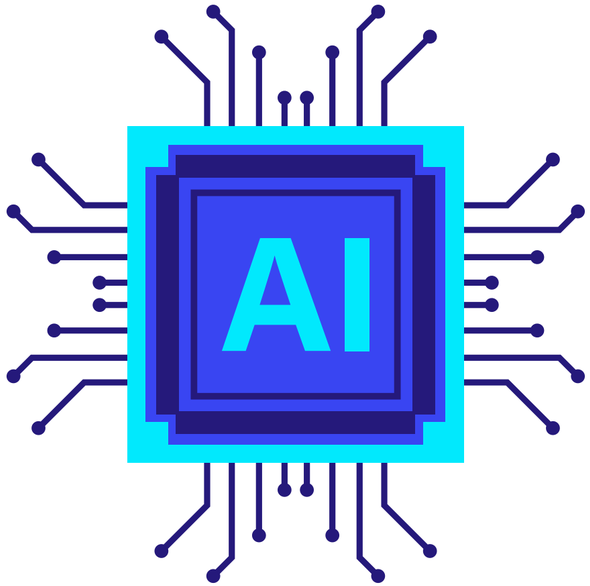
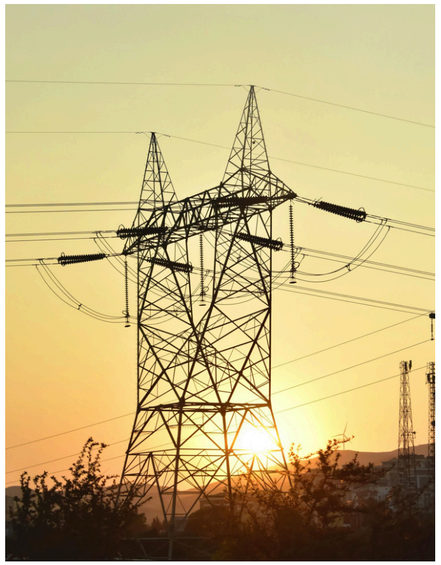
Leveraging AI for Power Grid Infrastructure Modernization





According to the Merriam-Webster dictionary,
modern = up to date

Presented by: Shaibu Ibrahim PE, PMP, NABCEP PVIP, LEED GA

SCAN QR : True or False Questions

1

Most of today's power grids were designed over 50 years ago and were not built to handle renewable energy or electric vehicles

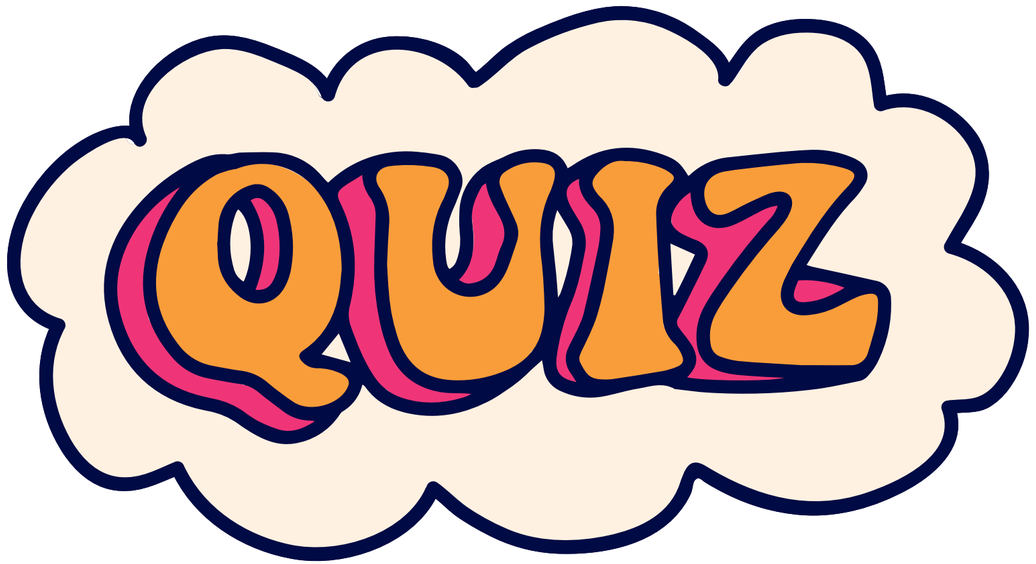
True

False

Submit

Incorrect

Let’s look at the answers on the next page



1

Most of today’s power grids were designed over 50 years ago and were not built to handle renewable energy or electric vehicles

Shaibu Ibrahim PE, PMP, NABCEP PVIP, LEED GA

- True ✓
- False

Incorrect

2

Artificial Intelligence can already predict power outages before they happen — in some countries, it’s being used to prevent storm-related failures.

Shaibu Ibrahim PE, PMP, NABCEP PVIP, LEED GA

True

False

3

India’s power system is fully automated and does not require AI to improve reliability.

Shaibu Ibrahim PE, PMP, NABCEP PVIP, LEED GA

True

False

Submit

Incorrect

4

Cyberattacks are now considered a bigger threat to modern power grids than physical storms.

Shaibu Ibrahim PE, PMP, NABCEP PVIP, LEED GA

- True ✓
- False

5

AI is only useful for predicting electricity demand, not for managing physical infrastructure like transformers or transmission lines.

Shaibu Ibrahim PE, PMP, NABCEP PVIP, LEED GA

True

False

Submit

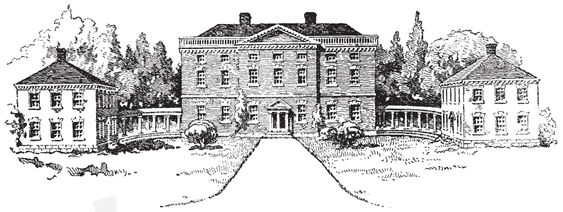
Over a century

Where it all start

First hydro-station in India **130 kW** in Sidrabong in 1897

Served

Governor House



Burdwan Palace

Tea Estates

Source: ieeemilestones.ethw.org

First thermal station in India, a **1,000 kW** in Emambagh in 1899

(the year of light)

