

Power Plant Engineering



UNIT 1 – Introduction to Power Plant Engineering

🧠 1.1 Basic Concept of Power Plant

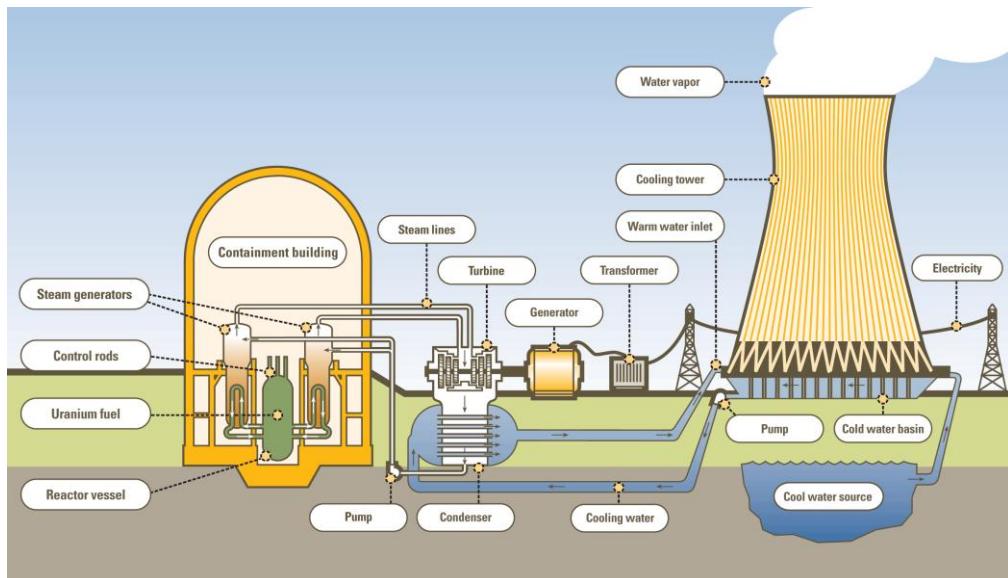
▀ What is a Power Plant?

A power plant is an industrial setup that is used to **generate electrical energy** from various types of fuel or natural energy sources. It works by converting **heat or mechanical energy** into **electrical power**, which can be supplied to homes, industries, hospitals, etc.

⚡ Energy Conversion Flow (Step-by-Step):

1. **Fuel Source:** Coal, natural gas, nuclear material, water, wind, or sunlight.
2. **Heat Generation:** If fuel is combustible (e.g., coal), it's burned to produce heat.
3. **Mechanical Energy:** The heat is used to produce steam that turns a **turbine**.
4. **Electrical Energy:** Turbine spins a **generator**, converting mechanical energy into electricity.

📌 **Example:** In a thermal power plant, coal is burned → steam is generated → turbine rotates → electricity is produced → supplied via transmission lines ⚡



1.2 Power Scenario in India and the World

IN India's Power Status:

- India is the **3rd largest producer** and **2nd largest consumer** of electricity globally.
- Installed capacity: ~ **415+ GW** (Gigawatts)
- Leading contributors: Thermal > Renewable > Hydro > Nuclear

Government Programs:

- **Saubhagya Scheme** – Free electricity connection to rural households
- **Solar Mission** – Targets 100 GW solar capacity
- **Ujjwal Bharat Abhiyan** – Reforms in power sector

Global Scene:

- **China**: World's largest electricity producer
- **USA**: Heavy reliance on natural gas and nuclear
- **Germany**: Pioneer in **green energy** transition
- **Norway**: 100% hydro-based electricity

India's Energy Mix (Approx):

-  Thermal (Coal, Gas, Oil) – 55%
-  Renewable (Solar, Wind, Biomass) – 25%
-  Hydro – 12%
-  Nuclear – 3%
-  Others – 5%

 Vision: Shift to low-carbon, sustainable power 

1.3 Classification of Power Plants

A. Based on Energy Source:

1. Thermal Power Plant – Uses coal/gas to boil water and generate steam

What it is:

A power plant that generates electricity using **heat energy**. Most commonly from **coal**, **oil**, or **natural gas**.

