

The Nigerian Electricity Conundrum: Unknotting the Transmission System for Sustainable Power Industry

By

Engr Dr Wilson Alli, PhD MBA REng FNSE

CEO/Lead Consultant Zaapton Energy Company/Zaapton Consulting Limited

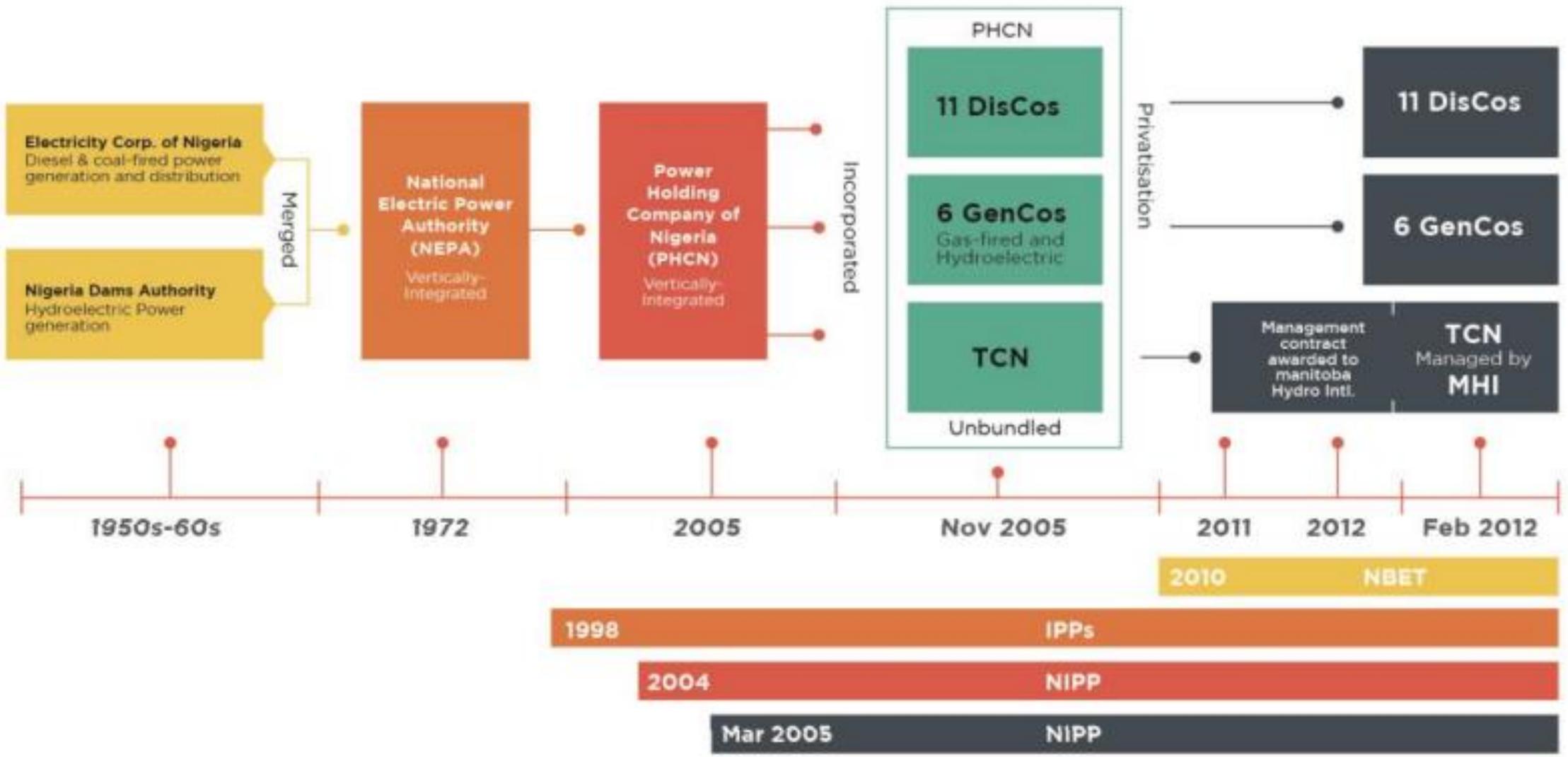
**A 'discussion' with the Fellows of the Nigerian Institution of Electrical and Electronics Engineers(NIEEE) on her
Monthly Webinar
delivered on July 30, 2021**

Content

- Introduction
- Status of the Nigeria Power System (GRID)
- Where the Nigeria Power System Ought to be Today
- The Status of the Electrical Power Transmission system
- Unknotting The Transmission System
- Sustainability of the Transmission Capability of the Grid
- Sustainability of the Nigeria Power System
- Bibliography
- Questions and Answers

