SMART GRID AND INDUSTRIAL POWER SYSTEMS

Shaibu Ibrahim, PE, PMP
IEEE IAS Presentation | August 1, 2026, 4:00 am CST

Nigerian Power Grid, How it all started

- ➢ Lagos Marina, 1896, approximately 60 kW
- ➢ Generating units: **two 30 kW generators**
- ➢ Output: approximately **1,000 V**
- ➢ Frequency: **80 cycles per second (80 Hz)**
- ➢ Phase configuration: **single-phase**
- ➢ Principal use: lighting
- ➢ Customers: Government House, a hospital and early streetlights around Lagos Marina

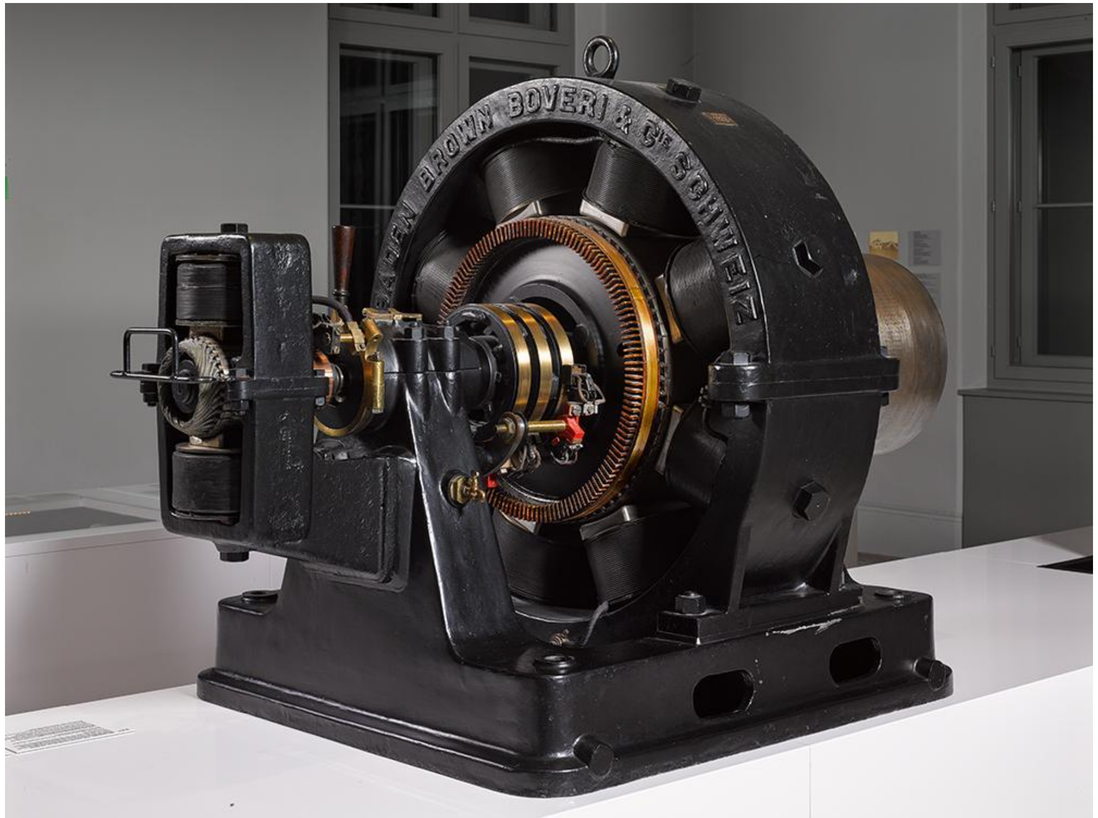

Image source: blog.nationalmuseum

NOTE: This is just for illustration and not a representation of the actual 30 kW generators used in the 1896

Progressed from 1923 …

- Ijora Power Station, commissioned in 1923.
- By the colonial Public Works Department.
- Thermal power generation
- Coal-fired steam plant
- Two generating units of approximately 10 MW each
- Initial plant capacity of approximately 20 MW

Image source: youandnigeriaelectricity.com

Thinking openly …

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Nigeria has substantial energy resources and industrial potential, yet many businesses still depend on self-generation.

