Navigating the Prevailing Challenges of the Nigerian Power Sector

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Abstract: - The Nigerian power sector continues to suffer from the resource curse. With the abundance of natural and renewable energy resources, somehow the Nigerian power sector has failed to meet the energy demand. Over the years, lack of political will and inadequate investments as regards the generation, transmission and distribution of electricity have led to very costly outages. The frequent collapse of the national grid has led to use of diesel/gasoline generators as a stop gap measure for producing electricity. However, this approach significantly increases the cost of production of goods/services (especially with the Russia-Ukraine war) and pollutes the environment/ecosystem.

The objective of this paper is to take and in-depth analysis of the problems of the Nigerian power sector beginning with the regulatory framework to the different actors of the Nigerian Electricity Supply Industry NESI (The Gas producers, The Nigerian Gas Company, The Generation Companies, The Transmission Company of Nigeria and the Distribution Companies). Our goal is to achieve a fundamental balance between the affordability, reliability and sustainability of electricity, otherwise known as the energy trilemma.

Key-Words: - Energy trilemma, Geographical Sector Coupling, GENCOs, TCN, DISCOs, NBET, NERC

Received: May 27, 2021. Revised: May 26, 2022. Accepted: June 24, 2022. Published: July 20, 2022.

1 Introduction

The deregulation of the Nigerian Power Sector did lead to the privatization of the Generation and Distribution Companies (GENCOs and DISCOs) with the Transmission Company of Nigeria (TCN) under the sole control of the Federal Government of Nigeria (FGN). The goal was to get investors who would bring in the needed investment and impetus required to fix the electricity crisis in Nigeria). However, years after the privatization of the power sector, the peak transmission capability of TCN is a poultry 5801.60MW[1]. And this, for a population of 202 million[2]. For years Nigerians in the private and public sector have had to rely on the use of diesel/gasoline generators for the production of

goods and services (despite the economic, environmental and health implications). In fact, the 2022 budget of the FGN did earmark 104 billion Naira(252 million dollars) for the purchase, maintenance and fueling of generators for ***some*** of its agencies[3]. But even this alternative to the national grid is fast becoming a non-viable solution due to the ever-growing cost of fuel. The Manufacturer's Association of Nigeria (MAN), the Broadcasting Organization of Nigeria (BON) and even the Association of Licensed Telecommunications Operators in Nigeria all lament the high operational cost of production of goods/services due to the high cost of diesel which sells for over 700 Naira per liter. And so bearing in mind the inextricable link between the socio-economic development of any country and the availability and affordability of electricity in that country[4], our goal is to take a panoramic view at the Nigerian Electricity Supply Industry and zoom in on the challenges that bedevil the electricity value chain. We would begin with the regulatory framework to the different actors of the Nigerian Electricity Supply Industry. Having identified the problems, we would then propose solutions and introduce the notion of geographical sector coupling of the grid so as to maximize the primary energy resources of the six geopolitical zones in Nigeria and hence balance the energy trilemma.

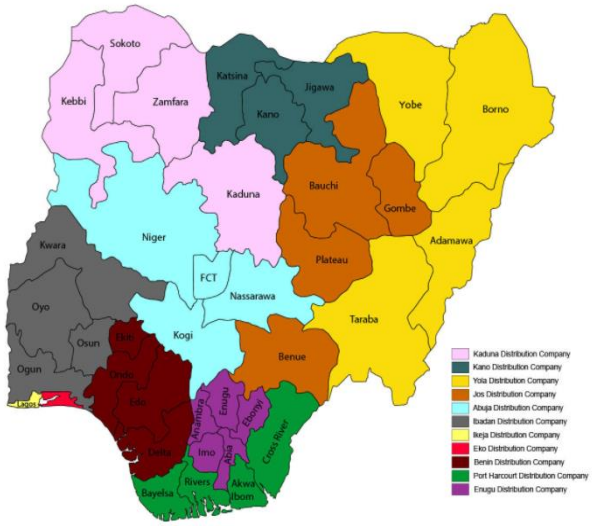


Figure 1: The Eleven DISCOs [3]

1.1 Research Methodology

We began this research with literature review of the prevailing challenges of the Nigerian Power Sector. This was followed by consultations and industrial visits of the major stakeholders of the NESI (The Gas Producers, The Gas Transporter NGC, The GENCOs, The TCN, The DISCOs & The Consumers) for the collection of data (primary & secondary data). The mix of qualitative and quantitative data was the approach used in this study.