Introduction

The Nigeria power system is saddled with inadequate gas supply for her thermal plants, stemming from pipeline vandalization and illiquidity, fluctuating water heads of the Hydro Dams, rendering only about 3.8GW available power generation capacity from the 12.5GW installed capacity. The entire chain is bugged by serial system collapses, arising from frequency fluctuation, voltage, and rotor angle collapses or deviations with an overall operational capacity of 3.88GW from the 5.3GW transmission system capacity meant to serve about 210m Nigerians. Undoubtedly, Nigeria is grouped among the lowest per capita (136KW/h) electricity usage globally, Libya is about 4,270KW/h, India, 616KW/h, and South Africa 2,803Kw/h.



This is perhaps the only country where its power technocrats will play politics and see nothing wrong in citing substations to underpopulated or underused areas, leaving densely populated areas in darkness, a place where her citizens see nothing wrong in vandalizing the gas pipeline, and transmission assets, and the government appointing a round peg in a square hole for ethnic or religious balancing instead of competences.

This is one place where realities are shied away from.

How did we get here?

How do we get out of the shackles?

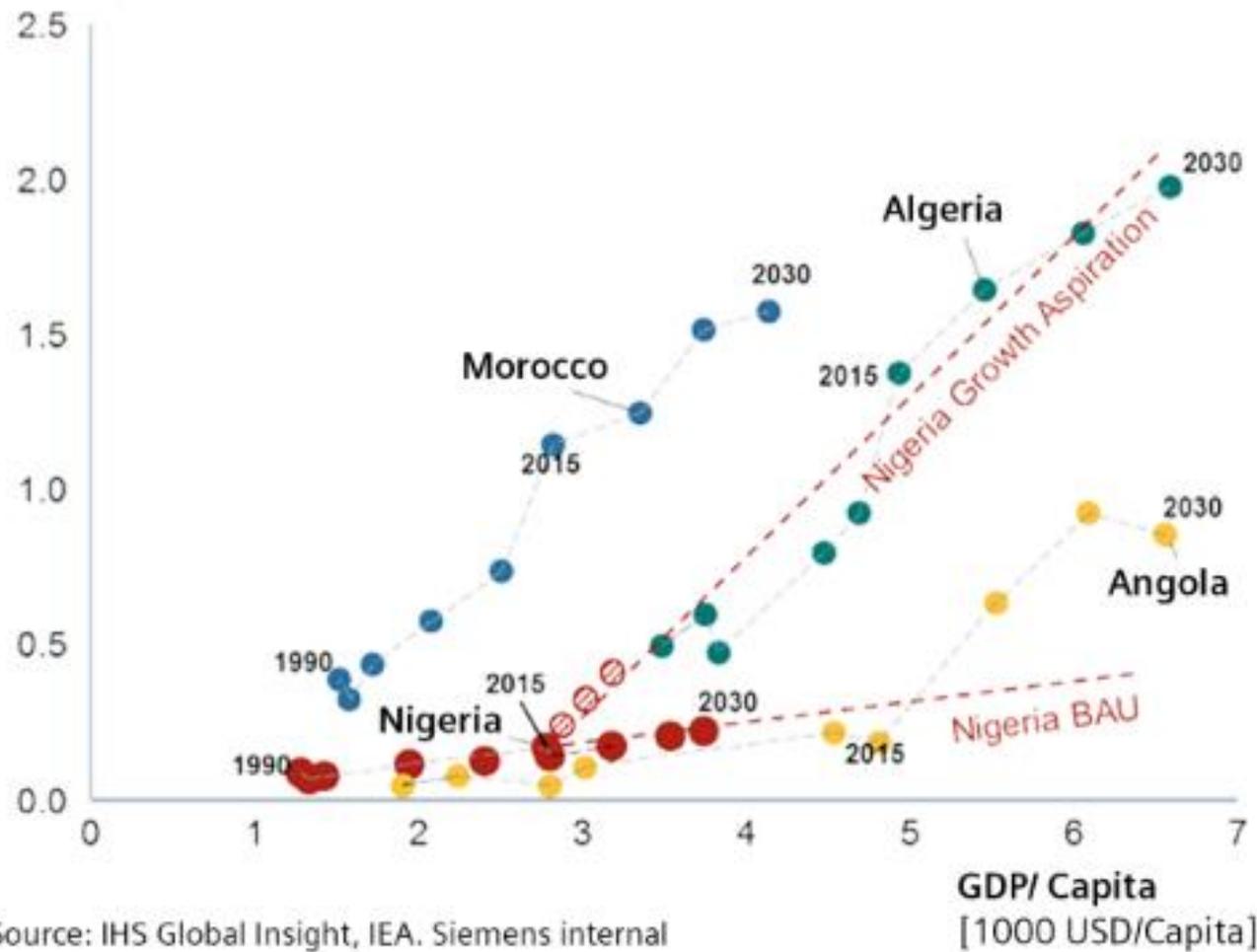
In a place where the will to do the right thing is lacking?