What would a truly smart Nigerian grid be like or intend to

solve first?

Nigeria's power challenge is larger than generation

Where we are today …

13,625 MW

installed grid-connected capacity

4,286 MW

average available for dispatch

31%

plant availability factor

The gap is not one problem.

- Availability and fuel constraints
- Transmission and distribution bottlenecks
- Limited visibility, metering and automation
- Commercial losses and weak operational coordination
- Industrial exposure to outages and poor power quality

Installed capacity alone does not equal dependable supply.

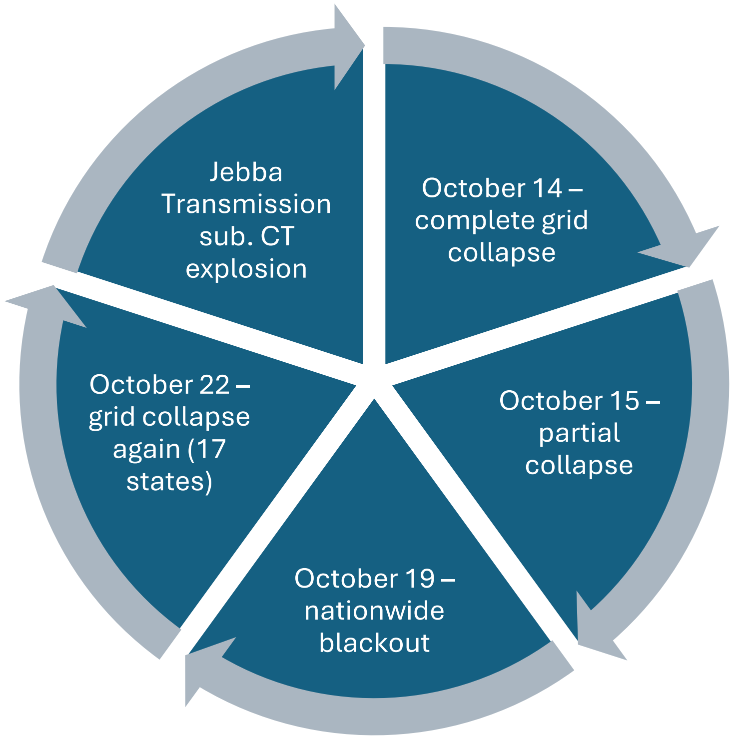
Source: Nigerian Electricity Regulatory Commission, Operational Performance Factsheet, April 2026: https://nerc.gov.ng/resource-category/operational-performance-factsheet/

But why the regular blackouts?

Image source: Legit.ng

Examples of nationwide power disruptions

2024 – the “Black October”



Back-to-back collapses

- December 29, 2025
- January 23, 2026
- Nationwide blackouts/disturbances
- These among many others reveal many challenges that the grid is currently facing