2 Problem Formulation

Taking a zoom at the Nigerian power sector we see that the population with access to electricity is about 62%[5]. In other words, there is the need to ensure reliable, affordable, sustainable and modern energy (SDG7) for the 38% of Nigerians living without access to electricity. We also need to make sure that the 62% of Nigerians with access to electricity, do have access to uninterrupted power supply. Simply put, our task is to guarantee the seventh sustainable development goal in Africa's largest Economy. And to do this we need to take a panoramic view of the regulatory framework to the different actors of the Nigerian Electricity Supply Industry NESI(The Gas producers, The Nigerian Gas Company NGC otherwise known as the Gas transporter, The Generation Companies, The Transmission Company of Nigeria and the Distribution Companies).

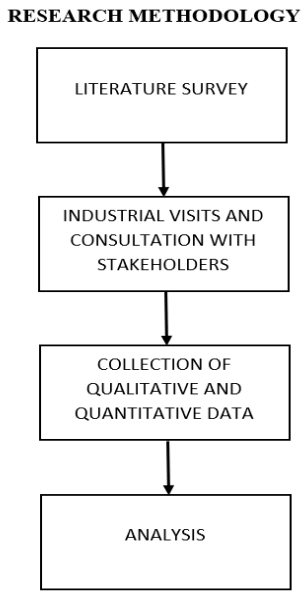


Figure 2: Research methodology

2.1 Problems as regards the regulatory framework of NESI

1) Unfortunately, the attempt at privatization which was aimed at revamping the power sector was skewed to benefit politically connected bidders and not the technically competent ones[9].

2) The fact that electricity has been on the concurrent legislative list for areas that are not covered by the National Grid. Yet private investors and state governments have not been properly incentivized to play the fundamental role of funding the power sector.

3) The huge dependence on spare part importation due to lack of local manufacturing companies capable of producing power system equipments.

4)The instability of the Nigerian naira and the problem of scarce foreign exchange needed for the purchase of equipments and spare parts. [6]

5) Complacency on the part of the GENCOs & DISCOs(who have failed to scale up their capacity to produce and distribute electricity) due to poor supervision on the part of NERC as regards the privatization contract which is supposed to be periodically reviewed.

6) Heavy dependence on gas for electricity generation.

2.2 Problems as regards the Gas producers & Transporter (NGC)

1) The gas producers, the Nigerian Gas Company and indeed the entire power sector continues to suffer from the willful vandalization of gas pipelines by vandals. This in turn leads to inadequate supply of gas to the GENCOs[6].

2) Inefficient maintenance of gas facilities and pipelines. The above sometimes leads to low gas pressure[6] and the delivery of off-spec gas to GENCOs

3) Liquidity issues as the Gas producers/transporter always receive late payments for gas supplied to the GENCOs

4) Gas flaring which leads to economic losses and environmental degradation[7]

2.3 Problems as regards the GENCOs

1) The GENCOs are also victims of the vandalization of pipelines, inefficient maintenance of gas facilities which result in the supply off-spec gas to the GENCOs. These result in inadequate generation of electricity due to gas constraints.

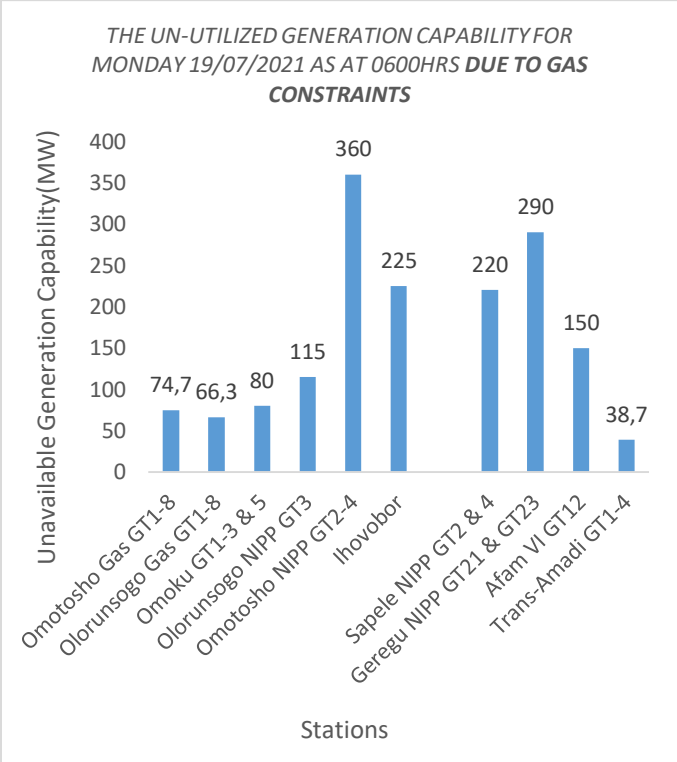


Figure 3: The un-utilized generation capability for Monday 19/07/2021 as at 0600hrs due to gas constraints[9]

2) The frequent request/order by the National Control Center to reduce the quantity of electricity produced by the GENCOs due to load rejection by the DISCOs or due to limitations of the electric grid.