Certainly, we are Nigerians we must solve these problems and rise to be who we are meant to be.

Status of the Nigeria Power System (GRID)

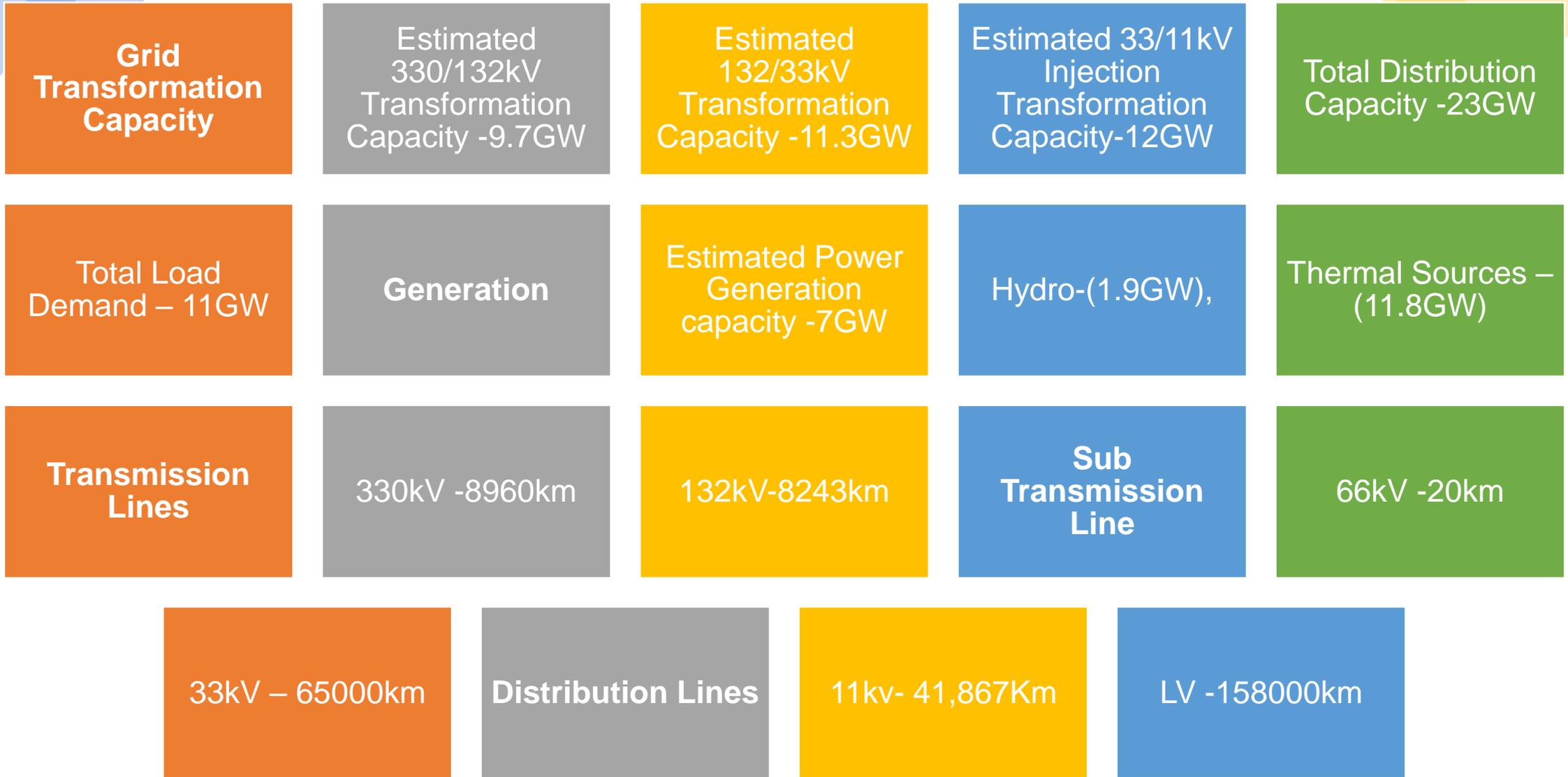
- The Nigeria Electrical Grid is about 164yrs old, 12 years away from the UK National Grid. Whose presently installed capacity is 75.8GW with 7.5% losses for 67.22m people and an economy of 2.708T USD, while that of Nigeria is estimated at 12.5GW with about 40% losses for an estimated population of 200m people for a 432.3B USD.
- It is ironic that about 164 years after electricity was birthed in Nigeria, the country is still grappling with under 5GW generation capacity. The 2016 World Bank statistics on population and electricity access indicate that 40.7% of the Nigerian population is not connected to the national electricity grid
- Power supply poses a severe problem for those connected as about 90% of total power demand is not met. Also, about 60% of the population relies on self-generation to meet their power needs
- Studies have shown that up to 27.7% of the load is rejected at the distribution level to exacerbate the already bad situation. This means that some classes of customers are constantly and deliberately under-served for reasons other than grid-associated problems.