Working:

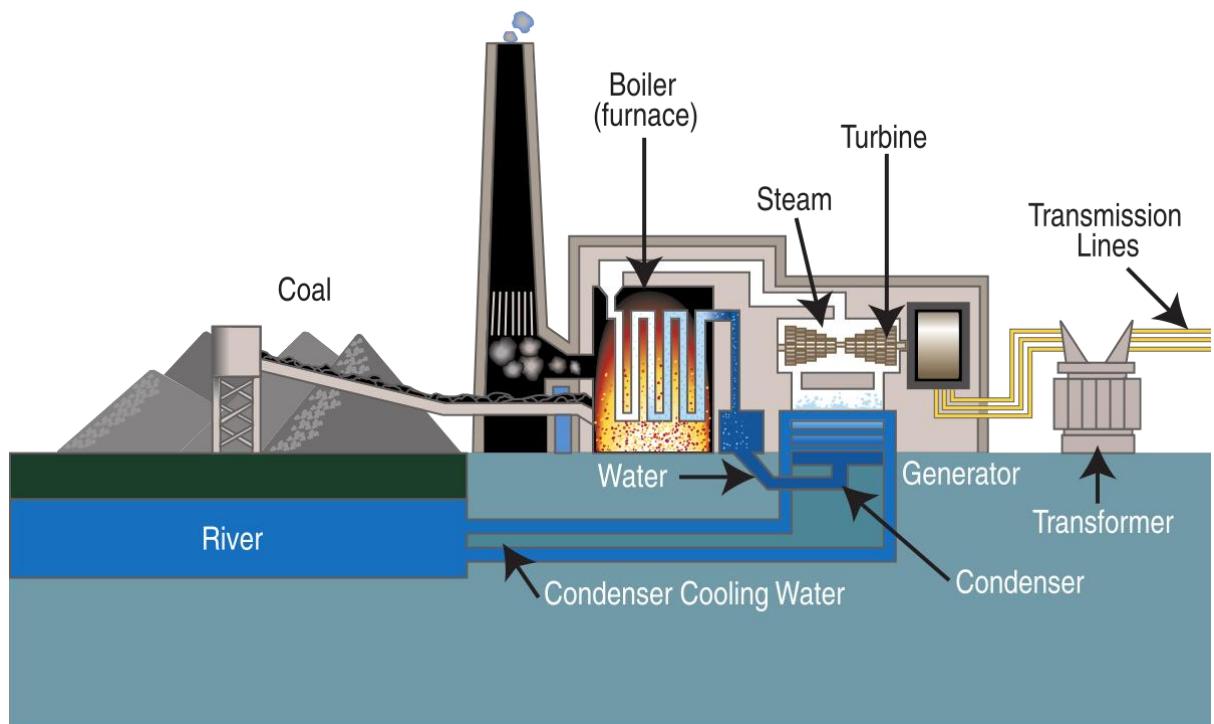
1. Fuel is burned in a **boiler** to produce **steam**.
2. Steam rotates a **turbine**.
3. Turbine drives an **alternator** (generator) to produce electricity.
4. Steam is condensed and reused.

Examples:

- **NTPC Singrauli**, Uttar Pradesh
- **Talcher Thermal**, Odisha
- **Kolaghat**, West Bengal
- **Chandrapur**, Maharashtra

Uses:

- Supplies **base load** electricity.
- Major contributor to India's total power.



2. Hydro Power Plant – Uses falling water to spin turbines

What it is:

Uses **falling or flowing water** to rotate turbines and generate electricity.

Working:

1. Water stored in **dams** has potential energy.
2. When released, it spins **turbines**.
3. Turbine runs a **generator** to produce electricity.