3) Lack of enthusiasm on the part of GENCOs to increase or invest in their installed or available capacity owing to the constraints of both the National Grid and the distribution networks.

4) Liquidity issues owing to the late and incomplete payment of the GENCOs by the Nigerian Bulk Electricity Trading Company NBET.

5) In a bid to maximize profit, the practice of preventive maintenance is often neglected. Top management of GENCOs are often reluctant to authorize the shutting down of generating units for routine inspection schedules.

6) Huge discrepancy between the installed and available capacity in some power plants due to obsolete and dilapidated generating units in some power stations

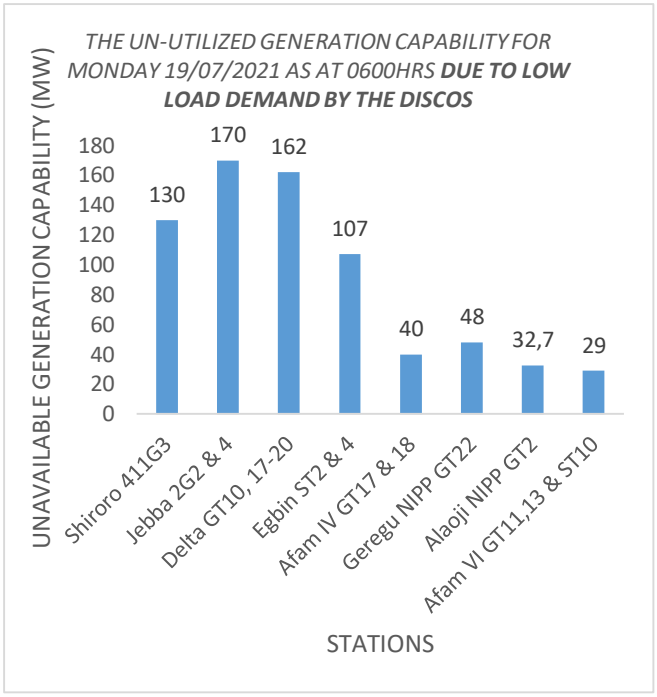


Figure 4: The un-utilized generation capability for monday 19/07/2021 as at 0600hrs due to low load demand by the discos[9]

2.4 Problems as regards the TCN

1) The inability of TCN to wheel the available capacity of the GENCOs

2) Inadequate grid coverage of Nigeria as a result of insufficient investments on transmission lines

3) High Transmission losses (47%-11%)[8]

4) Harassment and sometimes kidnapping (by locals) of TCN officials who patrol the transmission lines during intervention or inspection schedules

5) Terrain and vegetation challenges as transmission line routes go through swamps and forests with very fast regrowth

6) Earth faults as a result of vegetation challenges which sometimes cascade into system collapse

7) Willful vandalization of transmission towers

8) The use of vehicles to patrol transmission lines that go through swamps and thick forests instead of surveillance helicopters