Electricity Consumption / Capita [MWh/Cap]



Source: IHS Global Insight, IEA. Siemens internal

The Status of the Electrical Power Transmission system



The Nigerian Power System Structure

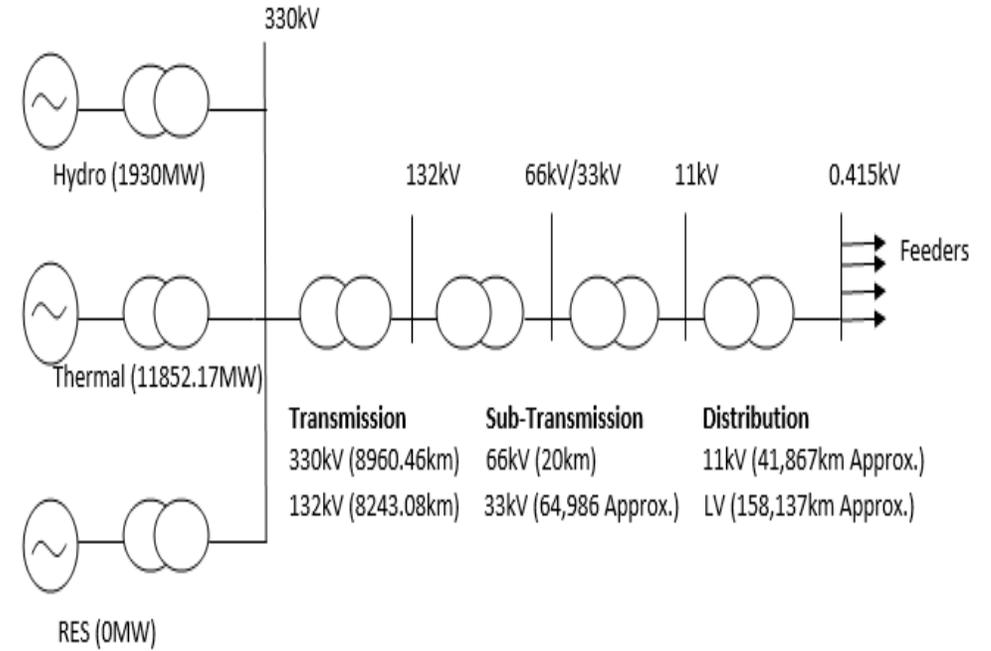
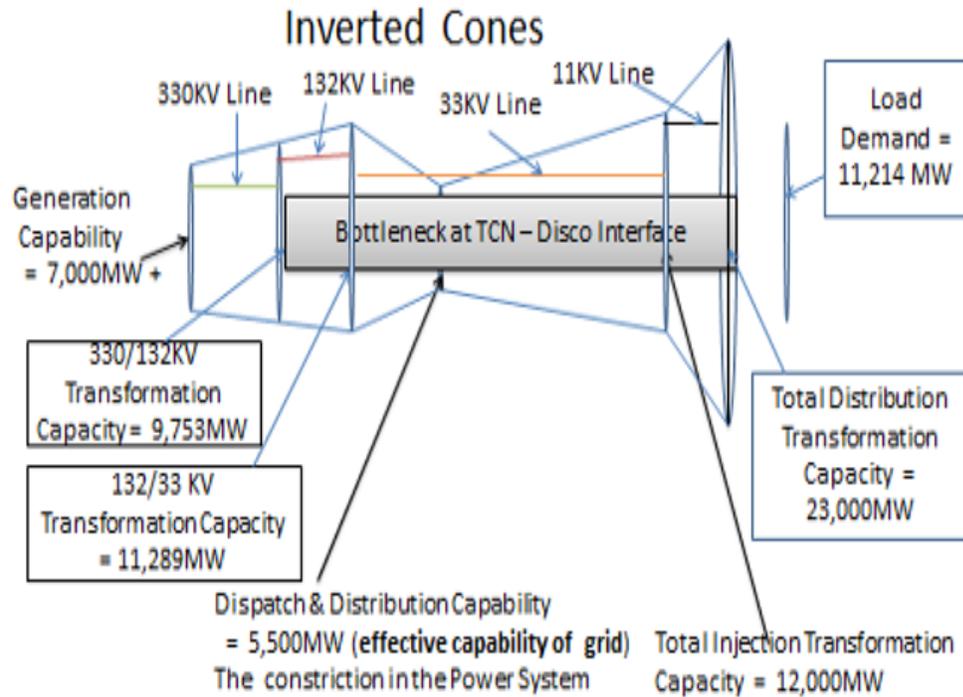


Fig. 1: Nigerian Grid Network Generation Mix and Lines Length Statistics.

