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Exploring the Electricity Market in Nigeria through the Incorporation of Stranded Generation

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Abstract

Electricity Markets are a prominent phenomenon in the developed world. Numerous countries across Europe, North America and Southeast Asia have a fully developed electricity market. In these countries, the value chain from power generation could be complex yet elegant in simplicity. All aspects of the value chain are commercial whereby there are commercial entities that generate and sell power while others could purchase power in bulk and sell to end users. The markets are dynamic despite regulations. Competition is in-built such that buyers and sellers have the robustness of choices within a given grid system. This work aims to explore the opportunities available in Nigeria for the introduction of the deregulated Electricity Markets within the ambits of the regulations of NERC (Nigerian Electricity Regulations Commission). The Nigerian public power supply infrastructure is classified into GENCOs (Generating companies), DISCOs (Distribution companies), and the TCN (Transmission companies). The TCN is limited in capacity and thus unable to effectively transmit the power generated by the GENCOs. The GENCOs are thus limited in output which limits the power allocated to the eleven DISCOs across the country. The market is thus limited in the product (electricity) and the DISCOs have insufficient power to sell to the final consumers. Independent Generating Plants have however been identified in this work, and recommendations based on incentives payments have been explored using the Electricity Market, to bring these Stranded Power Plants into play.

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1. Introduction

For a populous and developing country like Nigeria, the importance of efficient and innovative electricity markets cannot be over-emphasized. Ezenekwe et al (2014) remarked that the provision of electric energy to meet the needs of any economy depends to a large extent on the existence of electricity supply markets which are efficient and flexible to meet the needs of such economy (Joseph, 2019). KPMG (2019) also explained that the growth potential of any economy relies on the performance of the electricity supply mechanisms in place. In the case of Nigeria, the electricity market has been historically dominated by state-owned utilities such as the Electricity Corporation of Nigeria (ECN) and the National Electric Power Authority (NEPA). The wave of privatization of public enterprises led to the creation of the Power Holding Company of Nigeria (PHCN) and consequently the emergence of electricity generating companies (GENCOs) and electricity distribution companies (DISCOs). Makwe, Akinwale and Atoyebi (2012) remarked that the Nigerian electricity market system has over the years transformed from a vertically integrated monopoly market into a privatized power sector. The performance of the Nigerian electricity market is in itself a reflection of the low level of consumption of electricity in the country compared with other African countries (Ezenekwe et al, 2014).

Another important characteristic of the Nigerian electricity market with important implications for the development of the country's power sector is the general poor and inefficient allocation of resources. Studies by Onakoya et al (2013) and Edomah (2016) have argued that the poor allocation of resources is a major factor preventing the achievement of favourable outcomes for market participants in the power sector. World Bank (2021) reported that Nigerian firms experience some of the highest rates of monthly power outages in the world.

Table 1: On-Grid Electricity Infrastructure Data in Nigeria

S/N	DESCRIPTION	PARAMETER
1	Installed Capacity of Generating Plants (MW)	14,249
2	Available Capacity (MW)	7,122
3	Transmission Capacity	7,000
4	Transmission Losses (%)	25
5	Average Daily Output (MW)	2,493.69
6	Calculated Peak Load Demand (MW)	8,157
7	Load shortfall (MW)	5,663.31
8	Theoretical Base Load Demand (Domestic) MW	17,000
9	Average Market Size (MW)	4,000
10	Suppressed Domestic Demand (MW)	13,000

Source: NERC (2021)

This has negative implications for economic growth and development and a major factor in the exodus of manufacturing industries to other countries with more reliable power supply. For domestic users, the inefficient nature of the Nigerian electricity markets has served to reduce the level of use of electricity even though demand is high. This situation has also engendered corruption along the Nigerian electricity value chain at a detriment to the growth of the economy (Edomah et al, 2016).