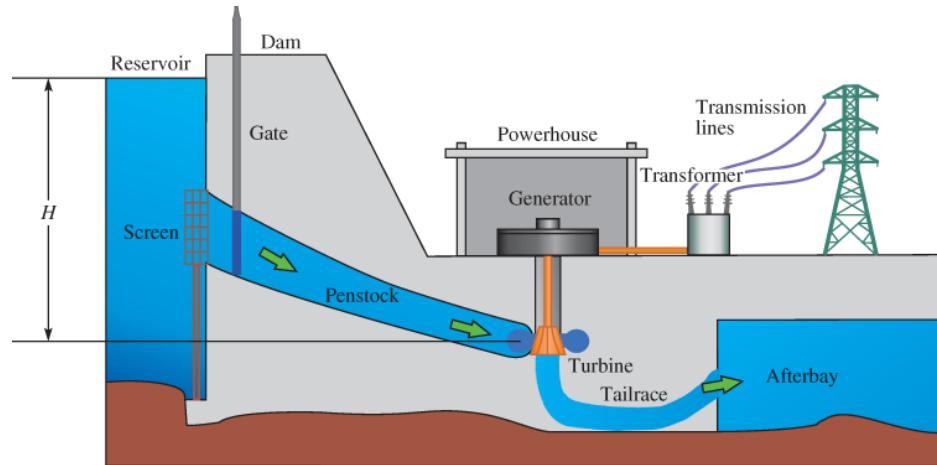
Examples:

- **Bakra Nangal Dam**, Himachal Pradesh
- **Tehri Dam**, Uttarakhand
- **Sardar Sarovar**, Gujarat
- **Subansiri Project**, Arunachal Pradesh/Assam

Uses:

- Renewable, eco-friendly 
- No fuel cost





3. Nuclear Power Plant – Uses fission of uranium atoms for heat

What it is:

Generates electricity from **nuclear fission** of uranium or thorium.

Working:

1. Uranium atoms split in a **reactor**, releasing heat.
2. This heat turns **water into steam**.
3. Steam rotates **turbine**, runs **generator**.

Examples:

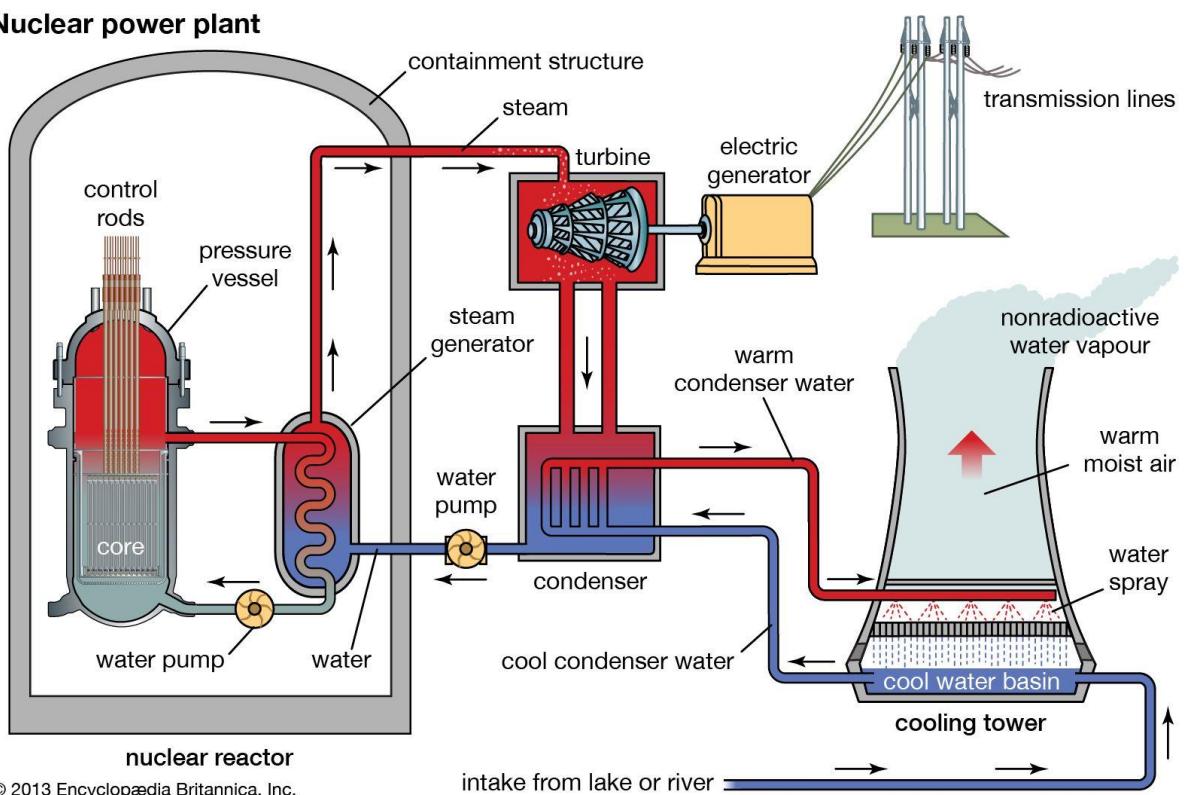
- **Kudankulam**, Tamil Nadu
- **Tarapur**, Maharashtra
- **Kaiga**, Karnataka
- **Rawatbhata**, Rajasthan

