



Electric Power Transmission

For Prelims: [Bhakra Nangal Dam](#), Alternating Current (AC), Direct Current (DC) , [Distribution Substations](#), [Transmission Substations](#), [Nuclear Reactors](#)

For Mains: Significance of streamlining the electricity generation and transmission to achieve the renewable energy targets.

[Source: TH](#)

Why in News?

With the rising demand for electricity in today's world, especially with increased individual and industrial needs, it's crucial to enhance the efficiency and reliability of [electric power transmission systems](#).

What Are the Basics of Transmitting Electricity?

▪ About:

- Any power supply system has three broad components: **generation, transmission, and distribution**. Electricity is generated at power plants as well as smaller renewable-energy installations.
- Then it is transmitted using a distributed network of **stations, substations, switches, overhead and underground cables, and transformers**, among other elements.

▪ Transmission Efficiency:

- The efficiency of electric current transmission is **higher at lower current and higher voltage**. This is because **energy loss during transmission is proportional to the square of the current**, while voltage and current have a 1:1 relationship.
 - Transformers are used to increase voltage and reduce current for efficient transmission.

▪ Resistance in Cables:

- Cables used for transmission still have some resistance, resulting in energy loss. **The thickness of the cable can be adjusted to control energy loss, with thicker cables losing less energy**, but at a higher cost.

▪ Distance and Transmission Cost:

- **Longer transmission distances generally result in lower transmission costs** due to factors such as requirement of less transmission towers, substations, and maintenance efforts.

▪ Alternating Current (AC):

- AC is preferred for transmission because **it can be easily modified using transformers and has higher efficiency**. However, higher AC frequencies increase resistance in the material.
 - AC power is the most common way to transfer electric power because voltage continuously changes polarity, causing the current to flow in alternating directions. **The AC frequency corresponds to the rate at which the voltage changes direction.**

Installed Electricity Generation Capacity (Fuelwise) as on May 2023:

- Total Installed Capacity (Fossil Fuel & Non-Fossil Fuel) is 417 GW.
- The share of various energy sources in the total Electricity Generation are:
 - Fossil fuel (including Coal) is 56.8%,
 - Nuclear fuel 1.60% and
 - Non-Fossil fuel is 41.4%.

How is Power Transmitted?

- **Power Transmission Infrastructure:**
 - In power transmission, a **three-phase AC circuit** is employed. Each wire carries AC current in a different phase. From a power station, the wires are routed to transformers that step-up their voltage.
 - The infrastructure is equipped with safety features, **such as insulators to divert excessive current** during surges and **circuit-breakers to disconnect the circuit** in case of overload.
 - Additionally, **grounding and arresters** are used to prevent voltage fluctuations caused by external factors like lightning strikes. **Dampers** help **mitigate vibrations that could affect the stability of the towers.**
- **Substation Network:**
 - The transmission wires ultimately lead to various types of **substations**, each serving a specific role in the power distribution system.
 - **Collectors** consolidate power from different sources and channel it to transmission substations.
 - **Distribution substations** play a vital **role in stepping down the voltage in power lines, preparing the electricity for consumption in households** and businesses.
 - **Transmission substations** act as hubs, merging or branching different lines and diagnosing issues within the network.
- **Diverse Functions and Infrastructure:**
 - To perform diverse functions, the infrastructure includes a wide array of support systems, from electrical engineering expertise to advanced computerized operations.
 - Safety measures, such as fire protection, are essential to safeguard critical infrastructure.

How Does an Electric Grid Function?

- **Grid Operation and Components:**
 - **Grids** are complex systems that play a vital role in the distribution of electrical power. They consist of three main components: **production, transmission, and distribution.**
 - The **transmission component** serves as the bridge between power production and delivery to end-users.
 - Some power sources, like coal-fired or nuclear reactors, can produce a continuous supply of energy, while renewable sources, such as wind and solar, are intermittent.
 - **In such cases, Grids become useful as Grids are equipped with storage facilities to store surplus electricity and release it when demand exceeds supply.**
- **Grid Resilience and Control:**
 - Grids must be resilient to **prevent failures in different parts of the network** from affecting others. They also need to manage voltage levels to meet varying demand and ensure a stable and reliable power supply which includes controlling the AC frequency and improving the power factor.
- **Wide-Area Synchronous Grids and Challenges:**
 - A wide-area synchronous grid is a network in which **all connected generators produce AC current at the same frequency.** An example of such a grid is the North Chinese State Grid is the world's most powerful, with a capacity of 1,700 GW. **India's national grid**

also operates as a wide-area synchronous grid.

- These grids have the advantage of lowering power costs due to **shared resources but require measures to prevent cascading failures** in the event of a local power supply failure.

Electric Grid of India

- The electric grid of India, also known as the **National Grid, is a high-voltage electricity transmission network** that connects power stations and major substations across the country. It ensures that electricity generated anywhere in India can be used to satisfy demand elsewhere.
- The National Grid is owned and maintained by the state-owned **Power Grid Corporation of India and operated by the state-owned Power System Operation Corporation**. It is one of the largest operational synchronous grids in the world with **417.68 GW** of installed power generation capacity as of 31 May 2023.

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)

Mains

Q. "Access to affordable, reliable, sustainable and modern energy is the sine qua non to achieve Sustainable Development Goals (SDGs)". Comment on the progress made in India in this regard. (2018)