The major problems facing the Nigerian electricity market are supply- sided factors and excessive regulation of the market. Participants in the market such as the GENCOs, DISCOs, the Transmission Company of Nigeria (TCN) and the Nigerian Bulk Electricity Trading Company PLC (NBET) are regulated by the Nigerian Electricity Regulatory Commission (NERC). Despite the high level of regulation, the problem of managing power supply remains a bottleneck; and create difficulties for both the DISCOS and GENCOS to operate in an efficient manner making it difficult for the electricity players to meet the demands of both the shareholders and stakeholders. The Nigerian power sector have several power plants which are neither connected to the grid nor involved in commercial power generation. Yet, they do have the capacity to lessen the burden of electricity by providing a different incentive system for them. This study explores the electricity market in Nigeria in the context of how stranded power generation plants can help in bridging the gap between supply and demand and contribute to more efficient markets.

2. The Concept of Electricity Markets

Globally, electricity markets have served an efficient role as the means through which value is transmitted along the electricity value chain. Electricity market as a mechanism which facilitates interactions between suppliers and demanders of electricity to determine the quantity and price of electrical power or electric energy. Generally, electricity markets are made up of four types of participants. These participants are in turn reflecting the four stages in the electricity value chain which are generation, transmission, distribution, and consumption (Mili & Momoh, 2000). In a free- market system, the pricing and supply of electricity also follow the market dynamics informed by the level of demand and supply. However, electricity markets also have several distinct properties. Unlike physical commodities, electricity cannot be stored to a relevant or commercially viable degree (Cramton & Ockenfel, 2012). This unique physical property means that electricity markets are dependent on momentary production conditions and as such buffers cannot be created during periods of low demand for sale during period of high demand. This has important implications for the efficiency of electricity markets.

In order to ensure a high level of efficiency in electricity markets, three key market mechanisms have been introduced over the years, these are spot markets, forward contracts and futures trading. The Electricity Spot Market is the primary market for electricity trading. The spot market system may vary from country to country, region to region or city to city depending on the regulations adopted in the market. The spot market is the primary market for the determination of pricing. Cramton and Ockenfel (2012) posit that the spot market is determined by the offer prices from the generation companies which depend on several parameters which include start-up cost, no-load costs, incremental costs, and plant technology. These generation price offers help to determine the marginal cost for determining the price per megawatt of electricity available.

In developed electricity markets, transactions often involve the sale of electric energy to utilities or industrial consumers using contracts. These may be spot contracts or over-the-counter (OTC) forwards. The utilities in turn sell the electric energy to other consumers. This framework also encompasses the transmission systems operators who are responsible for coordinating the flow of electricity from the generation points to the utilities. This widely- used market configuration has led to the evolution of systems whereby electricity markets are partitioned into wholesale and retail markets. Even though there are differences in specifics, electricity markets all over the world can be analysed using this description.

The use of spot contracts in electricity markets involves the meeting of market participants electronically in markets in which prices are determined by market forces within the allowable band determined by regulations imposed by the market operator and the technical limits of the systems operator. In cases where electricity markets make use of spot contracts to facilitate transactions, the market operator for the grid accepts price offers from the generating companies and help in setting up a spot market system. The spot market could be a managed spot market system in which the market operator determines the price paid by final consumers. Nnaji (2011) explained that in determining the final price paid by consumers for electricity, factors such as the costs of transmission, transmission losses and constraints, and the economic profit margins participants in the value chain (from generation to distribution) are considered. Furthermore, in the use of spot markets as the transactional basis for electricity markets, there are country to country differences in the extent of including participants in the market. In countries like Oman and Nigeria, participation in the electricity spot markets is limited to electricity generating companies while in the North American and most of the European countries, participation is not limited.