Uses:

- High efficiency
- Base load supply
- Needs strict safety



Nuclear power plant



4. Solar Power Plant – Converts sunlight into electricity using photovoltaic (PV) cells

 **What it is:**

Converts sunlight ☀️ into electricity using **solar panels** or **solar thermal systems**.

 **Types:**

- **Photovoltaic (PV)**: Direct conversion using **solar cells**.
- **Solar Thermal**: Uses mirrors to concentrate sunlight and heat fluid to run turbines.

 **Examples:**

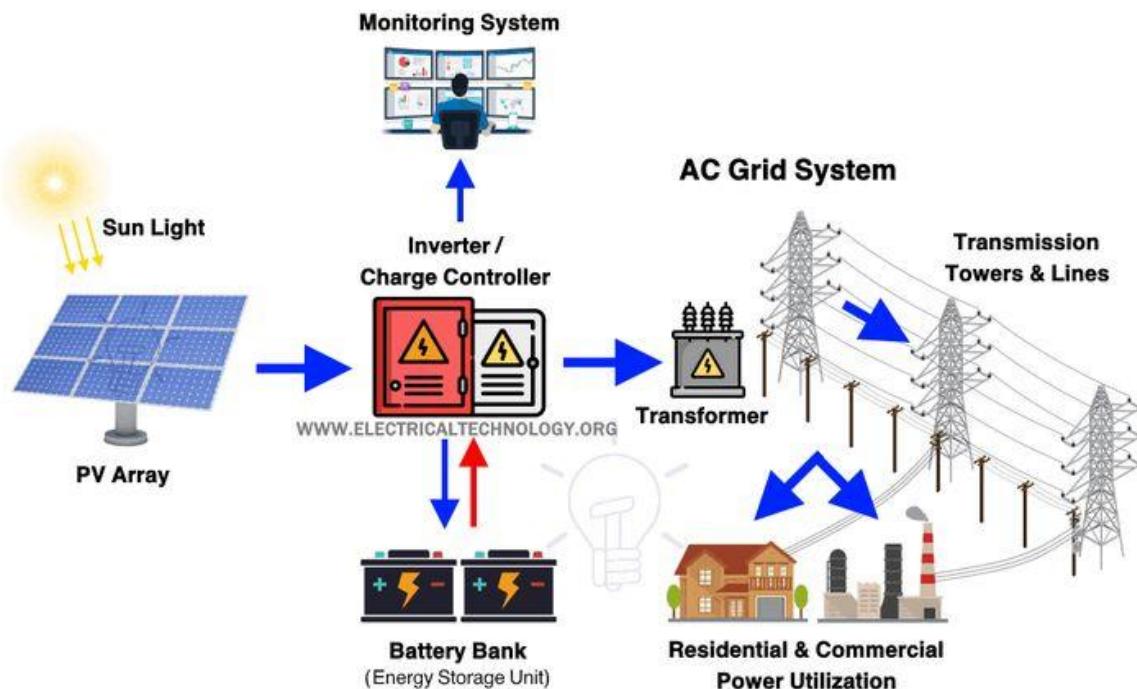
- **Bhadla Solar Park**, Rajasthan (🌐 Asia's largest)
- **Pavagada Solar Park**, Karnataka
- **Rewa Solar Plant**, Madhya Pradesh

