Perspective: Role of Transmission in India's Power Sector

For Prelims: **Renewable Energy Goals, Power Plants, India's Economic Growth, Coal, Gas, Nuclear, One Nation, One Grid, One Frequency" system, Company Act, 1956, Land Acquisition, Electrical Power Association (EPA), Tariff-Based Competitive Bidding (TBCB)**

For Mains: Key Transmission Challenges in India's Power Sector and Measures to Enhance Efficiency and Reliability.

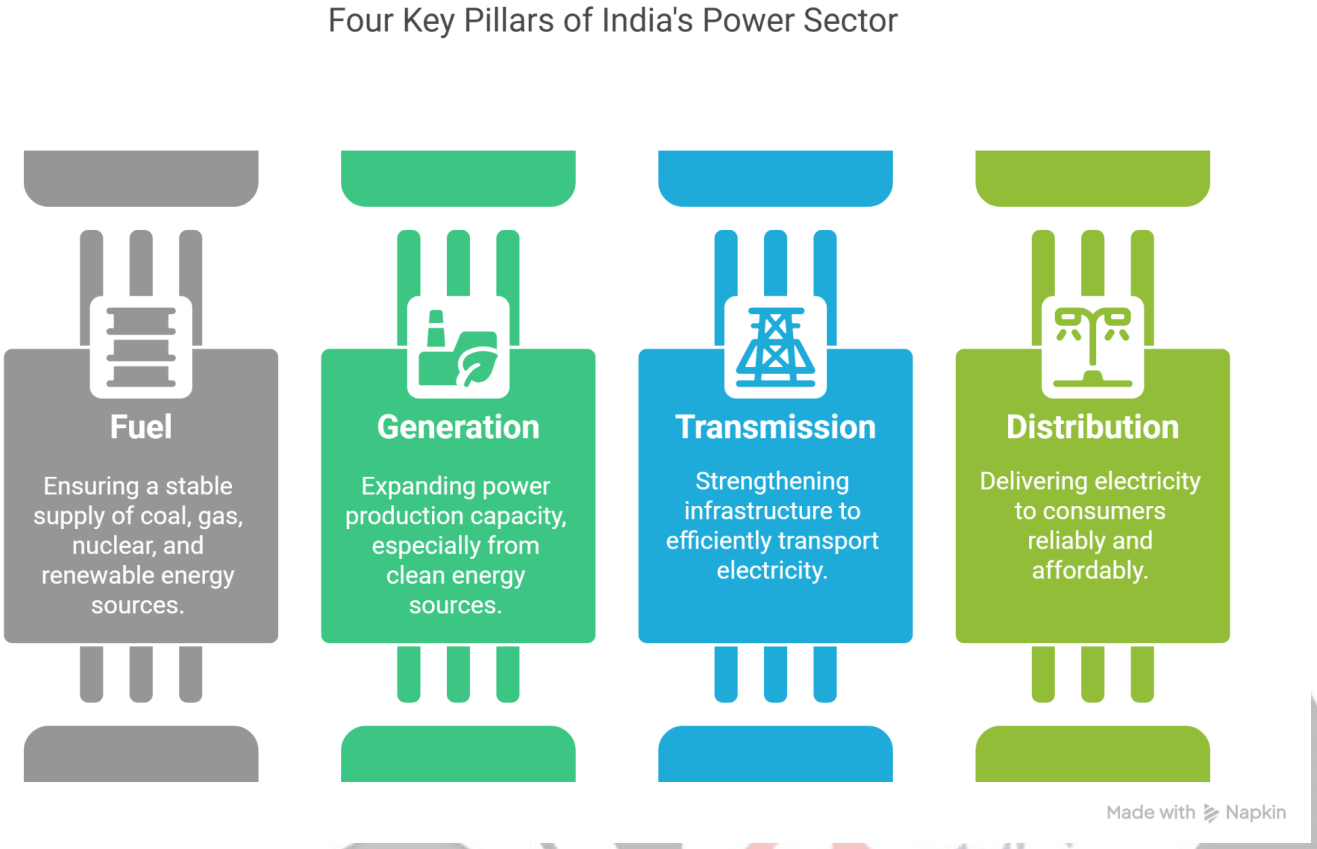
What is the Context?

India has one of the **largest synchronized power grids** in the world, with over **4 lakh circuit kilometers** of transmission lines.

- As the country advances towards its goal of achieving **500 gigawatts of renewable energy goals** by **2030,** modernizing and expanding the power transmission network remains a critical priority.
- The transition to a unified smart grid will enhance efficiency, reliability, and support the integration of renewable energy into the national grid.

What are the Fundamentals of Power Transmission?

- **About:**
  - A power supply system consists of three main components: **generation, transmission,** and **distribution.**
  - Electricity is generated at **power plants** and **smaller renewable energy facilities**. This technical process ensures that electricity is delivered efficiently to **homes, industries,** and **businesses**.
  - Transmission plays a vital role in **India's economic growth** and **clean energy transition**.
  - An advanced transmission network reduces **energy wastage, lowers costs,** and improves the **overall stability** of the grid.



- **India's Renewable Energy Goals:**
  - India aims to achieve **500 GW** of **renewable energy capacity** by **2030**. However, integrating this capacity into the **national grid** requires a **highly efficient transmission network**.
  - The **modernization of transmission infrastructure** is crucial to ensure a **seamless flow of electricity** from **generation hubs** to **consumption centers.**
- **Smart Grid & Technology Integration:**
  - India is transitioning towards a **smart grid** to enhance efficiency and reliability.
    - Smart Grid is an **Electrical Grid** with **Automation, Communication,** and **IT systems** that can monitor **power flows** from points of generation to points of consumption and control the power flow or curtail the load to match generation in real time or near real time.
  - Advanced technologies such as **765 kV AC transmission lines** and **High Voltage Direct Current (HVDC) lines** are enabling seamless power transfers between **surplus** and **deficit regions**, reducing inefficiencies and ensuring a more stable power supply.