9) Lack of stringing equipments for transmission lines

10) Frequency rise and over voltages as a result of load rejection by the DISCOs

11) Partial and total grid outage

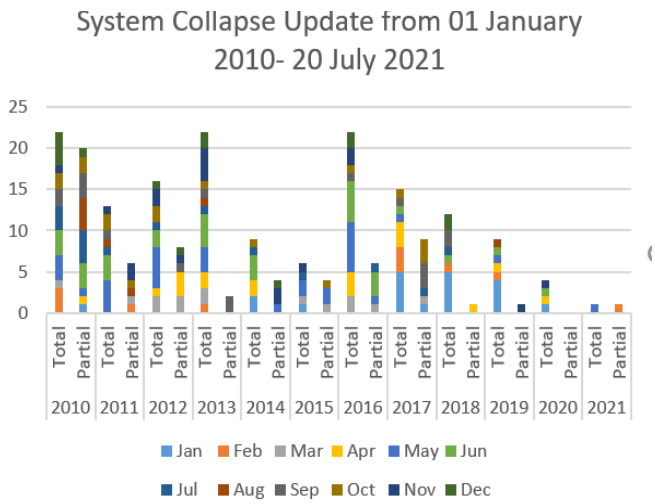


Figure 7: System Collapse Update from 01 January 2010- 20 July 2021

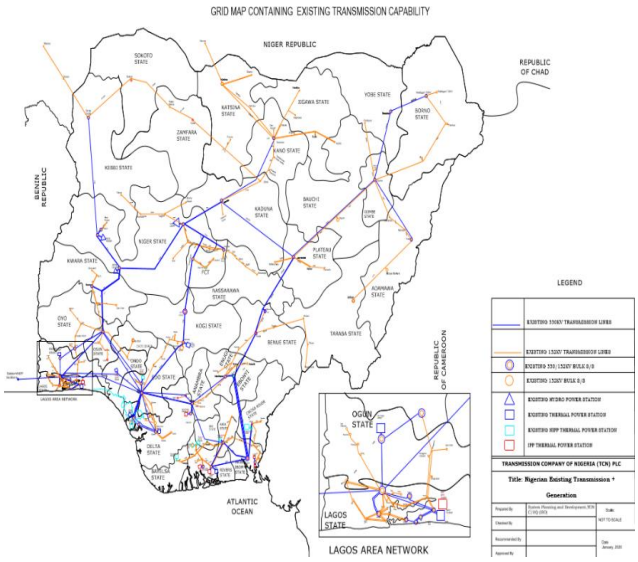


Figure 8: Transmission Capability of the Nigerian Grid

2.5 Problems as regards the DISCOs

1) Ageing and Infrastructural decay of distribution grid networks

2) Obsolete communication equipment[9]

3) Voluntary or involuntary load rejection

4) Insulation failure due to lightning strikes[10]

5) Little or no Investments in the distribution grid networks

6)Bad feeder pillars and overloaded transformers[11]

7) Substandard distribution lines[12]

8) Little or no maintenance of the distribution grid networks. Customers sometimes have to replace burnt transformers in their areas and even pay for the connection of these transformers to the distribution grid network

9) Inadequate supply of electricity to consumers and poor customer relations

10) Lack of regular training and low staff morale[9]

11) 22% Electricity theft[8]

12) Liquidity crunch challenge with poor and late remittance of funds collected (by the DISCOs) from end users to the Nigerian Bulk Electricity Trading Plc NBET[13]

13) Corruption on the part of Distribution company officials who collect electricity bills[14]

14) Neglect of economically poorer areas by the DISCOs and preference for customers who seem susceptible to pay their bills.

15) Lack of meters and estimated billing of consumers despite efforts by the national assembly to criminalize estimated billing

Table 1: Generation Profile: National Statistics[15]

Generation Profile : National Statistics	**MW**
Peak demand forecast (Connected +Suppressed load)	**28850**
Daily Available Generation	**4795.8**
All-time peak Gen. ever attained	**5801.6**
Maximum peak generation capacity to date	**7851.2**
The un-utilized generation capability for MONDAY 19/07/2021 as at 0600Hrs due to low load demand by the DISCOs	**718.7**
The un-utilized generation capability for MONDAY 19/07/2021 as at 0600Hrs due to gas constraints	**1779.1**

Table 2: Allocated load for Lagos and Abuja as at Monday 19/07/2021

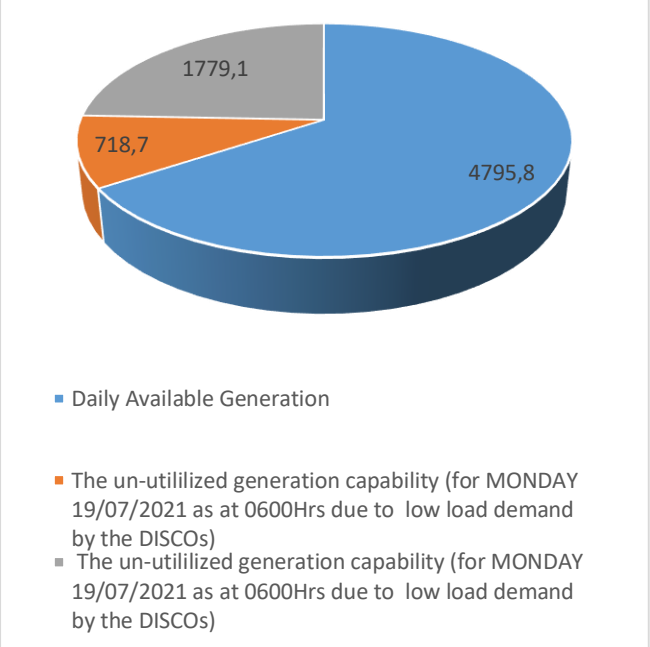
DISCO	**ALLOCATED LOAD(MW)**
Abuja	**455.50**
Ikeja	**549.55**

Table 3: Average Power Generated Vs Installed Capacity of the GENCOs(19/07/2021)