Used for

Thermal power plant

Street lighting

Residential

Office buildings

Source: ethw.org

United State Power Grid

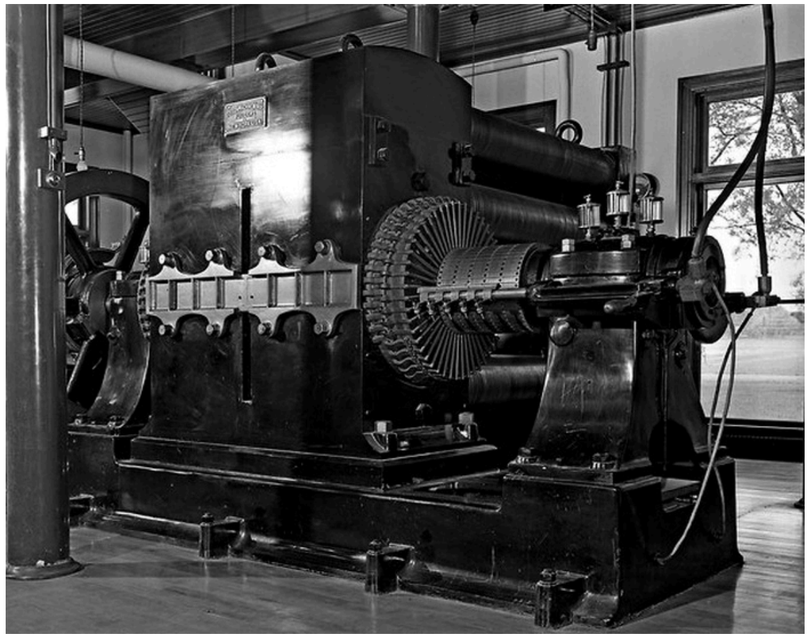


image: Jean C Antonelli on Pinterest

Pearl Street Station
in 1882

served

started with six
100 kW dynamos

Less technology
Less know how
... less access

59 customers, **800** lamps

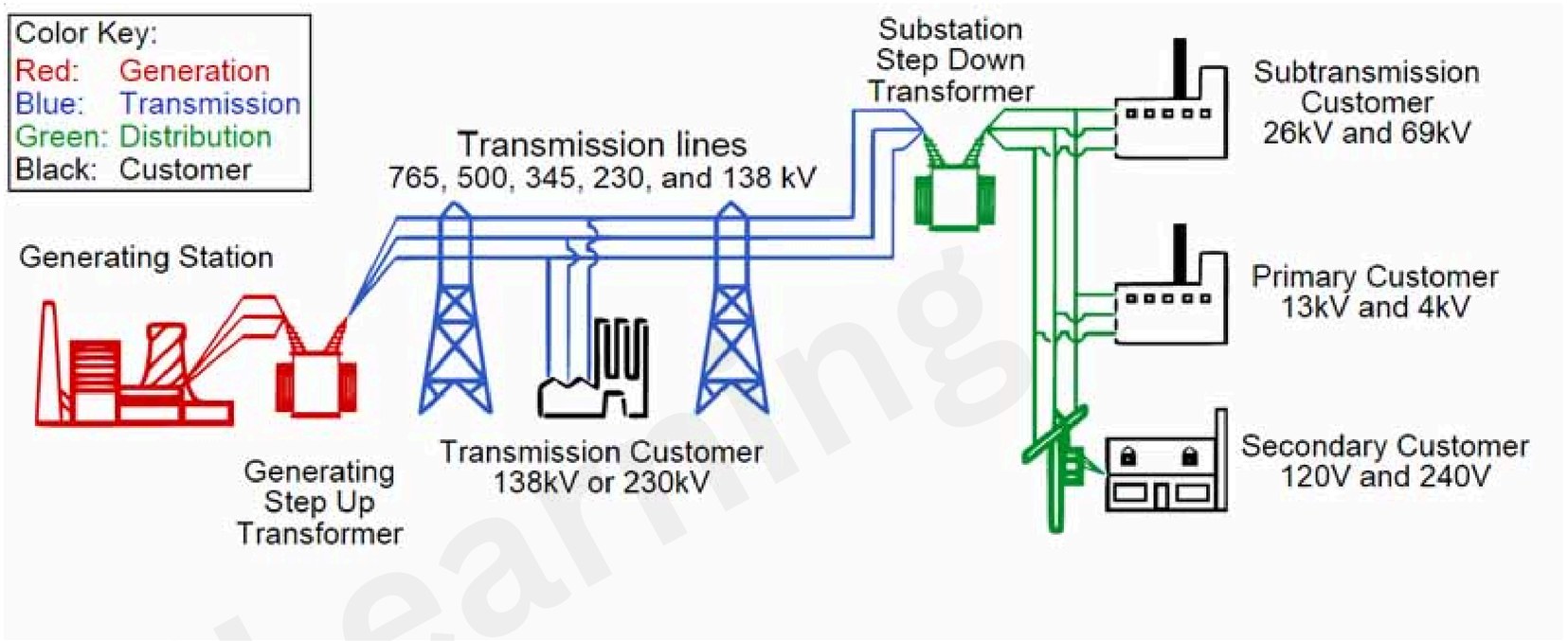
first
MONTH

first
YEAR

over **500** customers

What to expect after this webinar

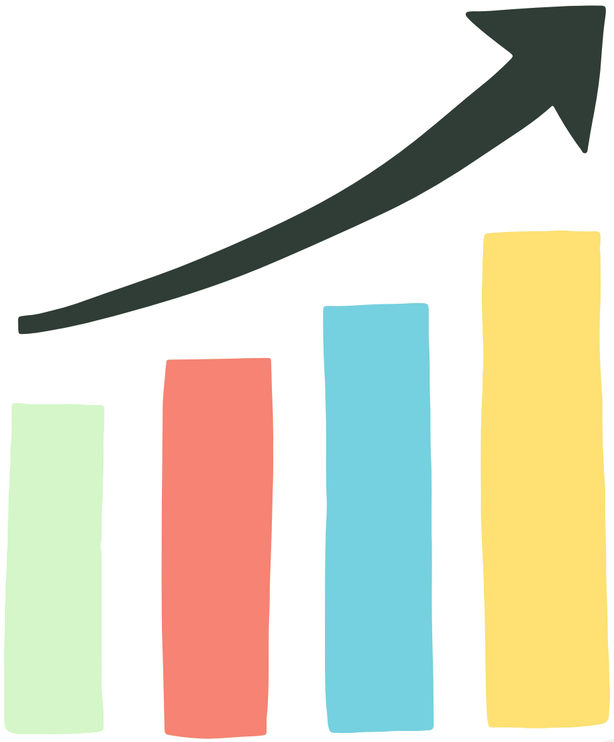
Understand how AI will shape the industry:



- **Generation**
- **Transmission**
- **Distribution**
- **Customer**
- **Today's Grid**
- **Challenges for modernization?**
- **Potential benefits of AI in the grid modernization**
- **Critical parameters for modernization?**