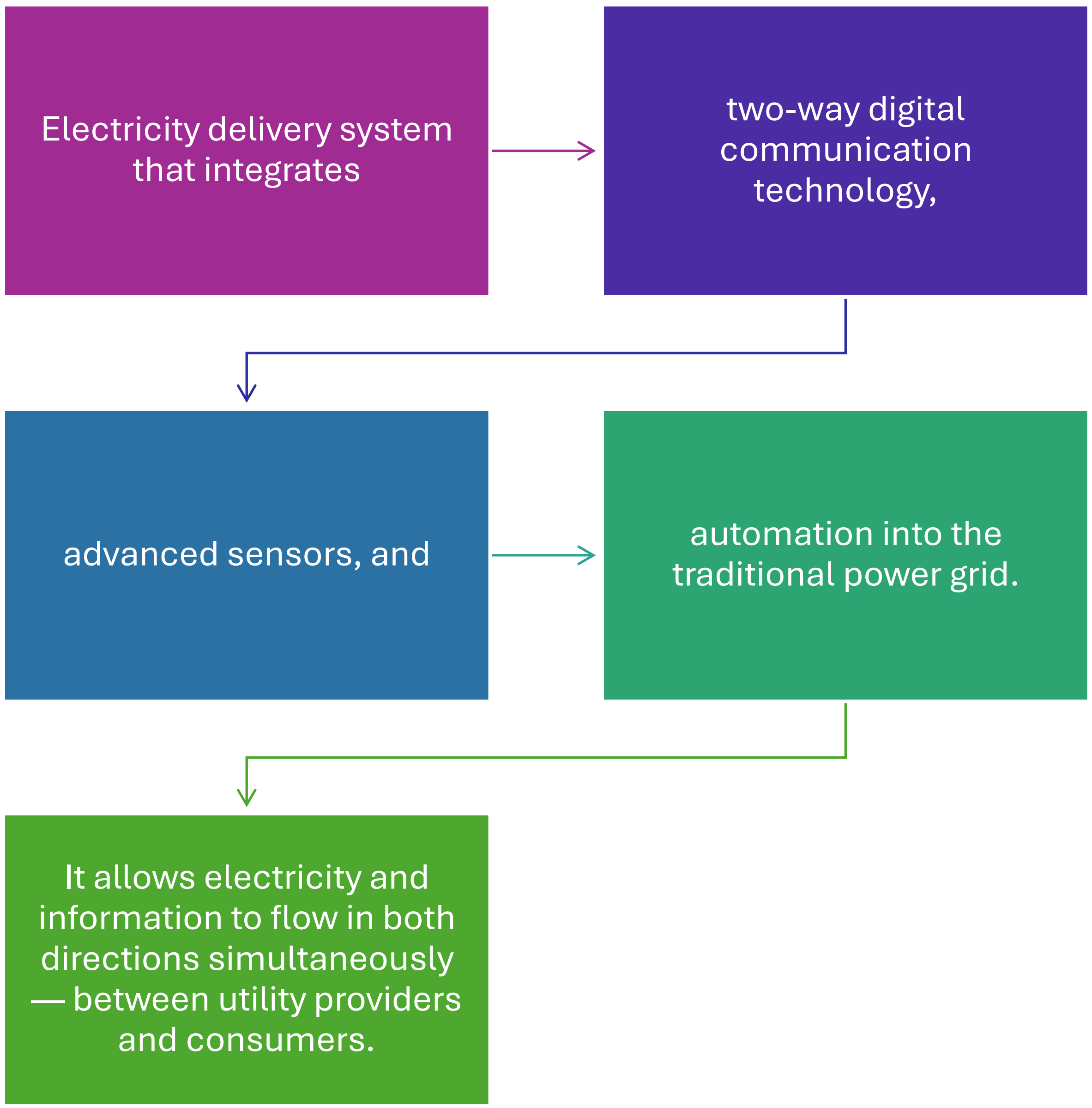
- But what is the solution?

Economic ambition becoming unrealistic …

Nigeria’s goal of a $1 trillion economy by 2030 will be illusional without a reliable and affordable electricity supply

Estimated outage cost of $29 billion/year (World bank)

What is a smart grid?



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Traditional Grid versus Smart Grid

Traditional Grid

Coms flow one way, utility to consumer	Electromechanical meters; manual reading; estimated billing common
operators have little real-time awareness of grid state	Fault detection after failure
Manual switching of feeders or restoration	Grid collapse is higher due to cascading impacts

Smart Grid

- Two-way coms. utility to consumer in real time
- AMI smart meters; automatic remote read
- Full real-time visibility via SCADA, PMUs, and sensors across the networking; actual consumption billed
- Detects fault in real-time
- Only affected zone isolated. Automated switching
- Reduce risk of collapse. PMUs detect cascade conditions early. Load shedding automated

A smart grid connects electricity, information and control

1

ELECTRICITY

Power plants, substations, feeders, industrial loads

2

INFORMATION

Meters, sensors, communications, data acquisition

3

CONTROL

Protection, automation, optimization, markets

A conventional grid delivers energy. Now it’s not enough
A smart grid knows exactly operational data and can respond dependably with coordinated action.