- 
- A key issue identified in Nigeria's Electricity Supply Industry is the lack of effective integration in infrastructure development across the entire electricity supply value chain, from fuel supply to power distribution.
 - These issues include an insufficient gas delivery system, inadequate and obsolete generation facilities, and wrong, poorly maintained, and unmatched transmission and distribution networks
 - Several initiatives and concerted efforts were designed earlier to address the Nigeria Electricity Supply Industry (NESI).
 - However, proper network studies did not precede the efforts to guarantee a data-driven implementation and enhanced service delivery. Therefore, the outcome of the enormous investments remained marginal compared to existing deficits and [targets](#).
 - To bridge the infrastructure gaps and enhance the effectiveness of service delivery in the NESI, a data-driven and innovative intervention is needed to improve baseline power supply through an all-inclusive network study package and grid solutions.
- 

Where the Nigeria Power System Ought to be Today

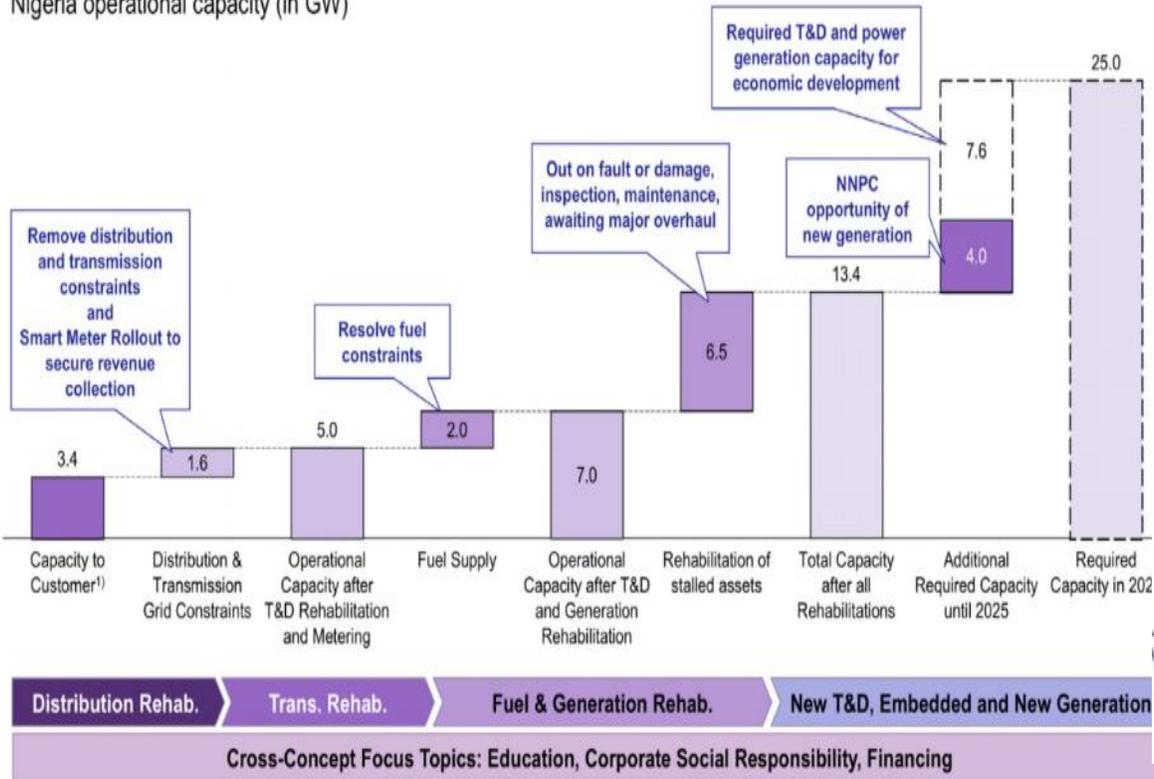
Specifically, the desired Technical Intervention would deploy the result of well-coordinated network studies to improve

- baseline power supply,
- enhance the transmission wheeling capacity
- increase redundancies,
- reinforce the distribution network,
- enhance grid design and electricity demand estimation.