Today's Grid

India has made significant progress



As of June 2025, 485,000,000 kW Grid

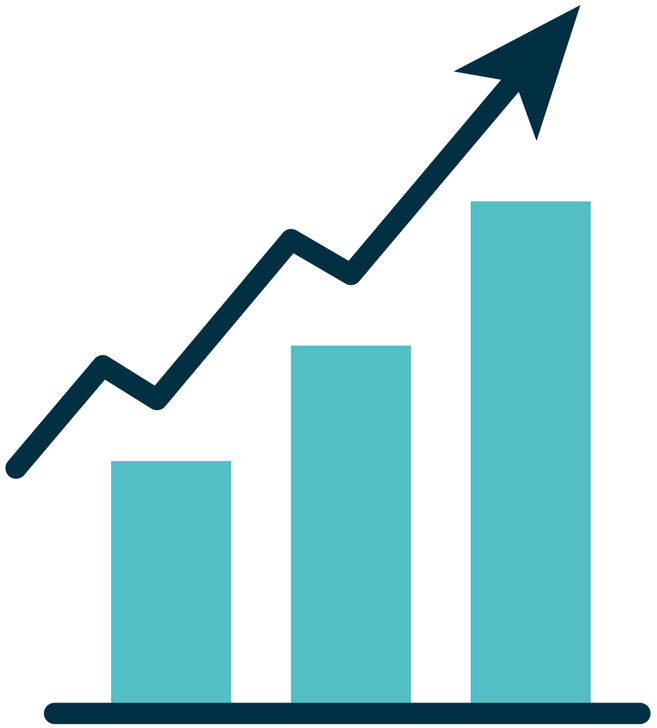
Exponential growth & built an infrastructure capable of handling 485 GW

Serving not only …

offices, palaces, residential or the tea estate but

Serving the 5rd largest economy in the world (world data)

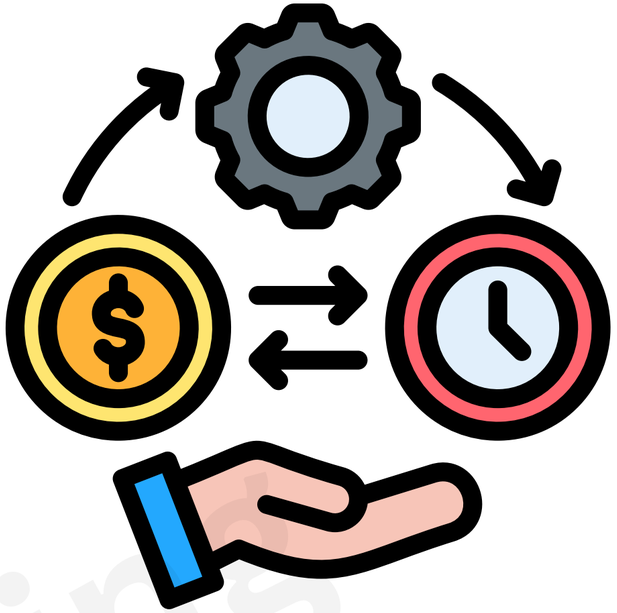
United Stated has achieved enormous

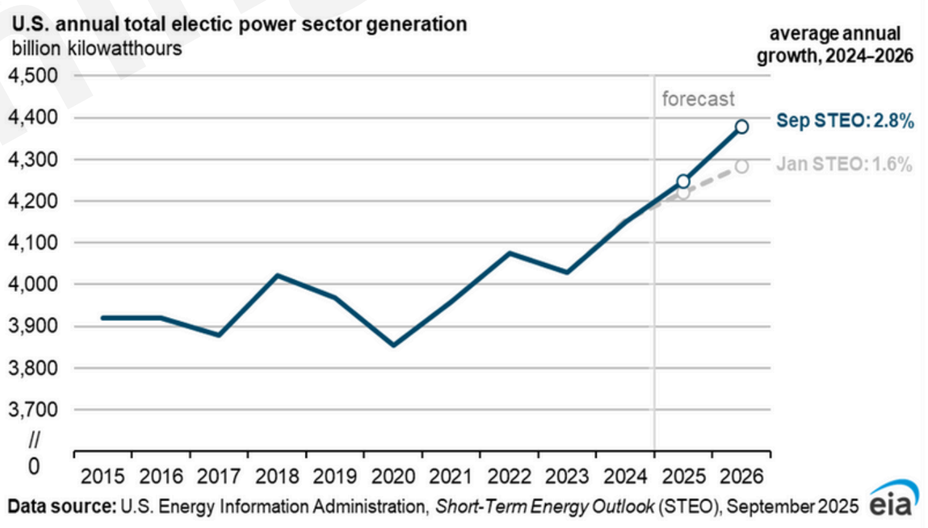


over **9,200** generating units with

Over **1,000 GW** generating capacity

More than **600,000 miles** or **965,400 km** of transmission lines





Simply, call it a giant grid

Similar to all countries

Factors leading to grid modernization

1

Energy Transition

India aims to hit 500 GW of renewables capacity by 2030 according to an article by “Energyworld.com”

this is massive

integrating large-scale wind, solar, BESS

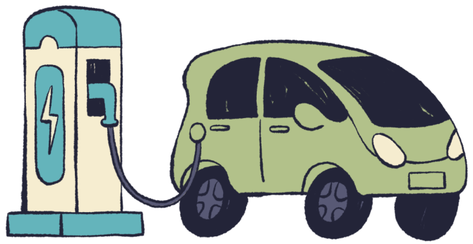
Enhanced NG plants

Traditional resources to → Non-conventional

2 Increasing demand

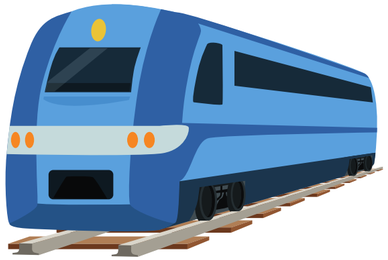
Due to the electrification of transportation

AI infrastructure deployments



EVs

smart buildings



Trains

Data centers

heating and cooling

USA

electricity consumption reaching

- 4,189 billion kWh in 2025
- 4,278 billion kWh in 2026

- (against 4,097 billion kWh in 2024).

steady growth of

~ 2%

Source: U.S. Energy Information Administration (EIA), 2025

India

India’s electricity consumption has been rising at ~9% per annum

due to urbanization, rising incomes, more cooling / air conditioning, industrialization, and electrification of services.