The Nigerian grid must evolve from reactive to anticipatory. This is common in most developing nations

	TODAY		SMARTER FUTURE
Power flow	Mostly one-way	→	**Increasingly bidirectional**
Operations	Manual and reactive	→	**Automated and predictive**
Customer	Passive consumer	→	**Flexible consumer or prosumer**
Outages	Reported and patrolled	→	**Detected, isolated and restored**
Planning	Periodic snapshots	→	**Continuous data-informed decisions**

Transition is will be progressive. Many power networks will remain hybrid or manual in some locations and highly automated in others. The goal is to place intelligence where it produces measurable value.

Improvements: Nigeria’s market is becoming more decentralized

GENERATION **GenCos • IPPs**	›	**TRANSMISSION** **TCN • SO**	›	**DISTRIBUTION** **DisCos**	›	**CUSTOMERS** **Industry • homes**	›	**DISTRIBUTED** **Mini-grids • DER**

Electricity Act 2023

States can regulate intrastate electricity markets—creating room for local generation, embedded networks, industrial clusters and new investment models.

16 states transitioned by July 2026

Five constraints define Nigeria’s smart-grid priorities

01	**VISIBILITY**	Incomplete metering, asset records and network models
02	**RELIABILITY**	Outages, constrained equipment and slow restoration
03	**POWER QUALITY**	Voltage variation, harmonics and weak reactive support
04	**COMMERCIAL**	Losses, billing disputes and poor energy accounting
05	**COORDINATION**	Grid, state markets, utilities and distributed resources

Question for you …

- Which power constraint do you see most often in your everyday experience in Nigeria?

Smart-grid capability is built in layers

SECURITY + GOVERNANCE	Identity > access > standards > data ownership
MARKETS + ANALYTICS	Forecasting • tariffs • asset intelligence
CONTROL	SCADA • EMS • DMS • relays • microgrid controller
COMMUNICATION	Fiber • cellular • radio • protocols
MEASUREMENT	Smart meters • PMUs • IEDs • sensors
PHYSICAL GRID	Plants • lines • substations • feeders • loads • DER

The physical grid remains the foundation. If conductors are overloaded, switchgear is unreliable, or protection studies are outdated, software cannot make the network safe.

Smart metering is the foundation; not the finish line

55.4%

of active registered customers metered
by September 2025

A prepaid meter may only manage payment; AMI provides two-way communications and operational data.

Customer trust is as important as technology

AMI enables

- Remote readings and outage awareness
- Tamper detection and load profiles
- Voltage-quality monitoring
- Time-based pricing and demand response

Remote disconnection and reconnection capabilities

But value depends on

- Feeder and transformer metering
- Clean customer data and reliable communications infrastructure
- Meter-data management and transparent billing

Source: Report, metering status as of September 30, 2025

Automation turns outage response into a controlled sequence

1

DETECT

Protection relays, sensors or meters identify abnormal conditions

→

2

LOCATE

SCADA/DMS estimates the faulted section

→

3

ISOLATE

Circuit breakers/reclosers or switches trip the fault

→

4

RESTORE

Healthy sections should remain or are re-energized safely

Automation must be backed by accurate protection settings, maintained switchgear and dependable communications.

FLISR—fault location, isolation and service restoration. A feeder trips at 2 a.m. Automation does not eliminate field crews; it gives them better information and reduces the area left without supply.

Distributed energy can strengthen or complicate the grid

VALUE

- Supply underserved locations
- Reduce diesel dependence
- Support industrial clusters
- Improve resilience and flexibility
- Defer selected network upgrades

ENGINEERING CHALLENGES

- Reverse power flow and voltage rise
- Protection miscoordination
- Islanding and resynchronization
- Harmonics and inverter behavior
- Forecasting and dispatch uncertainty

Nigeria's DARES program targets improved electricity access for more than 17 million people through distributed renewable energy.

The smart-grid opportunity is to make these systems measurable, interoperable and able to coordinate with distribution networks where they interconnect.

Connection is not enough

Industry needs quality and continuity of supply

OUTAGE	Lost production • restart time
VOLTAGE Sag	Drives, PLCs and contactors may trip
HARMONICS	Heating • nuisance trips • capacitor stress
UNBALANCE	Motor heating and reduced torque
Poor Power Factor	Higher current, losses and capacity use

Key industries like Cement, food processing, steel, oil and gas, fertilizer, mining, data centers and cold storage.