Another widely- used transaction mechanism in electricity markets are forward contracts. Davidsson (2019) explained that the utilisation of futures contracts in electricity markets is more suitable in markets that are highly deregulated. Akarakiri (2010) further explained that futures contracts work by a mechanism in which two parties contract on the future supply of power at a particular price and quantity. The prices agreed are determined by the spot market prices and the market projections for the period of interest (Hogan, 2013). Audet, Heiskanen, Kepp & Vehvilainen (2004) further explained that several parameters ranging from historical data for supply & demand, periodic consumptions, and technology among others to determine the prices of futures. Futures contracts are also visible to the market operator and must be within the technicalities allowable within prevailing regulations. Power companies often make use of futures contracts to hedge their positions and as such limit their risk exposure in the marketplace (Akarakiri, 2010).

2.1 The Nigerian Electricity Market and the Challenges Facing It

The Nigerian electricity market is markedly different from what obtains in the more developed countries. Evidence by Davidsson (2014), Ezenekwe et al (2014), Emodi and Yusuf (2015), and Edomah et al (2016) reveal that the features of developed and efficient electricity markets are conspicuously absent in Nigeria. These features include regulations creating and supporting a decentralized market, multiple grid markets (local or regional markets with two or more grids) and distributed generation markets (where multiple generating companies supply several retailers within a metropolitan area and its environs). These features have also been identified as being essential for the emergence of thriving electricity market systems and their absence probably contributes to the backward nature of Nigeria's electricity markets.

Arguably, the Nigerian electricity market can be said to also have spot markets, forward contracts, and future trading. At the moment, an electronic or virtual spots market is lacking but the rudiments are recognizable in the transactional mechanisms used in the trading of electricity. Ley et al (2015) explained that the Nigerian spot market for electricity is highly regulated by the government through the agency of the Nigerian Electricity Regulatory Commission (NERC). The determination of price is done using selected accounting systems to analyse the system marginal price for each GENCO and adding the costs of transmission and economic profits. This is the price at which electricity is sold to the DISCOs and further additions are made in order to determine the final price that will be paid by the consumers (Edomah et al, 2016; KPMG, 2019). In essence, the spot markets for electricity in Nigeria can be described as a managed system controlled by the NERC. This spot market is also characterized by the use of a graduated price system with four different price tariffs for the domestic, commercial, industrial and public services customers.

Futures trading in the context of the Nigerian electricity market revolves mainly around the setting of the Multi Year Tariff Order (MYTO) by the NERC. Obindah and Ezurum (2017) noted that the MYTO provides a 15- year tariff path for the Nigerian electricity market and has provisions for biennial and five- year reviews. The use of the MYTO is in accordance with Section 76 of the EPSR Act 2005. It can thus be argued that the setting of future prices in this context does not really encompass the trading of electricity futures but revolve around the setting of prices in order to achieve market stability. The MYTO 2015 methodology provides for the recovery of investments and profits by the participating companies between 2015 and 2024 (Adeyeye, 2017).

The relatively inefficient state of the Nigerian electricity markets has given rise to a wide range of challenges at the generation, transmission and distribution stages. At the generation stage, electricity markets are faced with the challenges of vandalism, unfavorable pricing regulation, delayed reforms in the oil and gas sector, inadequate gas infrastructure and the failure of generating companies to consistently meet up with gas payments (Moyo, 2012). At the transmission and distribution stages, the challenges of financial constraints, poor management, low transmission capacity, a high level of collection and technical losses, weak distribution networks, inadequate metering, electricity theft, and the use of a non-cost reflective tariff regime (Emodi & Yusuf, 2015). The use of the non-cost reflective tariff regime by the NERC has over the years served to make electricity markets inefficient by prioritizing the affordability of electricity over the workings of the supply- demand mechanism, this has limited supply and made the sector less attractive for investors.