Power Station	Turbine	Average Power Generated MW	Installed Capacity MW
A.E.S	GAS	0	270
AFAM IV-V	GAS	110.88	300
AFAM VI	GAS	421.96	650
ALAOJI NIPP	GAS	194.96	504
ASC0	GAS	0	
AZURA NIPP	GAS	416.9	461
DADIN KOWA	HYDRO	34.46	39
DELTA	GAS	430.7	915
EGBIN ST1-5	STEAM	619.42	1100
EGBIN ST6	STEAM	0	220
GBARAIN NIPP	GAS	0	225
GEREGU GAS	GAS	268.6	439
GEREGU NIPP	GAS	109.57	435
IBOM	GAS	0	198
IHOVBOR NIPP	GAS	0	337.5
JEBBA	HYDRO	287.25	540
KAINJI	HYDRO	198.08	800
ODUKPANI NIPP	GAS	198.19	625
OKPAI	GAS/STEAM	176.75	480
OLORUNSOGO GAS	GAS	119.84	336
OLORUNSOGO NIPP	GAS	0	750
OMOKU	GAS	40.08	150
OMOTOSHO GAS	GAS	109.13	336.8
OMOTOSHO NIPP	GAS	0	500
PARAS ENERGY	GAS	53.35	132
RIVERS IPP	GAS	0.79	180
SAPELE	STEAM	51.02	720
SAPELE	GAS	0	300
SAPELE NIPP	GAS	56.46	500
SHIRORO	HYDRO	234.54	600
		Total=4207.27	Total=13179.3

With the bulk price of 1MWh for gas power plants being NGN29,620, it therefore means that if the gas constraint problem of 19/07/2021 did last for an hour, a day, a week or a month, the NESI would have lost NGN52,696,942.00 in one hour, NGN1,264,726,608.00 in one day, NGN8,853,086,256.00 in one week or NGN37,941,798,240.00 in a month. Furthermore, the un-utilized generation capability for Monday 19/07/2021 as at 0600Hrs (due to gas constraints and low demand by the DISCOs captured in figure 5) far out way the load allocations for Abuja Distribution Company and the IKEJA Distribution Companies as captured in table 2

Figure 9: Daily Available Generation (MW) Vs. The Un-utilized Generation (MW) for Monday 19/07/2021[9]



3 Problem Solution

The roadmap of solutions to the numerous challenges of the Nigerian Power Sector must take into cognizance the numerous problems of the different stakeholders of the power sector.

3.1 Solutions as regards the regulatory framework of NESI

1) The depoliticization of the activities of the power sector. Going forward, the practice of citing critical and key infrastructure based on the wimps and caprices of government officials should be disregarded and discarded beyond redemption. Power stations should be cited at proximity to fuel resources for obvious reasons. And likewise, Substations should be cited close identified load centers.

2) The realization of the impact of Gas flaring on electricity growth[16] and the development of policies for the maximization of gas resources

3) Proper commissioning of power plants and substations with preliminary tests on all aspects of the systems so as to identify areas of the system susceptible to fail with the goal of proffering adequate solutions to the problems.

4) The diversification of resources used in the production of electricity. Table 4 shows that 20 states of the federation are endowed with primary energy resources which could be used for onsite production and distribution of electricity.

5) The use of Service Level Agreements to deter the DISCOs from voluntary and involuntary load rejection

6) The review of the contract with the DISCOs with the goal of proffering solutions to the existing problems. The DISCOs should be ready to invest or partner with other investors to strengthen the distribution networks and perfect electricity service delivery to Nigerians.

7) The procurement of only brand-new power plants and state of the art auxiliaries and not phased out equipments from developed countries.

8) The promotion of local factories for the production of locally manufactured products and spare parts

9) The realization of the fact that electric power is on the concurrent legislative list. And as such, the federal and state governments both have fundamental roles to play both in the regulation and funding of the power sector. It is therefore of primordial importance for the different state governments to consolidate and compliment the efforts of the federal government as regards the funding of the Nigerian Power Sector.

10) The payment of huge and lingering electricity bills of government agencies[17]

11) The encouragement of rich, illustrious and philanthropic Nigerians to either invest or finance power projects in their communities' in line with the National Power System Development Master Plan.

12) The incorporation of more cogeneration technology in the Nigerian Power Sector[18] to promote energy efficiency, reduce cost and reduce GHG emission to the atmosphere

13) Review of the metering contracts to companies who have done very little to solve the electricity meter deficit in Nigeria. The Meter Asset Providers and the National Mass Metering Program put in place by the government should be strengthened to meet their objective not just on paper but on the field. It would also be of tremendous help to engage more companies with licenses of no objection for metering to help in the supply of meters to the DISCOs in order to end the era of arbitrary or estimated billing.