Fast growth of

~ 9%

Source: Council on Energy, Environment, and Water (CEEW), 2025

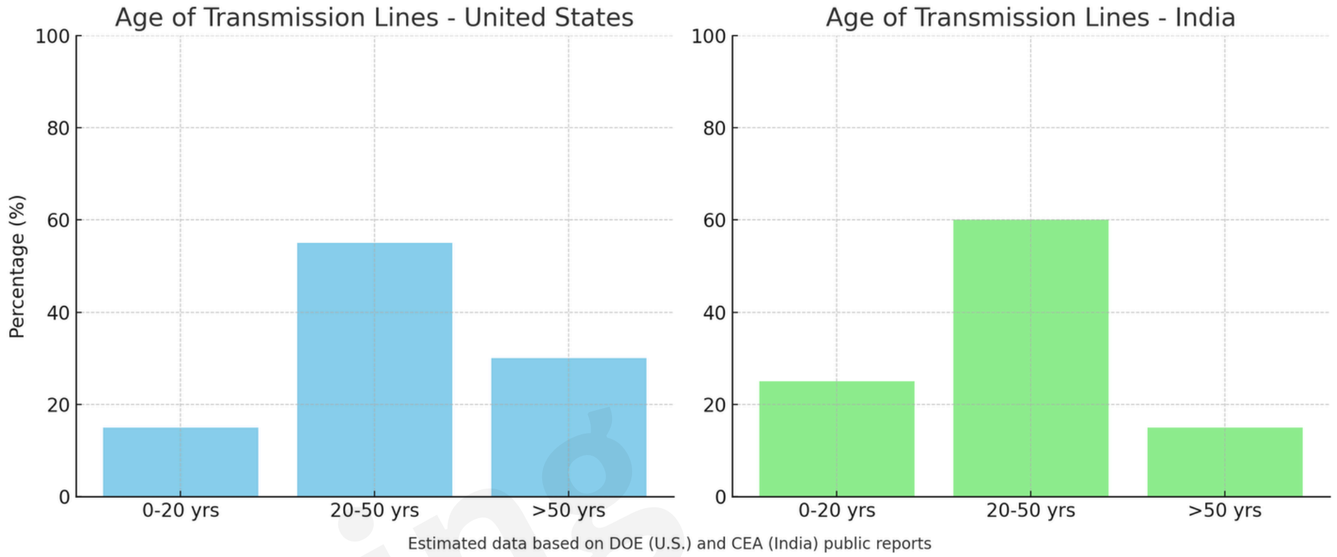
3 Aging grid infrastructure

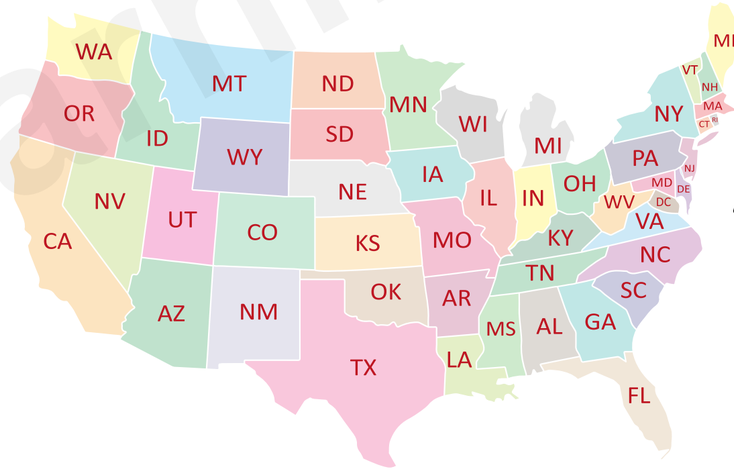
70% of US transmission lines are over 25 years old. Life expectancy – 50 - 80yrs

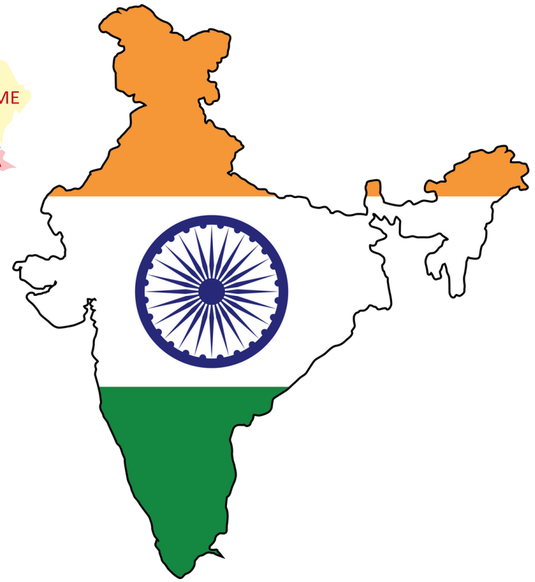
According to U.S. DOE (2023)

over 25% of those lines are over 50 years

i.e., About 150,000 miles of T-lines may require replacement - USA







4 Policy and Regulatory support for decarbonization

Global and national push for decarbonization

Paris Agreement
Net-zero targets by nations and the global

5 Cybersecurity & Resilience

Attack threats to control systems (SCADA)

Increasing system connectivity leads to potential online attacks.

Dramatic 70% surge in cyber attacks in US utilities, according to Reuters

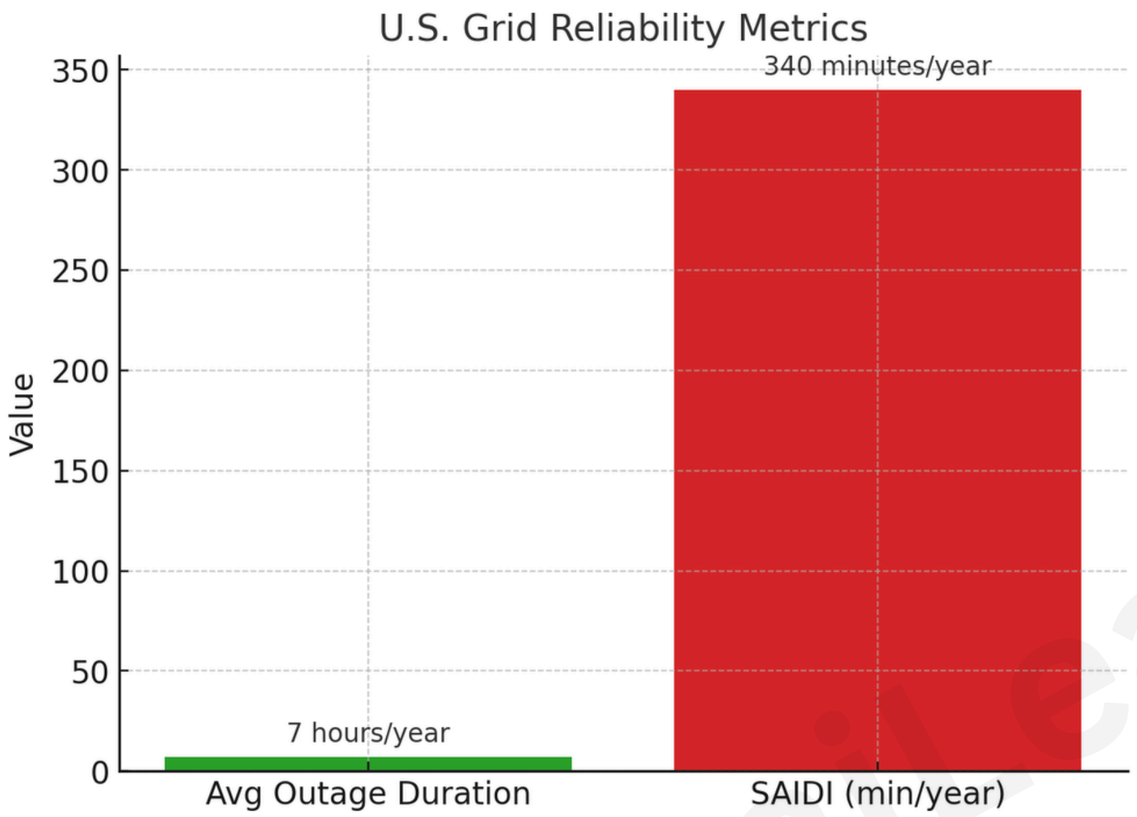
Extreme weather events threats grid resiliency