Coordinated network studies and power system planning will result in a definite power cone, as shown in figure 2 below, ensuring the transfer of more than 11GW to serve the current load demand.

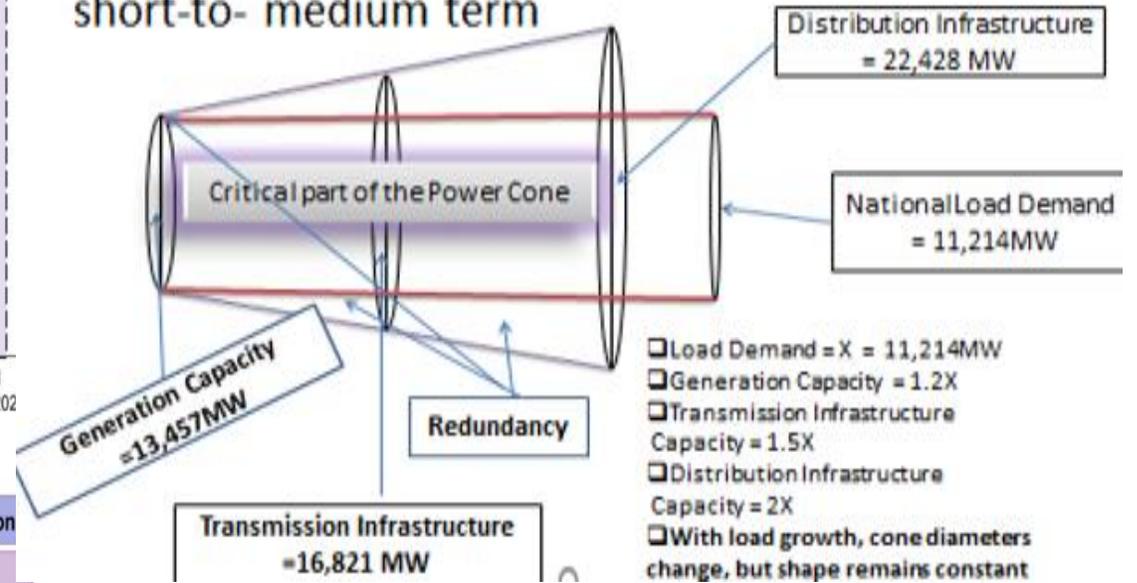


Nigeria operational capacity (in GW)



Source (as of March 19, 2017): NESO (Nigeria Electricity System Operator) daily operational report; TCN (Transmission company of Nigeria) daily operational report.

The Desired Power Cone Structure, for the short-to- medium term



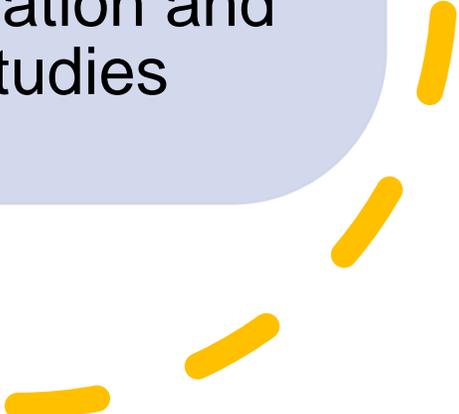
Unknotting The Transmission System

To address the power supply issues that will result in the appropriate power cone;

- the Nigerian government must embark on an intervention initiative, designed as a fit-for-purpose innovative program that aimed to leverage the outcome of a detailed network study of the national electricity grid. The Outcome would enable the implementation of identified generation, transmission, and distribution projects to effectively bridge identified infrastructure gaps for the phased power delivery, and this will hopefully result in improved reliability, security, and efficiency in the Nigerian power system.



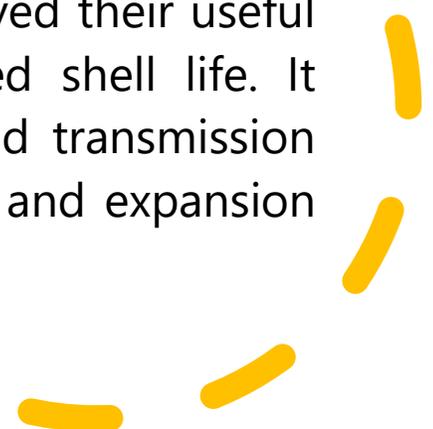
Systematic and sustained Load Demand Studies(LDS) that would cascade into the analysis of network infrastructure gaps. The following studies suffice

- Load Flow and Demand Studies
 - Grid Gap Analyses
 - Power Quality Studies
 - Optimal Power Flow & Economic Dispatch
 - System Reliability Studies
 - ATC, TTC, and TRM Evaluations
 - System Coordination and Securitization Studies
- 

The table below provides the summary of this sub-concept 'Resolving Transmission bottlenecks'.

