of Petroleum Exporting Countries, Nigeria's petroleum industry accounts for over 10% of its GDP, and crude oil shipments increased by an average of 81,000 barrels per day in January 2022, accounting for around 86 percent of total export earnings. In their master's thesis, [6] asked why the energy-rich country has been unable to adequately supply its own inhabitants with electricity, stating that in truth, the expansion of the industrial sector has been hampered due to power shortages.

Only 55% of Nigerians have access to power, according to the World Bank. Despite having a higher electrification rate than the rest of Sub-Saharan Africa, over 95 million Nigerians remain without power. Nigeria is currently the world's seventh most populous country, but by 2050, it is anticipated to surpass the United States as the world's third most populous. The world's population is expected to reach 9.8 billion people by 2050, with Africa contributing for half of that growth. Four of the world's fastest growing cities are located in Nigeria. Nigeria has been dubbed a "powerhouse economy" [7]. Unfortunately, Nigeria's infrastructure, particularly its energy grid, is under peril as a result of this population expansion.

The majority of the difficulties and challenges plaguing the Nigerian power industry have so far eluded a long-term solution, partly due to the government's failure to address the issues head-on, and partly due to corruption at all levels. As a result, a paradigm shift is required to address these issues. The smart grid and the prosumer solution spring to mind immediately. They aid in the introduction of cutting-edge technologies into the grid, hence reducing waste.

The main causes of insufficient energy for consumption are the rise in population and accompanying increase in loads caused by improvements in people's economic circumstances. The usage of a variety of traditional sources is insufficient to meet customer demand. This necessitates the usage of renewable energy, which has been determined to be both cost-effective and useful in providing consumers with the energy they require. Smart grids are being injected into current energy infrastructures to assist improve the quality and safety of renewable energy systems by giving monitoring and control capabilities via Information and Communication Technology (ICT).

[8] and [9]-[10], highlighted some initiatives by government aimed at providing power to consumers. They include:

i. Energizing Economies Initiative (EEI):

The Nigerian government launched this initiative in September 2017 to supply long-term power to commercial clusters.

ii. Energizing Education Programme (EEP):

The Nigerian government created the EEP to provide power to the country's 37 Federal Universities and 7 Teaching Hospitals.

RQ3: What are the current trends in global energy delivery?

The grid is one of the most basic prerequisites for supplying electrical energy to users. It manages the supply and demand for energy, which powers everything from domestic gadgets to industrial machinery.

A. The Power Grid

Our current electrical grids are too old, outdated, inefficient, unreliable, and do not provide enough fault protection. As indicated in Figure 2.0 below. [11] identified three key tasks of power grids: generation, transmission, and distribution. The first phase is the generation of electricity at the power station (coal, nuclear, geothermal, power station hydroelectric). Transmission is the second step of the power grid, and it involves moving electricity from power plants to distribution systems. Transmission is the electricity grid's third and final stage.

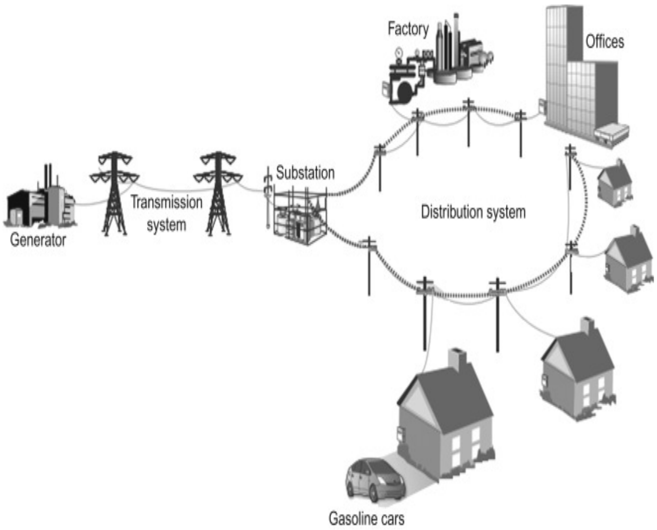


Figure 2.0: Conventional Power Grid
Source:ScienceDirect.com

Traditional energy sources such as coal, natural gas, nuclear power, and gasoline have traditionally been used to generate electricity. Electricity generated from traditional sources has an impact on the quality of the environment (due to pollution, greenhouse gas emissions and global warming).