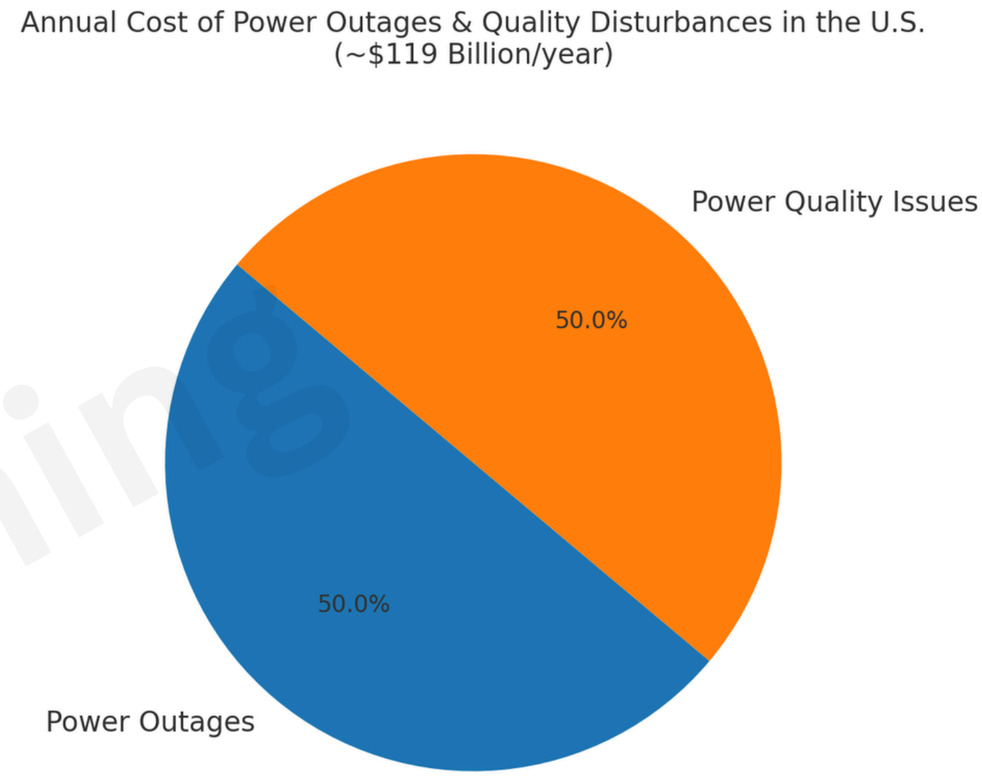
Why modernization matters

Adapting to meet today’s energy and technological needs.
Mitigating threat and energy insecurity

Power grids continue to evolve as electricity generation diversification and advanced intelligent systems are adopted