To resolve some of these challenges, different potential strategies can be applied. First, it is possible to increase the transmission capacity to at least be capable of wheeling the installed generation capacity of 15,000mW thus increasing the power allocated to each DISCO. A potentially viable strategy will entail the deregulation of power and licensing regimes which would allow DISCOs to strategically source for electricity to make up the shortfalls in their specific areas of operations. It is also workable to create new policies which would allow for distributed generation and control in each load center and the creation of commercial public utility and electricity marketing companies in each load center. The first strategy would necessarily entail large investments running into tens of billions of dollars and would take several years to come to fruition. The investment capital is not available in Nigeria as structured.

The second and third options could provide short term solutions to the seemingly protracted power situation. The deregulation as espoused in these strategies would include the liberalization of the electricity market and would provide a more economic market that is informed by the laws of supply and demands. These options are workable with the introduction of electricity markets dealing in power generated from stranded power assets which are spread all over the country. This will go a long way in addressing the imbalances between the supply and demand of electricity.

3. Stranded Power Generation and its Contribution to Electricity Markets Globally

An important aspect of the high level of efficiency of electricity markets in the developed countries involves the management of stranded power generation assets. In Europe and America, stranded power generation assets are described as assets that have called for closure before the end of their anticipated technical lifetimes (Moyo, 2012). In the developed countries, the utilisation of stranded power generation assets has significantly influenced the accelerated shift towards the use of renewable energy. Traditionally, these assets have been used in bridging supply gaps but in countries like USA, Germany, UK, South Africa, China and Canada, massive investments in power generation have led to the outstripping of demand by supply on the aggregate level (Funk, 2014). At the most basic level, the bridging of electricity supply gaps through the incorporation of stranded assets into the national grid performs the two functions of preventing power outages and blackouts which may disrupt the economy and help in making electricity markets more stable (Edomah et al, 2016). Furthermore, in countries with efficient and well-developed electricity markets, the utilisation of stranded power generation assets has been shown to contribute to the flexibility of power systems (Lannoye, Flynn & O'Malley, 2012).

3.1 Stranded Power in Nigeria

The power of the NERC provides a context for understanding the potentials of incorporating stranded power in the Nigerian electricity market. The NERC has power to do the following as enshrined in the EPSR Act of 2005.

1. License electricity generation more than 1mW
2. License electricity distribution more than 100kW
3. License the Transmission Network Operator
4. Carry out System Operatorship
5. Trading.

A cursory inspection of the regulatory powers of the NERC as mentioned above shows that despite having oversight functions on the larger generating and distribution companies, the NERC should be actively engaged in licensing the smaller companies that have the potentials to operate at the municipal, district, and village levels (Edomah, 2016). With this licensing regime, the generating companies registered with NERC are those recognised by the NERC and considered in the power mix of the country. Research, however, has revealed that there are several power plant assets with excess capacity that are available across Nigeria, with the capacity to increase electricity availability (Edomah et al, 2016). These power generating assets are neither connected to the grid nor involved in commercial power generation. Yet, they do have the capacity to lessen the burden of electricity by providing a different incentive system for them. These assets are known as the Stranded Power Plants in Nigeria. The table below shows a few of the stranded power plants across Nigeria. There are several more which are built and operated by private entities for internal use. The table below however shows those with excess capacity that could be incorporated for public distribution.

Table 2: Power plants with excess capacity in Nigeria

S/N	**Description**	**Installed capacity**	**Used capacity**	**Excess capacity**	**Asset owner**	**Location**
1	4x14MW Steam Turbines & 3x24MW Gas Turbines	128MW	15MW	113MW	PHRC	Port Harcourt
2	4x14MW Steam Turbines	56MW	15MW	43MW	KRPC	Kaduna
3	2x30MW Gas Turbine, 1x20MW Gas Turbine & 3x15MW Steam Turbines	125MW	18MW	107MW	WRPC	Warri
4	6 x 10MW Gas Turbine	60MW	30MW	30MW	AGIP	Ebocha
5	6 x 10MW Gas Turbine	60MW	30MW	30MW	AGIP	Obite
6	3 x 10MW Gas Turbine, 1 x 10mW Solar PV, 1 x 10MW Co-generation turbine	50MW	20MW	30MW	TOTAL	Obagi

Source: Roy- Omeni (2018).