14) A reorientation of investors who engage in diesel/gasoline generator importation to Solar PV generators[4] to accelerate the decarbonization of the Nigerian economy and boost the rural electrification project by the Rural Electrification Agency

15) The Nigerian Electricity Regulatory Commission should be unbiased in its role, effective, efficient and corruption-free, while maintaining its independence[16]

3.2 Solutions as regards the Gas producers & Transporter(NGC)

1) Onward location of power plants at proximity to fuel resources to avoid the supplementary cost of building and maintaining lengthy pipelines, pigging stations and compressor stations.

2) To reduce drastically the risk of pipeline vandalization

3) To guarantee the delivery of dry gas

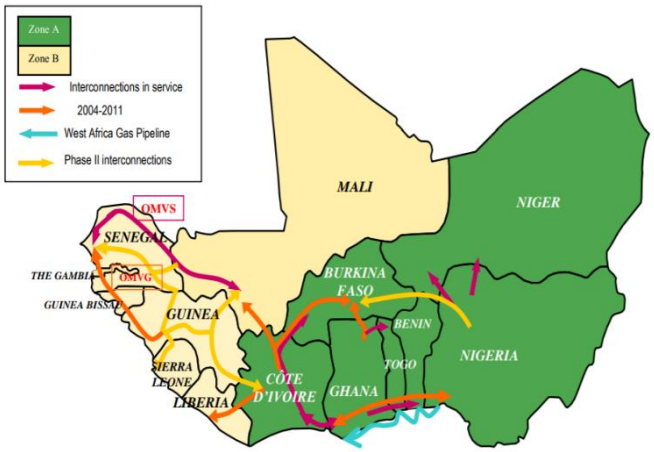


Figure 10: West African Power Pool Zones A & B

The importance of reducing the production cost of gas cannot be over emphasized as it translates into cheaper rate of bulk electricity generation, more dividends for shareholders, bonus to the staff, more profit retention which could be used for the expansion of the gas sector thereby creating employment and great industrial prospects for the economy.

3.3 Solutions as regards the GENCOs

1) Gas contracts between the GENCOs, the gas producers and transporters would help guarantee reliable access to dry or consumer- grade natural gas and help address the problem of late payments of gas supplied to the GENCOs

2) The encouragement of the DISCOs to partner with the GENCOs for onsite production and distribution of electricity as an alternate route to the grid in order to avoid stranded generation (the drop load or go down order of "X"MW by NCC as a result of TCN grid constraints). This would definitely reduce the cost of building transmission lines

3) The encouragement of the eligible customer regime and not its reversal especially in regions where the DISCOs reject load. The reversal of the eligible customer regime could push industries to captive generation of electricity instead of returning to the status quo ante bellum of poor service delivery by the DISCOs. Culminating in a loss of revenue for the entire Nigerian Electricity Supply Industry.

4) The encouragement of the West African Power Pool project with the goal of promoting and developing infrastructure for power generation and transmission. And to ensure the coordination of electric power exchange between the member states of ECOWAS.

5) The practice of proactive and responsive strategies of maintenances by the GENCOs. The importance of proactive and responsive maintenance cannot be overemphasized as this will help bridge the huge gap between the installed and available capacities of some GENCOs (see table 3)

3.4 Solutions as regards TCN

1) Investments to build new transmission lines, strengthen the existing transmission grid network and to ensure adequate coverage of the Nigerian nation. With the exponential growth of the Nigerian population, the Siemens Electricity roadmap should be one among the numerous investment projects to light up the Nigerian economy.

2) Massive sensitization campaigns against the harassment of TCN officials who patrol the transmission lines during intervention or inspection schedules

3)Removal of trees from transmission line paths to avoid earth faults which could cascade into system collapse.

4) The use of FACTS for voltage improvement and transmission loss reduction[19]

5) Massive sensitization campaigns against the willful vandalization of transmission towers

6) The use of surveillance helicopters to patrol transmission lines that go through swamps and thick forests

7) The swift procurement of spare parts for planned replacement of equipments

3.5 Solutions as regards the DISCOs

1) Adequate funding of distribution grid networks to build and strengthen existing networks in order to end the reign of voluntary or involuntary load rejection.

2) The practice of proactive and responsive maintenances strategies to ensure reliable supply of electricity to consumers. This would bring to a halt the practice of customers having to replace burnt transformers and pay for their reconnection to the distribution grid.