Status	Challenge	Proposed solution	Benefit	Next step
<ul style="list-style-type: none">High ATC&C losses	<ul style="list-style-type: none">Improve quality and efficiency	<ul style="list-style-type: none">Upgrade with high voltage product, system and solutions	<ul style="list-style-type: none">Reduce ATC&C lossesSafe and reliable transmission of electricity	<ul style="list-style-type: none">Potential pilot substations: Oko Oba, Epe, and EPZ (Free Trade Zone).

The Transmission System is bugged by aging, dilapidated, and discredited infrastructure and most of these types of equipment have served their useful life span of 25years, and the lines exceeded the prescribed shell life. It becomes imperative therefore to have holistic equipment and transmission lines renewal programs along the planned network upgrades and expansion programs. The renewal will mitigate system instability.



The Presidential Power Initiative (PPI) was conceived during a meeting between the Presidents of the Federal Republic of Nigeria, Muhammadu Buhari and German Chancellor, Angela Merkel on August 31, 2018.

- The PPI aims to rehabilitate and expand the nation's generation, transmission, and distribution systems to meet future power needs.
- The project spans three phases with the ultimate objective of delivering 25GW to electricity consumers across Nigeria by 2025. The PPI will deliver much needed electricity needs and drive growth and expansion of Nigeria's economy.

Smart Metering system for end customers and all metered entities to ensure revenue security (pilot DISCOs before a national rollout).

Resolving distribution and transmission bottlenecks: +1.6 GW (INTERFACE)

Additional small-scale power generation to support the T&D grid (

Rehabilitation of power generation: +6.5 GW

Resolve fuel supply (gas) constraints: +2.0 GW

Additional NNPC power generation (central and northern regions): +4 GW

Additional power generation to support economic growth ambitions: +7.6 GW

Increasing Redundancies in the network (T-Lines/SS Equipment)

•Most Transmission lines are radial, not double circuits, so we have limited redundancies in the system hence the increased system instability.

Transformation capacity:

•There is also the compulsive need to build the network transformation capacity to have the same n-1, and n-2 contingencies in our equipment such as transformers, Circuit Breakers, etc., this shall afford us enough flexibility in our operations, this will reduce system collapse to a minimum.



Redundancy of T- Lines/SS Equipment:

•Embark on massive construction of new DC transmission lines in areas where load exists and where we have a lot of generators to enable evacuation of this power rather than it being stranded.

Creation of Transmission lines

Backbone: To reduce system collapse we need to develop new Transmission lines in the form of a backbone utilizing the 330KV DC Quad conductor's transmission lines right around the country as a ring. This is important because it will help evacuate all the stranded generators as well as new ones that are constructed.

Creation of Islands:

- Another way to stem the incessant grid collapse is by creating operational islands, this will enable the separation of the faulty circuits from the healthy ones by opening the island breakers. Therefore, we can deploy at least three islands which we can get by carrying out a critical study on the grid. If we have a plan to construct these lines and ensure the funds are made available, we will see that the grid will be very stable and robust i.e., n-2 and n-3 for a robust grid. All the power plants that are developed, and connected shall be evacuated by the grid to load centres



Deployment of the right compensation Equipment:

- This is another way of reducing system collapse. You find out that some transmission substations are hubs where so many circuits meet like Benin, Ikot Ekpene, Jos, and IkejaWest. Therefore, very high voltages are experienced, so we need to install the proper size of shunt reactors to help us bring this voltage down to the acceptable operating voltage which is +5% and -15% for 330kV, and +-10% for 132kV. The same applies to boosting the voltage up at the end of a long-distance lightly loaded line whose receiving end voltage is below the operational voltage, so we deploy a good capacitor bank to improve the voltage.

Equipment Auditing:

- We need to carry out quarterly equipment auditing in our substation as well as our transmission lines and accessories.

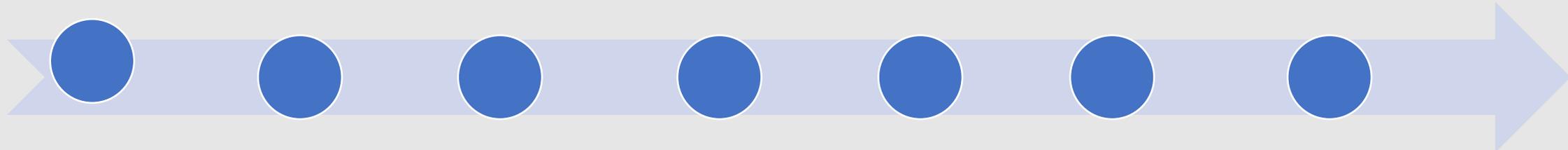
Developing new double circuit lines:

- Instead of re-conducting, we can develop a new Double circuit line, utilizing the same Right of Way (ROW) for the 330kV transmission lines.