Table 3: Demand and supply of electricity in the country on the basis of the peak load demand in megawatts (MW) of the DISCOs

S/N	DISCO	Average Power Transmitted (MW)	% Transmission	Peak Load Demand (MW)	LOSS (%)
1	ABUJA	284.35	11.40	835	35
2	BENIN	235.60	9.45	100	21
3	EKO	271.99	10.91	1105	18
4	ENUGU	222.53	8.92	1017	6
5	IBADAN	329.44	13.21	1193	8
6	IKEJA	370.89	14.87	1335	18
7	JOS	135.99	5.45	507	22
8	KADUNA	197.81	7.93	520	25
9	KANO	197.81	7.93	596	40
10	PORT HARCOURT	160.72	6.45	773	-
11	YOLA	86.54	3.47	176	22
		2,493.69	**100**	**8,157**	

Source: NERC (2017).

These power plants have excess capacity, but they have not been captured or recognised by the NERC and despite their potentials as off- grid facilities that can be incorporated into the distributed generation framework they have not been used as such.

The importance of incorporating stranded power generation assets in a bid to improve the overall supply of electricity and create more functional and efficient electricity markets cannot be overemphasised. While demand for electricity in Nigeria has reached 24,500 MW, total generating capacity stands at 7,139MW leading to significant short- falls in supply. The table below depicts the demand and supply situation of electricity in the country on the basis of the peak load demand in megawatts (MW) of the DISCOs and the power transmitted to them by the GENCOs.

The utilisation of stranded power generation assets will go a long way in bridging this gap between demand and supply. The potential power represented by the stranded assets in the table above will go a long way in bolstering supply in some areas and can serve as a basis for improving the efficiency of the electricity market in Nigeria.

Roy- Omeni (2018) argues that incorporation of stranded assets into the national grid has significant benefits for the national grid and electricity markets. The author further demonstrated the workability of this by considering the licensing the Warri Refining & Petrochemical Company (WRPC) as a DGS (Distributed Generation System) Company, to provide distributed power to the Warri Metropolis at minimum cost, with minor technical changes for the interconnection of the WRPC power assets, to the Warri area network. Dedicating the WRPC DGS to the Warri area network and incorporating it into the grid (grid interactive) will improve robustness and reliability. The table below depicts electricity data for the Warri Metropolitan area;

Table 4: Electricity data for the Warri Metropolitan area

S/N	DESCRIPTION	Value
1	Per capita electricity demand for Nigeria	150kWh
2	Population of Warri	727,000
3	Base Load Energy Demand (Population x Per capita demand)	109.05mW
4	Peak Load Energy Demand (Base Load Demand x 1.4)	152.67mW
5	Average Daily Electricity supply to Warri	39.15mW
6	Supply Shortfall (Calculated Peak Demand – Actual Average Daily Supply)	113.52mW
7	Installed Generation Capacity of WRPC	125mW
8	Average Daily Demand of WRPC	18mW
9	Excess Capacity of WRPC	107mW
10	Theoretical Capacity of WRPC available for Distribution	107mW
11	Injection Station Capacity available in the Warri Metropolitan Area	35mW
12	Load Rejection from Warri to the National Grid (Injection Capacity – Total Injection)	4.15mW
13	Available Injection Capacity of WRPC	125mW
14	Total Injection Capacity Required in Warri for Electricity Availability	155mW
15	Total Number of 5mW Capacity Injection Stations required (132kVa/33kVa)	31
16	Total Number of Transmission Substation (132kVa/33kVa), 160mVa capacity required in WRPC	1
17	Potential Electric Power Injection available to Warri (Grid supply + the WRPC DGS supply)	146.15mW
18	Energy Shortfall on the Grid Interactive DGS from WRPC into the Warri Area Network	8.85mW
19	Total Potential Power from WRPC with the current injection substations within Warri	35mW