3) The implementation of the Nigerian Electricity Regulatory Commission Electricity Theft and Other Related Regulations, 2014

4) The provision of prepaid meters at affordable prices for customers to end the regime of poor and late remittance of funds collected (by the DISCOs) from end users to the Nigerian Bulk Electricity Trading Plc NBET

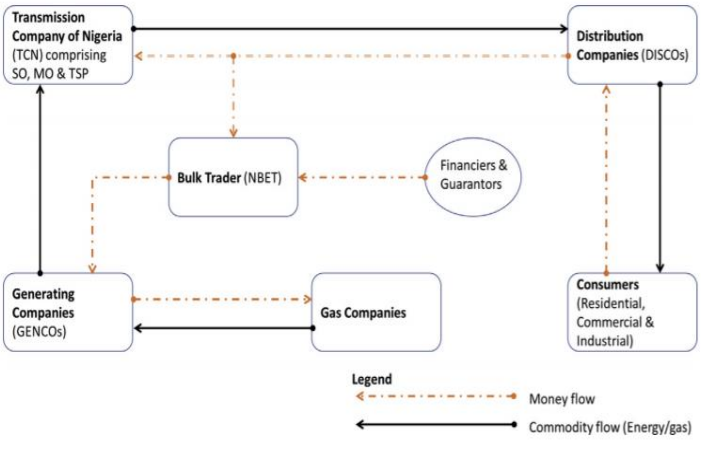


Figure 11: Transitional electricity market structure of the Nigerian Electricity Supply Industry [20]

4 Discussion

Implementing the solutions listed above would no doubt require colossal investments (private public partnerships) in the power sector. According to the world bank, it would take about $100 billion over the next ten years to solve Nigeria's electricity quagmire (Generation, Transmission and Distribution)[20]. Also, successive governments have shown little or no political will to solve the electricity crisis. Most Ministers of power assume office and spend their 4-year tenure trying to understand the problems that plague the power sector while setting out to do very little to solve the issues. And the cycle continues with every regime. This paper proffers a step by step approach using geographical system coupling for the resolution of the problems in the Nigerian power sector. The notion of geographical sector coupling in this paper refers to the use of primary sources of energy in each geopolitical zone for the onsite production and distribution of electricity in that zone/region with a point of common coupling to the national grid. Table 4 shows the six geo-political zones with the primary energy resources of the region. Once the problem of electricity is solved in a state using its primary energy resources for onsite production and distribution of electricity with a point of common coupling to the national grid, it would be much easier to replicate the concept to the other states and geopolitical zones of the country and even beyond.

Table 4: Primary Energy Resources in the Six Geopolitical Zones

Primary Energy Resource	Geo-political zone	State
Hydro	North East	Adamawa(kiri Dam)
Hydro	North East	Gombe (Dadin Kowa Dam)
Coal	North East	Bauchi
Hydro	North West	Kaduna (Shiroro Dam)
Coal	North West	Zamfara
Hydro	North Central	Niger (Jebba)
Hydro	North Central	Niger (Kainji)
Coal	North Central	Benue
Coal	North Central	Plateau
Hydro	South West	Ogun (Kainji)
Hydro	South West	Oyo (Ikere Gorge)
Oil/Gas	South West	Ondo
Coal	South West	Ondo
Oil/Gas	South East	Abia
Coal	South East	Enugu
Oil/Gas	South East	Imo
Oil/Gas	South South	Akwa Ibom
Oil/Gas	South South	Bayelsa
Oil/Gas	South South	Cross River
Oil/Gas	South South	Delta
Oil/Gas	South South	Edo
Oil/Gas	South South	Rivers

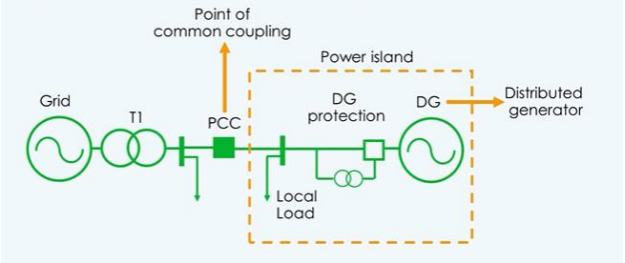


Figure 12: Distributed Generation with PCC

5 Conclusion

The above present a formidable strategy and road map to solving the prevailing challenges of the Nigerian power sector, but we must remember that culture will always eat strategy for breakfast as Peter Drucker would say. And as such, developing values in tandem with the execution of the salient points mentioned above is of inestimable importance. The different stakeholders of the electricity value chain must resolve earnestly to change the tide and give reliable service delivery to Nigerians.

It is imperative to note that with abundance of human and natural resources, Nigeria has both the potential of becoming an electricity sufficient nation and the capacity of gaining foreign exchange from the sale of electricity to other African countries. However, this would only be a reality if adequate policies, regulations and funding are put in place as regards all the stakeholders bearing in mind their individual challenges.