The failure of traditional grids, as well as the vulnerabilities that come with it (such as constant power outages caused by faulty circuit breakers and overgrown vegetation), prepared the way for a paradigm shift. Solar PV is a renewable energy resource that is currently attracting attention in Nigeria for utility-scale electricity generation. Nigeria could theoretically produce 207,000 GWh of power per year from solar Photovoltaic (PV) technology (ten times the amount produced in 2011) if only 1% of the country's land area was covered with PV modules (Nigeria Energy Support Programme -NESP, 2015). In Nigeria, unfortunately, there is currently no large utility-scale electricity generation.

In his article "Nigeria: energy supply ranked second worst in 2017," [12] quoted Vanguard as saying that the national grid capacity at the time was 4,000MW, according to the Advisory Power Team report. Nigeria was named the country with the second poorest electricity supply in 2017 by the Spectator Index due to frequent power outages and supply concerns.

B. Trends in Global Energy Delivery

According to the International Energy Outlook for 2019, global energy demand is on the rise [13]. Global electric power consumption is predicted to rise by roughly 50% on average between 2018 and 2050. The demand for energy is increasing as the world's population grows. As a result, annual oil consumption has increased, resulting in significant carbon dioxide emissions. If population growth continues, annual consumption is expected to triple by 2050. As a result, to reduce the adverse consequences of fossil-based supplies, harmless, renewable, and natural supplies must be employed or chosen. Renewable energy sources include wind, solar, hydropower, biomass, and geothermal. Worldwide, hazardous, renewable, and natural supplies are employed to reduce the detrimental effects of fossil-based supplies.

C. The Bi-directional Model

The current trend is for the unidirectional, supplier-user paradigm of power networks to be gradually altered and replaced with a bidirectional model. The bi-directional model acts within an intelligent network and has a double supplier-user and user-supplier sense. In comparison to a unidirectional energy network, prosumers in bi-directional smart energy networks contribute to increase the efficiency and efficacy of energy systems. Communication technology and intelligent equipment are used in two-way networks to help store energy surpluses and balance local electricity demand.

Transitioning from passive consumers to prosumers (also known as active consumers) offers financial advantages, but it also helps to safeguard and even improve environmental quality [14].

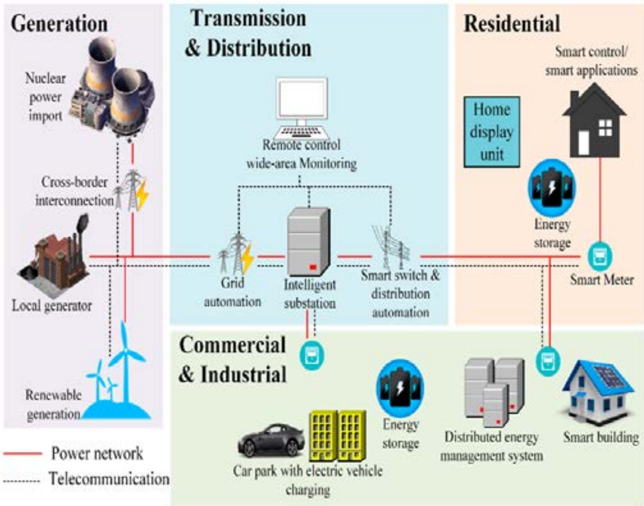


Figure 2.1: The Bi-directional Model of the Smart Grid; (Source: https://www.mdpi.com/asi/asi-03 00005/article_deploy/html/images/asi-03-00005-g001.png)

D. The Smart grid

Smart grids are cutting-edge active distribution networks that combine distributed renewable and conventional generators, energy storage devices, and a wide range of loads to function in a controlled and coordinated manner. [15]. All aspects of the electricity system, including generation, transmission, distribution, and consumption, could benefit from smart grid technologies. Due to the widespread use of intelligent communication monitoring and management technologies, a smart grid can be defined as an updated energy grid network that facilitates two-way information and power exchange between electricity suppliers and customers.

The concept of the smart grid initiative was articulated by [16] as follows: To maintain the stability and implementation of the electric power network, smart grid technology monitors the condition of the electric power system and makes intelligent judgments, quickly clears faults, restores power, and monitors demand. By utilizing higher-tech imaging diagnostic tools, the smart grid can improve the efficiency of the network system, allowing for self-healing structures. Remote monitoring and control are also carried out by the technology, which boosts efficiency and reduces losses in the event of human error or natural disasters by anticipating difficulties.