A short disturbance can stop a process whose recovery takes hours

Reliable industrial power is an economic-development capability.

AN INDUSTRIAL MICROGRID

Coordinate every source around the production process

- Utility grid
- Solar PV
- Battery storage
- Gas or standby generation
- Critical and flexible loads

The microgrid controller chooses and coordinates resources while protection systems maintain safety. During grid loss, critical processes may island while noncritical loads are shed.

One controller. Many operating modes.

OPERATING MODES

A microgrid’s value changes with the operating condition

NORMAL GRID

Optimize energy cost
and power factor

GRID DISTURBANCE

Ride through or transfer
without unsafe
paralleling

ISLANDED

Balance generation and
load;
protect critical
processes

RESTORATION

Resynchronize and
return
to economic dispatch

The design priority is stable, selective and safe operation, not simply minimizing electricity cost.

Load-generation balance, spinning reserve or fast storage, grounding configuration, protection settings, synchronism check and black-start strategy.

Industrial flexibility can become a grid resource

Flexible when safe

- Water pumping
- Cold storage
- Compressors
- HVAC and thermal storage
- Battery charging
- Selected batch processes

Never compromise

- Personnel safety
- Critical process continuity
- Product quality
- Environmental compliance
- Equipment operating limits

An industrial participant must define which loads can move, for how long, and under what production constraints.

ASSET MANAGEMENT

Condition data can move maintenance ahead of failure

TIME-BASED → **CONDITION-BASED** → **PREDICTIVE**

TRANSFORMERS

- Temperature
- Dissolved gases
- Moisture ingress

MOTORS

- Current signature
- Vibration
- Temperature

SWITCHGEAR

- Operations
- Contact wear
- Partial discharge

BATTERIES

- State of charge
- Health
- Temperature

condition monitoring creates the data foundation, engineering rules create context, and analytics help prioritize inspections and maintenance.

AI improves decisions only when sensors, records and engineering assumptions are trustworthy.

PROTECTION ENGINEERING

Smarter grids create new protection conditions

Bidirectional power	→	Directional elements and coordination review
Changing fault levels	→	Multiple settings or adaptive logic
Inverter-based resources	→	Limited and controlled fault current
Intentional islanding	→	Grounding, anti-islanding and transfer trip
Reconnection	→	Synchronism check and controlled restoration

Short-circuit studies, coordination, arc-flash implications, relay setting groups and inverter behavior

Cybersecurity is now part of power-system reliability

THREATS

- Stolen or shared credentials
- Unpatched relays, PLCs and RTUs
- Ransomware and remote-access abuse
- False data and communications failure
- Vendor and supply-chain exposure

ENGINEERING CONTROLS

- Separate operational and business networks
- Role-based access and secure remote gateways
- Asset inventory and vulnerability management
- Monitoring, backups and incident exercises
- Local/manual fallback for critical functions

An insecure smart grid can be less reliable than a simpler grid.
A loss of communications must lead to a safe operating state.

IMPLEMENTATION ROADMAP: KEY RECOMMENDATION

Nigeria can modernize in four disciplined phases

1

MAKE IT VISIBLE

- Metering
- asset records
- network models
- power quality

2

MAKE IT CONTROLLABLE

- SCADA
- feeder automation
- protection
- outage management

3

MAKE IT FLEXIBLE

- Storage
- Microgrids
- DER
- demand response
- forecasting

4

MAKE IT INTELLIGENT

- Predictive maintenance
- Optimization
- dynamic operations

Start with measurable operational problems

Visibility comes first because every later capability depends on trusted data. Pilots should be designed for replication, not as isolated demonstrations.

KEY RECOMMENDATIONS

Five choices can accelerate useful smart-grid investment

1. **Prioritize visibility before advanced intelligence**
2. Anchor projects around productive industrial demand
3. Link grid modernization with industrial policy
4. Require interoperability and build local capability
5. Design safety, maintenance and cybersecurity from day one

DISCUSSION

Where should Nigeria’s smart-grid journey begin?

Advanced metering	Distribution automation	Industrial microgrids
Grid-scale storage	Cybersecurity + skills	

Questions & Answers

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