References:

[1] "Transmission Company of Nigeria." [Online]. Available: https://www.tcn.org.ng/blog_post_sidebar110.php. [Accessed: 14-Aug-2021].

[2] "Nigeria Overview." [Online]. Available: https://www.worldbank.org/en/country/nigeria/overview. [Accessed: 14-Aug-2021].

[3] "FG budgets N104bn to maintain, purchase generators in 2022." [Online]. Available: https://punchng.com/fg-budgets-n104bn-to-maintain-purchase-generators-in-2022/. [Accessed: 03-May-2022].

[4] E. A. Obar, A. Touati, and N. Rabbah, "Embedded Generation Using Shared Solar," vol. 01026, pp. 1–7, 2021.

[5] "• Nigeria: electricity access, by area 2019 | Statista." [Online]. Available: https://www.statista.com/statistics/1119633/s

hare-of-households-without-electricity-access-in-nigeria-by-area/. [Accessed: 10-Jul-2022].

[6] I. O. Joseph, "Issues and challenges in the Privatized Power Sector in Nigeria," *J. Sustain. Dev. Stud.*, vol. 6, no. 1, pp. 161–174, 2014.

[7] O. B. Adewuyi, M. K. Kiptoo, A. F. Afolayan, T. Amara, O. I. Alawode, and T. Senjyu, "Challenges and prospects of Nigeria's sustainable energy transition with lessons from other countries' experiences," *Energy Reports*, vol. 6, pp. 993–1009, 2020, doi: 10.1016/j.egyr.2020.04.022.

[8] P. Roy, K. C. Iwuamadi, and J. Ibrahim, "Breaking the cycle of corruption in Nigeria's electricity sector: a political settlements analysis," *ACE SOAS Consort.*, vol. 020, pp. 1–19, 2020.

[9] A. S. Sambo, B. Garba, I. H. Zarma, and M. M. Gaji, "Electricity generation and the present challenges in the Nigerian power sector.," ... *Energy Power ...*, pp. 1–17, 2012.

[10] C. A. Awosope, *Nigeria Electricity Industry : Issues , Challenges and Solutions*, vol. 3, no. 2. 2014.

[11] H. O. E. and T. O. E. U.P. Onochie, "The Nigeria Electric Power Sector (Opportunities and Challenges)," *J. Multidiscip. Eng. Sci. Technol.*, vol. 2, no. 4, pp. 494–502, 2015.

[12] E. State, D. U. Onyishi, and O. Ejofodomi, "The effect of transmission and distribution losses on daily electricity supply in," vol. 2, no. 1, pp. 60–68, 2021, doi: 10.47524/tjst.21.8.

[13] PWC, "Solving the Liquidity Crunch in the Nigerian Power Sector4," 2019.

[14] A. H. Sule, "Major Factors affecting electricity generation, transmission, and distribution in Nigeria," *Int. J. Eng. Math. Intell.*, vol. 1, no. 1 & 3, pp. 159–164, 2010.

[15] TCN-NCC, "Daily Operational report," *Niger. Electr. Syst. Oper.*, 2021.

[16] O. Adekomaya, T. Jamiru, R. Sadiku, Z. Huan, and M. Sulaiman, "Gas flaring and its impact on electricity generation in Nigeria," *J. Nat. Gas Sci. Eng.*, vol. 29, pp. 1–6, 2016, doi: 10.1016/j.jngse.2015.12.042.

[17] K. Oladipo, A. A. Felix, O. Bango, O. Chukwuemeka, and F. Olawale, "Power Sector Reform in Nigeria: Challenges and Solutions," *IOP Conf. Ser. Mater. Sci. Eng.*, vol. 413, no. 1, pp. 1–13, 2018, doi: 10.1088/1757-899X/413/1/012037.

[18] O. P. Oshevire and F. O. Odiase, "Challenges of Incorporating Co-Generation Technology in Nigeria Power System," vol. 2, no. 4, 2013.

[19] A. Zoppi *et al.*, "C Urrent T Herapeutic R Esearch," vol. 60, no. 3, pp. 26–41, 1999.

[20] "As Nigeria Grapples with Blackouts, W'Bank Says $100bn Needed to Solve Erratic Power Supply – THISDAYLIVE." [Online]. Available: https://www.thisdaylive.com/index.php/2022/06/16/as-nigeria-grapples-with-blackouts-wbank-says-100bn-needed-to-solve-erratic-power-supply/. [Accessed: 10-Jul-2022].

Contribution of individual authors to the creation of a scientific article (ghostwriting policy)

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