Reliability metrics - U.S.A



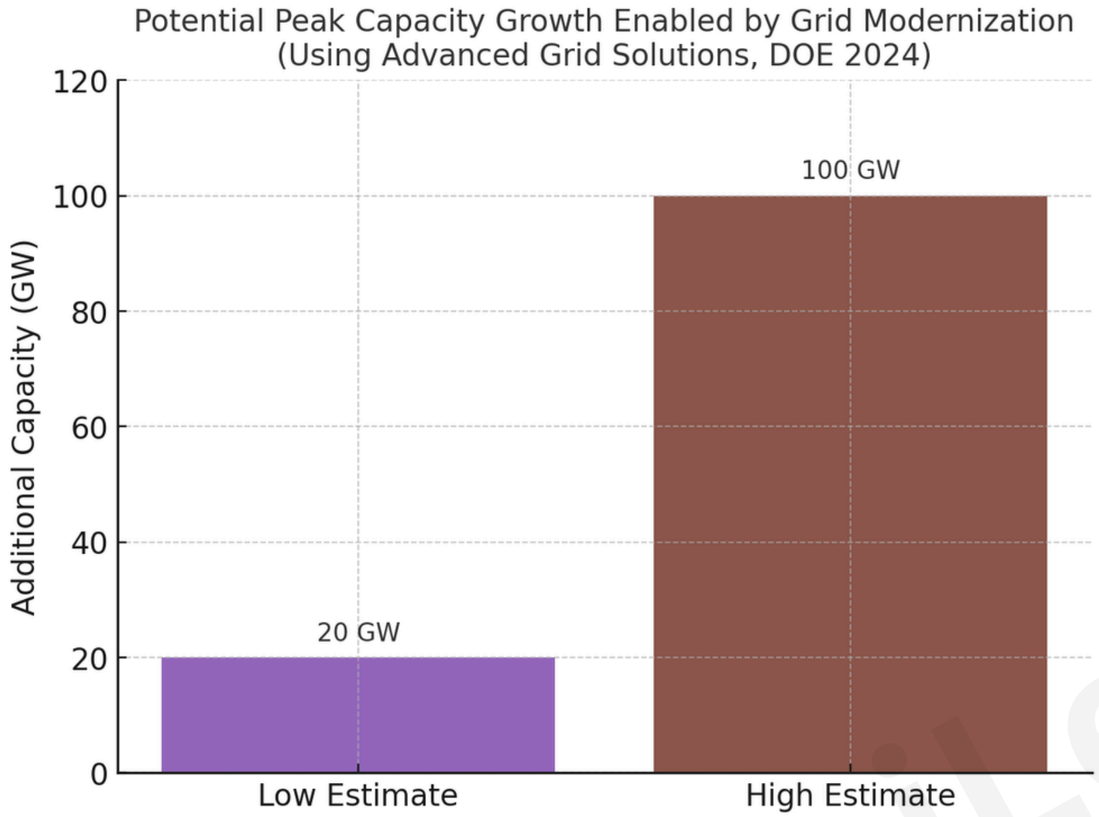


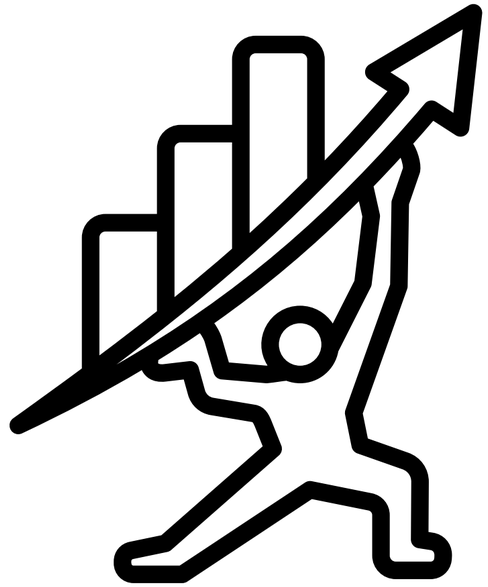
Over $80 billion/year --- **outage cost**

System Average Interruption Duration Index (SAIDI)

is dividing the sum of all customer interruption minutes within the year by the number of customers served during the year

Capability to absorb demand





Grid modernization has an enabling capacity growth potential using:

- AI-driven optimization solutions
- Dynamic line rating
- Advanced conductors
- Energy storage

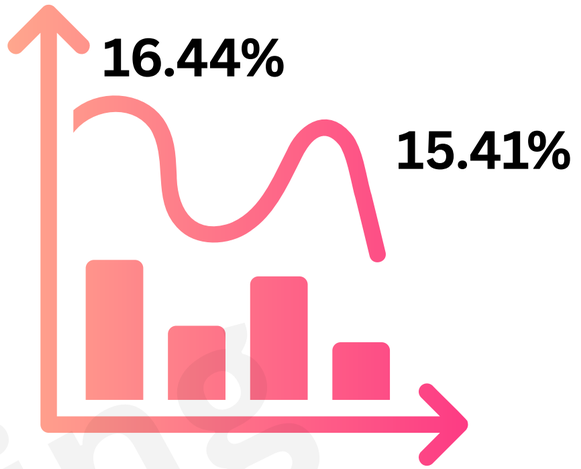
1GW = ~ 750,000 homes

- Advanced conductor - has higher ampacity, less sag, and
- can operate at higher temperatures
- U.S DOE is funding advanced conductors through the “Grid Resilience and Innovation Partnerships (GRIP) program

Reliability metrics - India

Aggregate technical and commercial (AT&C) losses

Approximately 16.44% in FY 2021-22;
dropped further to 15.41% in FY 2022-23 under the Revamp Distribution Sector Scheme (RDSS)



Transmission and distribution losses

16.64% for FY 2023-24: that is
Transmission losses = ~ 3.55%
Distribution losses = ~13.09%
of generation is lost.

Put into perspective, nearly **17 MW is lost** from a 100 MW generation plant before reaching end users.

This is not only MW lost, but revenue/cash

if a MWh = $40

Revenue lost = $489,600/month

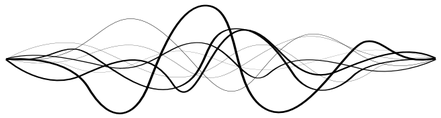
i.e. ~ $6 million/yr

Should we care about saving this huge loss/month?

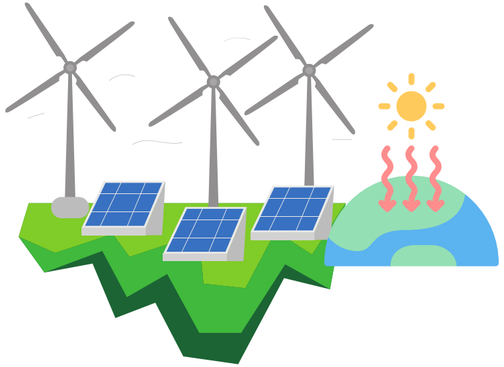
Critical parameters for AI grid modernization