Unification of India's Power Grid:

- India started implementing **grid management** on a regional level in the **1960s.**
- **State grids** were interconnected to create **five regional grids** covering mainland India: **the Northern, Eastern, Western, North Eastern,** and **Southern Grids.**
- The unification process began in **1991** with the formation of the **Power Grid Corporation** in **1989.**
- This was completed in **January 2019** with the integration of **Leh-Ladakh** into the grid, culminating in the **"One Nation, One Grid, One Frequency" system.**
- This unification has significantly enhanced power availability and stability across states.

Power Grid Corporation of India Limited (POWERGRID):

- **Power Grid Corporation of India Limited (POWERGRID),** is a **Schedule 'A', 'Maharatna' Public Sector Enterprise of Govt. of India** which was incorporated on **23rd Oct 1989** under the **Company Act, 1956.**
- **POWERGRID** is a listed Company, with **51.34%** holding of **Government of India** and the balance is held by Institutional Investors and public.

What are the Challenges in the Transmission Sector?

- **Right of Way (RoW) Issues:**
  - **Land acquisition** and **Right of Way approvals (legal authority granted to a utility to construct, maintain, and operate a transmission line across a specific strip of land)** remain slow, causing delays in **transmission projects.**
  - Additionally, **private sector players** require **clearer cost pass-through mechanisms** to ensure financial feasibility.
    - A **cost pass-through,** also called **price transmission or simply pass-through,** is the process where a business adjusts its output prices to account for changes in its input costs.
- **Supply Chain Constraints:**
  - The rising number of project bids has led to **shortages of essential transmission equipment**.
  - Furthermore, restrictions on **equipment imports** from certain countries have limited availability, creating additional challenges.
- **Deficiencies in Infrastructure:**
  - A large portion of **India's transmission infrastructure** is outdated and needs upgrades. This affects the **overall reliability** and **efficiency of power distribution**.
  - In many parts of the country, particularly **rural** and **remote areas, transmission networks** are either insufficient or absent, leading to **electricity losses** and difficulty in reaching consumers.
- **Losses in Transmission:**
  - These occur due to the **inherent resistance of transmission lines**, leading to energy wastage.
  - **Theft** or **pilferage of electricity** is another significant concern, especially in urban slums and rural areas, contributing to financial losses and grid instability.

Way Forward

- **Right of Way Solutions:**
  - To address land acquisition challenges, the government has increased **compensation from 15% to 30%,** linking it to market rates.
  - Revised compensation guidelines introduced in **2024** have doubled the **tower base area** and **corridor compensation.**
- **Supply Chain Improvements:**
  - Efforts are being made to tackle **equipment shortages** and import restrictions that hinder transmission projects.
    - A significant focus is on improving supply chains for critical materials, such as **CRGO steel,** necessary for constructing transformers to support **renewable energy initiatives.**
- **Modernization and Upgradation of Infrastructure:**
  - Invest in **upgrading outdated transmission infrastructure** with advanced technology to improve **reliability, efficiency,** and **reduce power losses.**
  - **Expansion of Transmission Networks:** Strengthen and expand transmission networks, especially in rural and remote areas, to ensure equitable electricity access and minimize distribution challenges.

- **Private Sector Investments and Expansion Plans:**
    - A significant investment of **USD 100 billion** is expected in the transmission sector over the next **7–8 years**. The transmission network is planned to expand from **4.9 lakh circuit kilometers** to **6.5 lakh circuit kilometers** by **2032.**
    - **Private Transmission Service Providers (TSPs)** currently manage **15%** of the **Interstate Transmission System (ISTS) networks,** a figure projected to rise to **50%** in the coming years.
    - States like **Madhya Pradesh** and **Maharashtra** are already implementing bidding processes for their transmission projects, showcasing a proactive approach to infrastructure development.

Conclusion

India's power transmission sector is undergoing a transformative expansion to support its ambitious renewable energy goals. Competitive bidding, private sector participation, and AI-driven solutions are key to making the transmission network more efficient, reliable, and secure. By addressing policy challenges and enhancing coordination between stakeholders, India is on the path to a sustainable and robust power infrastructure that will fuel its economic growth and energy transition.

UPSC Civil Services Examination, Previous Year Questions (PYQ)

Prelims

Q. With reference to the Indian Renewable Energy Development Agency Limited (IREDA), which of the following statements is/are correct? (2015)

1. It is a Public Limited Government Company.
2. It is a Non-Banking Financial Company.

Select the correct answer using the code given below:

(a) 1 only
(b) 2 only
(c) Both 1 and 2
(d) Neither 1 nor 2

Ans: C

Q. Which one of the following is a purpose of 'UDAY', a scheme of the Government? (2016)

(a) Providing technical and financial assistance to start-up entrepreneurs in the field of renewable sources of energy
(b) Providing electricity to every household in the country by 2018
(c) Replacing the coal-based power plants with natural gas, nuclear, solar, wind and tidal power plants over a period of time
(d) Providing for financial turnaround and revival of power distribution companies

Ans: (d)

Mains

Q. Give an account of the current status and the targets to be achieved pertaining to renewable energy sources in the country. Discuss in brief the importance of the National Programme on Light Emitting Diodes (LEDs). (2016)