20	Excess Power available for Grid Distribution	35mW

Source: WRPC ETSD & BEDC

From the table above, it could be observed that the WRPC power assets have an excess capacity of 107MW while the Warri Metropolitan area has an estimated peak demand of 152.67MW. 39MW is allocated to the Warri Metropolitan area from the national grid which is grossly inadequate. The excess capacity of the WRPC can thus be allocated to the Warri Metro area and as such boost total supply available to this area to 146MW or 95.6% of total demand as opposed to the 25.6% of the total demand which the area is currently getting.

4. Employing the Spot, Forward and Futures Market to Incorporate Stranded Power Assets in Nigeria

Significant potentials also exist for the use of spot, forwards, and futures market to incorporate stranded power assets in the country. The incentives of pricing and the adjustments of regulations to accommodate Distributed Generation (either grid-interactive or otherwise) could be explored to incorporate output from stranded power assets. Making this work would involve a consideration of the following.

1. Each DISCO to source its power shortfalls via off-grid assets

2. Off-grid asset within a DISCO area should be pre-licensed by the DISCO as a DGS Company to distribute power to specific Load Centers using the DISCO Facilities

3. Private Power Utility Companies (Retailers) to be pre-licensed by each DISCO to serve specific districts or areas within a Local Area Network

4. DISCO to set up an Electronic Spot Market where the Power Utility Companies and the Stranded Power Companies (pre-licensed & designated by the DISCO as DGS) would sell and purchase power at the spot market price.

Deriving from the works of Burton (2016), Edomah et al (2016), and KPMG (2019), it is evident that companies with stranded power generation assets can make use of the framework described above to monetize their excess capacities by selling these to the Power Utility Companies through a Spot Market Platform created by the DISCO. In this scenario, each DISCO acts as a regional grid operator while performing its responsibilities as a Distribution Company. To achieve this, there is a need for the NERC to amend the regulations so as to incorporate these stranded assets. The MYTO 2015 shall be the prevalent pricing regime with minor adjustments to provide for the energy mix and Marginal System Costs of the DGS companies within the area of operation of the DISCO.

The incentive to monetize excess capacity of the stranded power assets within a DISCO area through the creation of the Spot Market could lead to an explosion of power assets within the entire market. Private investors with the opportunity to supply electricity to the DISCO at an incentive cost through the spot market at commercial rates would be encouraged to establish power generating plants in areas of need not covered by a DGS.

5. Conclusions

This paper has examined the Nigerian electricity markets and the potential role that can be played by the utilisation of stranded power generation assets which are scattered all over the country. A number of points succinctly summarizes this examination.

- The Nigerian electricity market is still in a rudimentary phase and tightly controlled by the NERC and as such the impact of the market forces of demand and supply is low.
- The demand for electricity is significantly more than the supply creating significant gaps that can be filled if functional electricity markets are available.
- There are stranded power generating assets with excess capacity around Nigeria. These stranded assets are not incorporated into the power infrastructure of Nigeria.
- The incorporation of these stranded power assets through regional establishment of the Electronic Spot Market and the licensing of the stranded assets as distributed generation systems alongside the downstream public utility companies, would greatly improve access to public power in Nigeria.

Based on the above, the following recommendations are hereby made. They include.

1. The Nigerian Electricity Regulatory Commission (NERC) should amend its regulations for DISCOS to source their power shortfalls through power generating assets within their area

2. DISCOs should be empowered to carry out minimal pre-licensing functions for identified Distributed Generation Systems within their area of operation.

3. DISCOs should be empowered to license down-stream Power Retailers to carry out the distribution of power to the final consumer on a district by district basis

4. DISCOs should be empowered to carry out Spot Market functions for the licensed DGS and Public Utility companies for direct trading

5. DISCOs should be given limited Grid-operating licenses to serve as regional grid operators within their areas of operation.

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