The grid operates continuously, leaving footprints of large data

Vibration

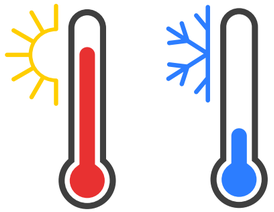


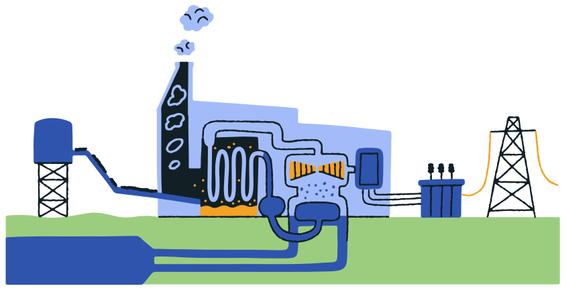
Wind speed



irradiance

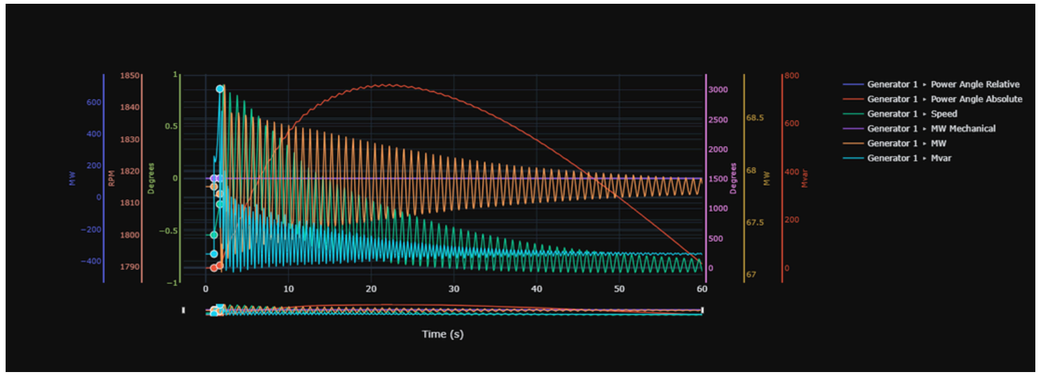
Temperature





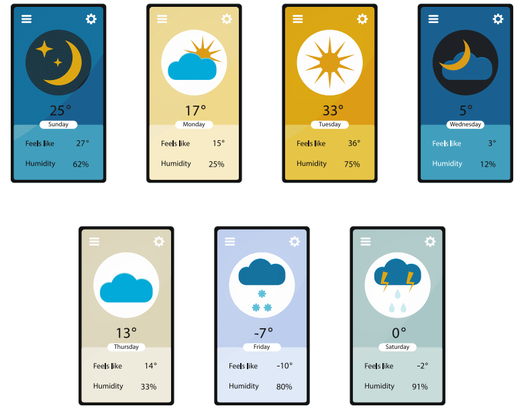
Water usage

System loading - current, voltage, power (MW), Q, S, pf, and frequency



Dynamic data & disturbance recording

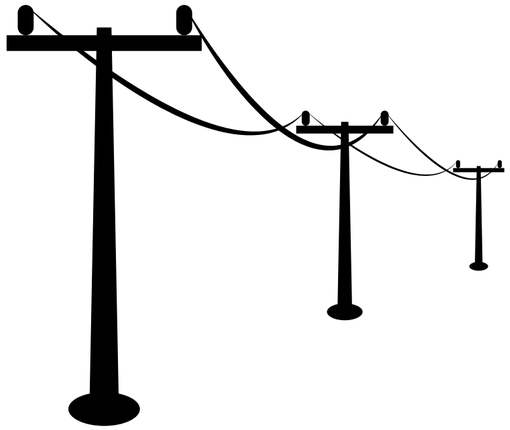
Heat



Weather resource forecasting data

Emission monitoring
Fuel consumption rate

Insulator condition
Conductors
Cables
Sag



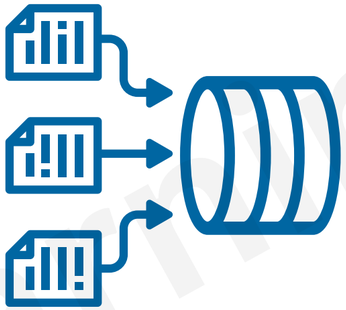
Measure data

Intelligent electronic devices (IEDs)

Protection relays
Automation controllers

Smart meters

Retrieve data

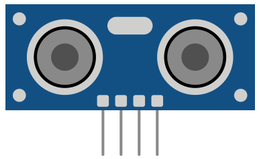


Use measured data against

- Factory Acceptance Test
- Site Acceptance Test
- Performance
- Historical reports/data

To understand
deviations
trends

Sensors



IoT devices

AI Applications for Grid Modernization

We need a solid understanding of
gaps/challenges and opportunities

1 Grid Planning

Use AI to

Capital allocations/upgrades

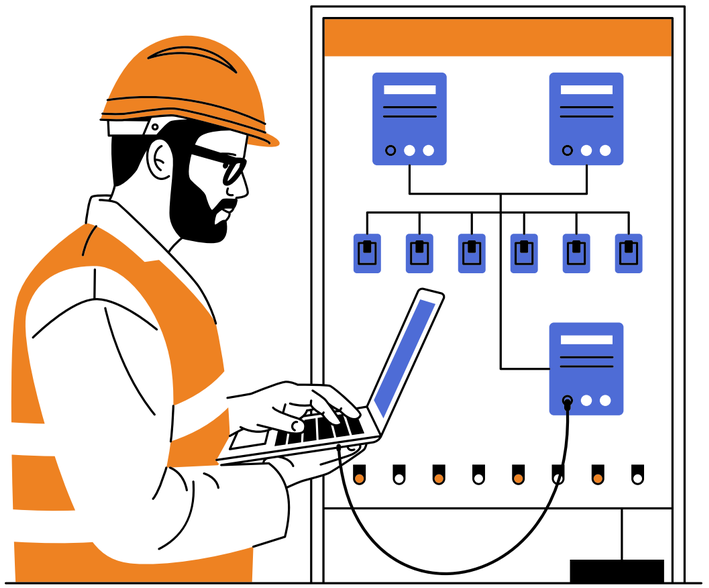
- Forecasting asset risk
- Load growth
- Guide substation upgrades
- Decide on capacity expansions

2 Siting and permitting

- Analyze land restrictions
- Local permitting codes
- Identify barriers earlier in the development phase

AI Applications for Grid Modernization

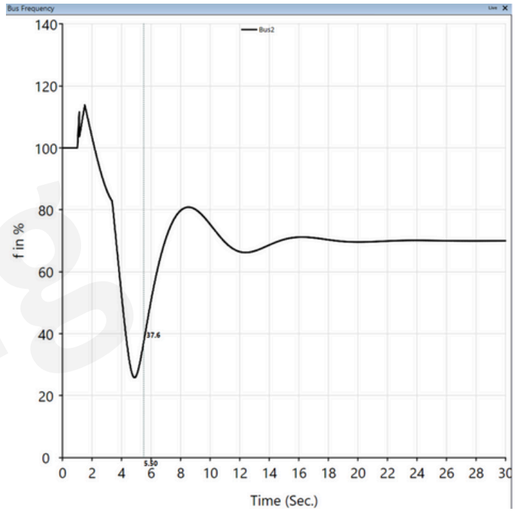
Use AI to



- Improve short-term load forecasting
- Optimize generation dispatch
- Predict asset degradation or failure
- Analyze operator reports to recognize the pattern of human error and provide training needs

3 Operation and Maintenance/Reliability

4 Resilience



- Identify and localize grid faults
- Help restore service in real-time
- Synthesize extreme weather and create operator awareness
- Coordinate DERs during grid disturbances - support backup power options during emergencies

Not without risks

Cybersecurity vulnerability

attackers could manipulate

- Demand forecasts
- Dispatch schedules or,
- Fault detection models

Over-automation may lead to the automation complacency problem

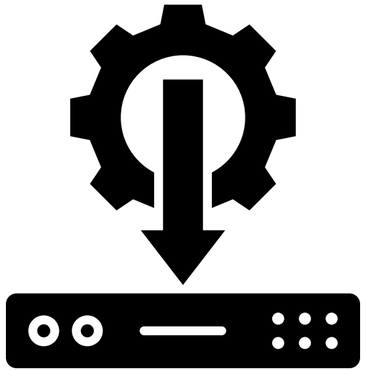
AI is powerful, but human oversight, regulation, and robust cybersecurity are critical to safe deployment.