According to the authors, smart grid systems include both hardware and software. Counters, home equipment, and large systems are examples of hardware, whereas data sub-blocks and internet-based systems are examples of software. Wireless, WiMax, and Broadband over Power Line Systems are the technologies used to build communication networks. Smart grid technology transfers electricity from providers to consumers via sophisticated two-way digital communications, allowing users to manage equipment in their homes, reducing energy consumption, increasing dependability, and increasing transparency.

Smart grids have become increasingly popular in recent years. They have aided in the improvement of energy transmission and distribution. They have proven to be dependable, adaptable, efficient, long-lasting, and customer-focused. The efficient smart grid technology benefits both the suppliers and the customers. The smart power grid is planned to deliver sustainable energy services by allowing bidirectional data and power transfer, which is supported by sophisticated information, communication, and control infrastructure.

[17] defines smart grid as an advanced electric power system of the future that blends cutting-edge power electronics, computers, information, communication and cyber technologies. It is a high-tech power system with integrated communication infrastructure that allows energy and information to flow in both directions. He summed up the smart grid's major goals as follows:

i. Increased resource efficiency
ii. Optimal resource usage
iii. Improved system dependability
iv. Increased system security
v. Affordable distributed power to consumers.

He went on to say that smart grid capabilities include the ability to connect an increasing number of distributed Renewable Energy Systems (wind, PV, etc.) with bulk power generation plants (hydro, fossil, etc.) with the end aim of carbon-free generation. It will also include bulk energy storage devices due to the erratic and statistical nature of renewable energy supplies (battery, pumped storage, flywheel, hydrogen, and so on). To achieve some of the aforementioned goals, the Author explained how smart grid can incorporate power-electronics-based high voltage direct current (HVDC) systems, flexible alternating current transmission systems (FACTs), static synchronous compensators (STATCOMs), uninterruptible power supply (UPS) systems, and so on.

The smart grid concept is employed all around the world to achieve the goal of sustainable, secure, and cost-effective electricity supplies with active customer participation. Furthermore, smart grid is intended to increase the quality and safety of renewable energy systems by providing monitoring and control capabilities using information and communication technology.

The smart grid concept can be utilized to improve and facilitate communication and information flow in smart networks. A smart grid is a technological move from a traditional electric grid with an electro-mechanically managed system to a smart, intelligent, and electronically controlled one [18]. It has the potential to alleviate a variety of problems, including power outages and energy waste. Smart energy-controlling gadgets installed in homes in smart cities and creative-innovative communities provide effective energy usage monitoring via a smartphone-based application, for example.

Without a question, a smart grid will enable unprecedented levels of customer participation. Controls, computers, electrical lines, and new technologies and equipment make up a Smart Grid, which comprises of millions of bits and parts. The Smart Grid is about giving people the knowledge and tools they need to make informed decisions about how they use energy, not only about utilities and technologies. Users can generate electricity, share it with other customers, and finally store it within the smart networks formed by smart grids.

[19] presented a methodology for the joint capacity optimization of a typical residential standalone microgrid employing renewable energy sources such as solar photovoltaic, wind turbines, diesel generators, and battery energy storage systems in their paper "An Improved Optimal Sizing Methodology for Future Autonomous Residential Smart Power Systems." To improve the capacity optimization methods, realistic mathematical models of solar photovoltaic, wind turbines, diesel generation systems, and other systems are developed. To ensure reliable, efficient, effective, and economical operation of the power system, the difficult optimization issue is framed and solved innovatively to minimize cost, reduce greenhouse gas emissions, and curtail dump energy.

Load shifting's effects on cost, greenhouse gas emissions, emissions reduction benefit cost, and clean energy supplied by the system were also evaluated. The authors concluded that shifting load demand can lower costs, reduce greenhouse gas emissions, save money on Emission Reduction Benefit Costs, and boost the green energy share. It was discovered that transferring only 20% of overall load demand resulted in a 5.5 percent per unit cost savings.

Most countries of the world are investing heavily on smart grid system. They have begun reorganizing their company to support a Smart Grid program [20]. The smart grid, with all of its smart technologies, tools, and devices, will undoubtedly improve efficiency, reduce emissions, and improve the robustness and security of our national power infrastructure.