Sustained Training and retraining of technical staff are very important.

Enhancing Protection Interface:

Transmission needs to have a good protection interface protocol with distribution and meet regularly with them to analyze the faults and protection coordination of the relays.



Re-Conducting of T-Lines: We need to look into existing radial circuits that are critical, meaning that some radial circuits shall be attended to too quickly. we may reconductor with a new higher different conductor if it is a sub-transmission line such as Gap Conductors (GTZACSR, and GTACSR).

Grid discipline:
•This is in line with the discipline in operating the grid. The ethics of operating the grid needs to be practiced. Also, operational and maintenance staff should be encouraged and trained to maintain and operate these transmission facilities for optimum electricity delivery.

Regional SCADA/EMS Development:
•Completion and deployment of SCADA and EMS systems for both operation, maintenance, and communication are very key.

Sustainability of the Transmission Capability of the Grid

The Grid problem is predicated on the resolution of three key factors which could either be a blessing or a curse. An earlier discourse on these factors above posited them as a malaise, but in another twist could be leveraged to turn things around.

- Technical
- Political
- Social

Resolution of the technical problems without weaning the system off politics will still bring the whole industry to its knee. The social aspect could be addressed if the government decides to embark on a massive awareness program to educate the population about the ills of destroying critical infrastructure especially power infrastructure, the foundation of economic prosperity. Incidentally, no one will solve these power issues for us but us. A deliberate effort at growing our grid from its present state of mere existence to availability to reliability and finally to resilience grid system must be embarked upon. This requires a massive commitment of resources and is driven by Nigerians who are driven by legacies.

Sustainability of the Nigeria Power System

Attaining the transmission system sustainability is sustaining is critical to sustaining the entire Nigeria Power system and this can be attained through the following steps

- Unbundling the Transmission Company of Nigeria into its component – TSP, ISO, and IMO. With the government retaining TSP 100%, Privatizing the ISO under the PPP scheme, full privatization of IMO with TCN, ISO and GECOS, NDPHC, and DisCos as Stakeholders who will appoint the Board
- Commercializing NDPHC with a similar business framework as NLNG, to be able to build power plants, transmission lines, distribution infrastructures, etc.
- Strengthen regulations, Regulators to enable enforcement of grid discipline(NERC, NEMSA)
- Continual and sustained integrated planning, load/demand Studies
- Regional grid System with SCADA/EMS System
- Centralized Power Infrastructure Data Centre
- Streamlining the Power agencies in the country

Bibliography

- Achinanya, U., Alli, W., Osunkwo, G, Obi, S (2022) A proposal for the grid Optimisation program. A technical proposal (2022)
- Agberagba, V and Jose-Adelaja, K (2022) Energy problem in Nigeria-Is renewable energy way out? A paper presentation at IPECON 2022
- Alli, W (2020) Unbundling TCN: The imperatives of leveraging PPP in entrenching grid availability, reliability, and resilient power system. A technical presentation to NIMechE monthly series
- Alli, W (2022) The Nigeria power system collapse conundrum: A technical perspective. A LinkedIn publication series
- Alli, W. (2020) Reconfiguring the Nigerian power system for improved service delivery. An NSE Apapa monthly technical presentation
- Inugonum, T (2022) Practical solution to reduce grid collapse in Nigeria. A Presentation on NIPE Monthly Symposium Series
- Odubiyi, A. (2021) Leveraging the synergy between Transmission Company of Nigeria and distribution companies for increased and sustained power availability in Nigeria: Issues and solution (2021). A Presentation on NIPE Monthly Symposium Series
- Oyedele, I (2021) electrification of Nigeria is a sine qua non to building a great, industrialized, and safe nation. 15th DEEEAL distinguished electrical & Electronics Engineer Annual Lecture
- Oyedele, I (2022) Nigeria electricity power industry in crisis: Separating 'undue' politics from power. A keynote address at IPECON 2022
- Siemens (2019) Electrification roadmap for Nigeria: Technical and Commercial Proposal. Siemens. Abuja
- Siemens Energy (n.d) Electrification Roadmap for Nigeria: Siemens Energy's value proposition supports and reliable and affordable power supply. Siemens Energy. Abuja



Questions & Answers

Thank you
all for
Listening

NAGODE

Natick

Grazie

Danke

Ευχαριστίες

Dalu

Thank You

Köszönöm

Tack

Спасибо

Dank

Gracias

谢谢

Merci

Seé

ありがとう

شكرا

E SE PUPO

EDERIM

Obrigado