Data privacy and quality concerns

Corrupted data leads to

- Wrong decision
- Inaccurate forecasts

Interoperability and legacy systems



Legacy systems will require massive upgrades

Regulatory and ethical risks

Economic and workforce issues

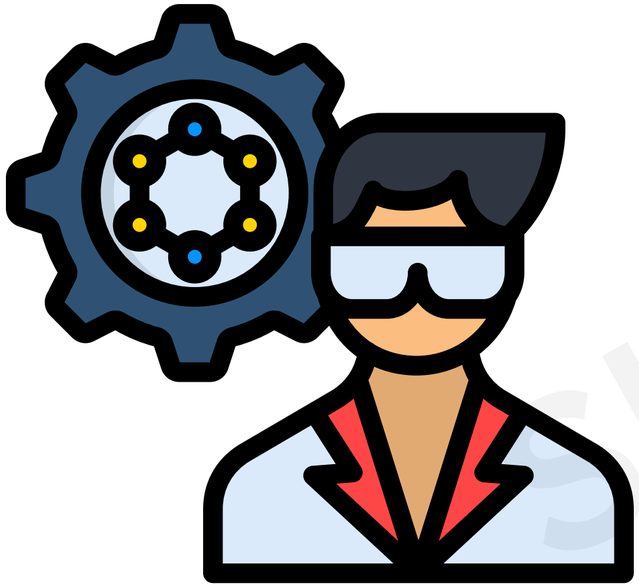
- heavy investment
- workforce displacement

OPPORTUNITY USA

To

Leverage AI for

Grid Planning and Operations



The U.S. National Renewable Energy Laboratory (NREL) is exploring how AI can help with

- Real-time decision support
- Predictive control
- Scenario planning for 100% clean electricity systems
- Resilience under cyber or extreme weather threats
- Situational awareness
- Better forecasting
- Anticipating disruptions
- Optimizing responses

OPPORTUNITY India

To

Leverage AI for

New skills and jobs

Tata Power and BlueWave - AI Pilot for real-time dispatch & intra-day scheduling

Both intra-day and day-ahead dispatch were generated

Use live weather feeds, historical output, and grid constraints.

The pilot outperformed legacy tools; then a three-year deal was signed

CONCLUSION

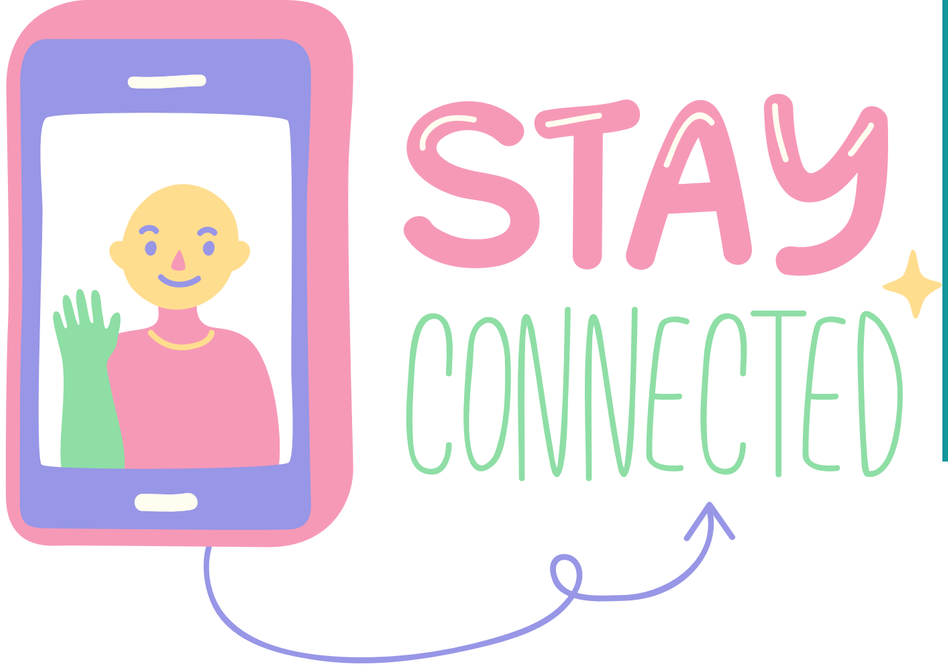
India, like many other countries, has a similar history and background about how the grid started and evolved till today

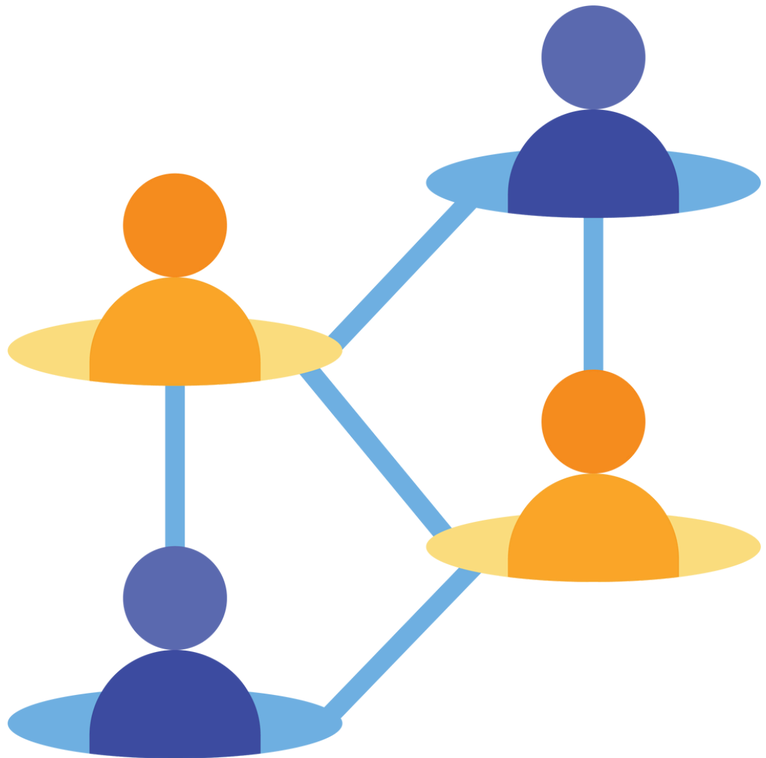
Most critical lesson: these milestones uplifted local livelihoods, marking the beginning of an unprecedented human transformation

The future of the grid won't end with us, but continue with our perpetual need for

- Growth and prosperity
- Speed and dependability
- Reliability, stability, and resilience
- and above all
- Human Well-being & Safety

THANK YOU





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