Table 1: Differences between conventional grid and smart grid

Conventional Grid	**Smart Grid**
Cannot meet renewable energy penetration demand Efficiency of overall grid is poor	Requires higher renewable energy penetration Efficiency of overall grid is excessive
Limited customer interaction and one way flow of information	Extensive customer interaction and two ways flow of information
Central generation of electricity Metering is purely electromechanical	Distributed generation of electricity Digital and enabling real-time metering
Spiral grid topology Manual restoration following disturbance	Networked grid topology Self-healing following disturbance
Environmental pollution is high	Environmental pollution is low
Prone to failure and outages, therefore it is reactive and unreliable	Prevent outages before they start. Reliability is high

E. Smart Meters

Smart meters are part of the smart grid architecture. In smart grids, smart meters are used. They are advanced digital metering infrastructures that connect generation plants to smart sockets and other smart grid-enabled products via a communication link. Utility firms can obtain information on how customers use electricity by deploying smart meters. For both gas and electricity, a smart meter is a new type of metering equipment. It digitally transmits actual energy consumption to the utility provider. It eliminates the need for households to rely on anticipated and outrageous energy bills, which are a regular occurrence in Nigeria, or to invite meter readers into their houses or compounds to manually read the meters. The conventional (traditional) grid and the smart grid are depicted in Figure 2.2.

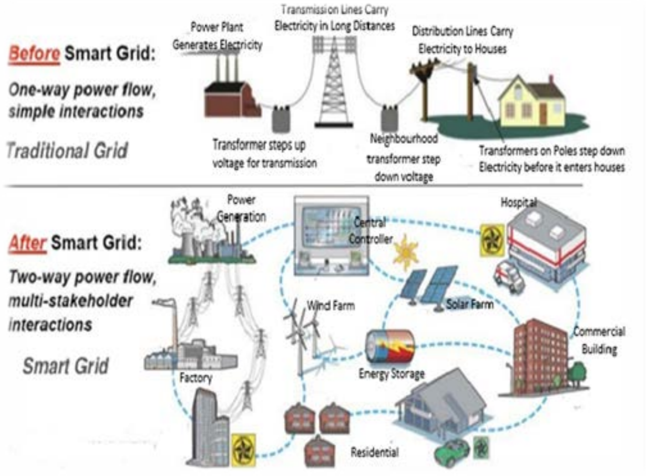


Figure 2.2: Smart grid, Bi-Directional vs Unidirectional; Source: https://d3i71xaburhd42.cloudfront.net/3ce91ff4aa69e7d4823ea4ef3668ca4286696f73/250px/2-Figure2-1.png

RQ4: How can prosumers be encouraged to leverage smart grid in the energy value chain?

Alvin Toffler was the first to develop the concept of prosumers [21]. The prosumer, according to the author, is a group of people who produce some of the services or goods they consume. Consumers who can essentially and possibly supply important services to the energy system are referred to as prosumers in this context.

Electricity can be consumed as well as produced by a prosumer. Prosumers and bi-directional smart grids are two novel ideas that have the potential to significantly alter the way electricity is generated, distributed, and stored. Private persons, communities, businesses, and public entities, such as schools and hospitals, are examples of prosumers who utilize electricity generated from their own electrical power source. The prosumers are defined as "consumers who also create and share surplus energy with grid and other users" [22]. Prosumers can be regarded as an essential stakeholder in smart grids and play an important role in peak demand management.

As our energy systems become more decentralized and the number of small and medium-sized renewable intermittent sources grows so will the number of prosumers. Smart energy's main advancements, such as the widespread use of alternative energy sources and the digitalization of energy production and distribution, all contribute to environmental sustainability, energy supply security, and decreased energy consumption costs. When these trends are joined with the involvement of various actors in smart city life, fertile ground for prosumers' vision emerges.

Another type of prosumer is one who makes use of photovoltaic energy in a specific way. Micro-generations tend to form inside clusters in this instance, allowing numerous families to profit from photovoltaic energy. For example, the location of the site and unique local characteristics, such as the right level of solar irradiation, are factors that influence the establishment of a photovoltaic agglomeration.

Prosumer energy management and sharing necessitates an advanced communication infrastructure, which can also be employed for communications technologies required and available for smart grid applications. These technologies include: GPRS, WIMAX, Bluetooth, ZigBig, Power Line Communication (PLC) etc. [22] also enumerated different optimization techniques for energy management in smart grid. They include:

i. Linear Programming (LP)
ii. Integer Linear Programming (ILP)
iii. Particle Swarm Optimization (PSO)
iv. Genetic Algorithm (GA)

[23] used the Internet of Things to develop extended Demand Side Management (DSM) techniques that included Distributed Energy Resources (DERs). End-user energy consumption and generation are both a part of DERs. Two controlling entities, the Local Control Hub (LCH) and the Global Control Hub (GCH), collect the DERs' parameters. DERs are gathered in LCH using IoT ideas to forecast energy needs and behaviors so that relevant decisions can be made.

LCH has a user interface that shows various parameters such as energy use and production over time. Energy demand and extra energy availability are forecasted using the user interface. All of the LCHs are combined at GCH. With its own interface, GCH collects data from LCHs, forecasts energy usage, and manages prosumers. LCH has a user interface that shows various parameters such as energy use and production over time. Energy demand and extra energy availability are forecasted using the user interface. All of the LCHs are combined at GCH. GCH uses its own interface to collect data from LCHs, estimates energy demand, and controls prosumers in a flexible manner.

A. The prosumer challenge

Although using a prosumer strategy to solve Nigeria's energy problems is a start in the right way. However, it remains a challenge to best integrate, harness, and leverage these prosuming services for the benefit of society and prosumers. According to [22], the following are some of the issues related with prosumer services:

i. Development of energy sharing vision
ii. Stakeholder engagement
iii. Funding and investment

iv. Equipment installation
v. Maintenance and troubleshooting

B. Security and privacy Data

In a smart grid setting, security and user privacy are major considerations. These considerations are also critical for the implementation of prosumer systems, which necessitates accurate data flow across stakeholders. Strong security and privacy standards are required for this type of data transit.

III. METHODOLOGY.

The theoretical approach was used in this study, with the goal of collecting and analyzing scientific articles on energy concepts such as power grids, smart grids, and prosumer systems as they relate to providing affordable and sustainable electrical energy to Nigerians who are both energy-hungry and energy-deprived. The methodology aids in the resolution of the research questions posed in the literature review part. The papers were gathered from a variety of resources and properly cited.

IV. RESULT AND DISCUSSION

The myriad of issues that the power business faces are largely due to population growth. It is common knowledge that when load increases, power demand rises, owing to factors such as social status, economic growth rate, regional variances, and population demography [24]. Renewable energy will be incredibly cost-effective and beneficial in providing consumers with the energy they require. Furthermore, smart grid is intended to use ICT to improve the quality and safety of renewable energy systems by offering monitoring and control capabilities.

Power outages and inconsistent power supply have remained a recurring decimal in Nigeria for decades, with no obvious remedy in sight. The government has identified policies and programs that were either partially implemented or were not closely monitored by appropriate organizations due to poor resource management by relevant agencies. As a result, the power sector continues to sway in the ruins. Although, the smart grid, prosumer-based energy management and sharing are a relatively recent paradigm, given the necessary enabling environment, it can be effectively deployed in Nigeria to fulfill the variable electricity demand of end-users.

By utilizing the smart grid's bi-directional paradigm, which converts passive consumers into prosumers, the smart grid and prosumer concept can assist in resolving the majority of Nigeria's power challenges. The Smart Grid also enables power and network firms to predict and respond to problems remotely, allowing local distribution repair personnel to resolve power outages more quickly. Utility firms will need to analyze the viability of any prosumer system mechanism in order to receive meaningful information about potential benefits when building an energy sharing strategy and meeting the issue in the power industry. In order to achieve the desired energy and cost savings, various utilities will need to agree on specific prosumer system architecture.

Photovoltaic panels are the most prevalent facility for producing power at the household level. This is due to the fact that, as a result of increased use, the cost of installing solar panels has reduced dramatically over the last decade. Because of the increased promotion of these technologies, this is expected to grow even more. Smart metering security, data transfer security protocols for communication among smart grid devices, cryptographic algorithms for various applications, and other cyber security protocols in smart grid applications are currently in use around the world.

One of the possible equipment installation options is to promote renewable energy resources that can be installed on roof tops and take up less space. Similarly, government agencies and utilities must educate customers and make it easier for them to install energy monitoring and management systems at their homes. Furthermore, efficient storage technology is required to eliminate intermittency concerns and proper prosumer participation in the energy sharing mechanism. The communication infrastructure has to be investigated further from a smart grid approach.

V. CONCLUSION

We are expecting that a more in-depth investigation of the collected documents would help us to improve certain fascinating features in order to find a resolution that is not only theoretical, but also practical for future smart grid installations and cities in Nigeria that are expanding along a smart road. Despite the fact that present technologies were not designed for smart grid applications such as the prosumer system, new communication protocols may be created to better satisfy the smart energy management needs. Prosumer systems and smart houses can become a reality in most Nigerian cities with the correct legislation and an energy-focused infrastructure funding framework.

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