 **Uses:**

- Cleanest source 🌱
- Good for remote & rural areas



Components of Solar Power Plant



5. Wind Power Plant – Converts wind energy via turbines

What it is:

Uses **wind energy** to rotate turbines and generate electricity.

Working:

1. **Wind turns the blades** of a windmill.
2. The rotor turns a **generator** to produce electricity.

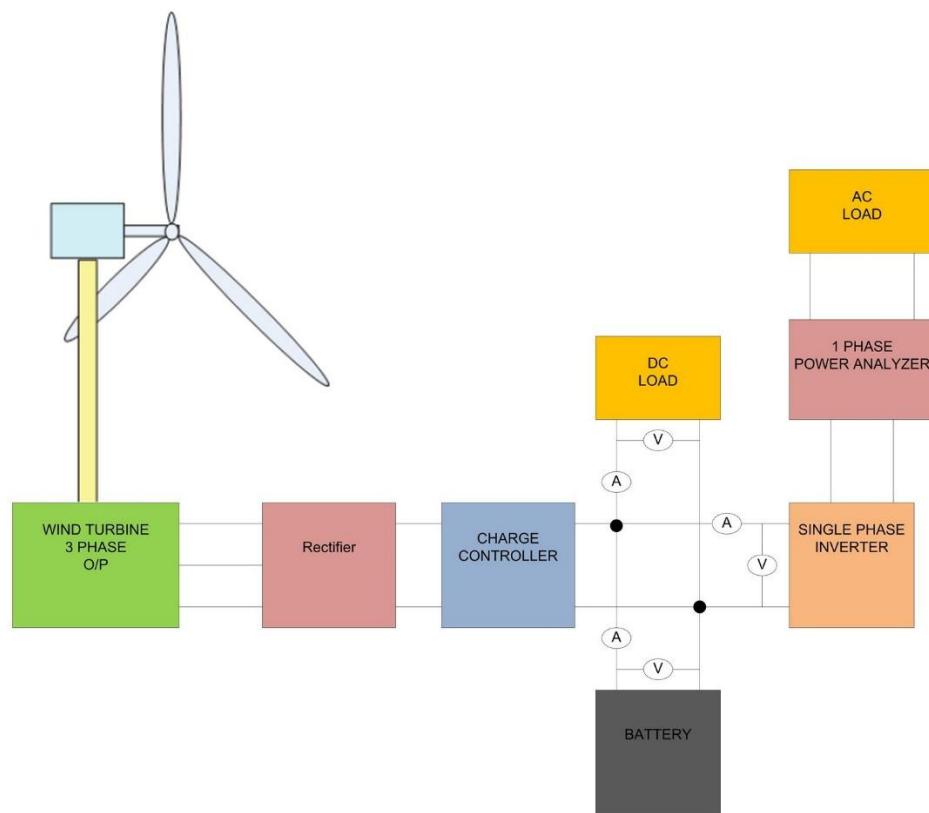
Examples:

- **Muppandal**, Tamil Nadu (India's largest)
- **Jaisalmer**, Rajasthan
- **Koyir**, Maharashtra

- Chakala, Gujarat

📌 **Uses:**

- No pollution 🌱
- Useful in windy areas only



6. Biomass/Geothermal – Uses organic waste or Earth's heat

✓ What it is:

Generates electricity using **heat from the Earth's core** 

⚙️ Working:

1. Underground **hot water or steam** is extracted.
2. It rotates a **turbine**.
3. Turbine drives **generator** to produce electricity.

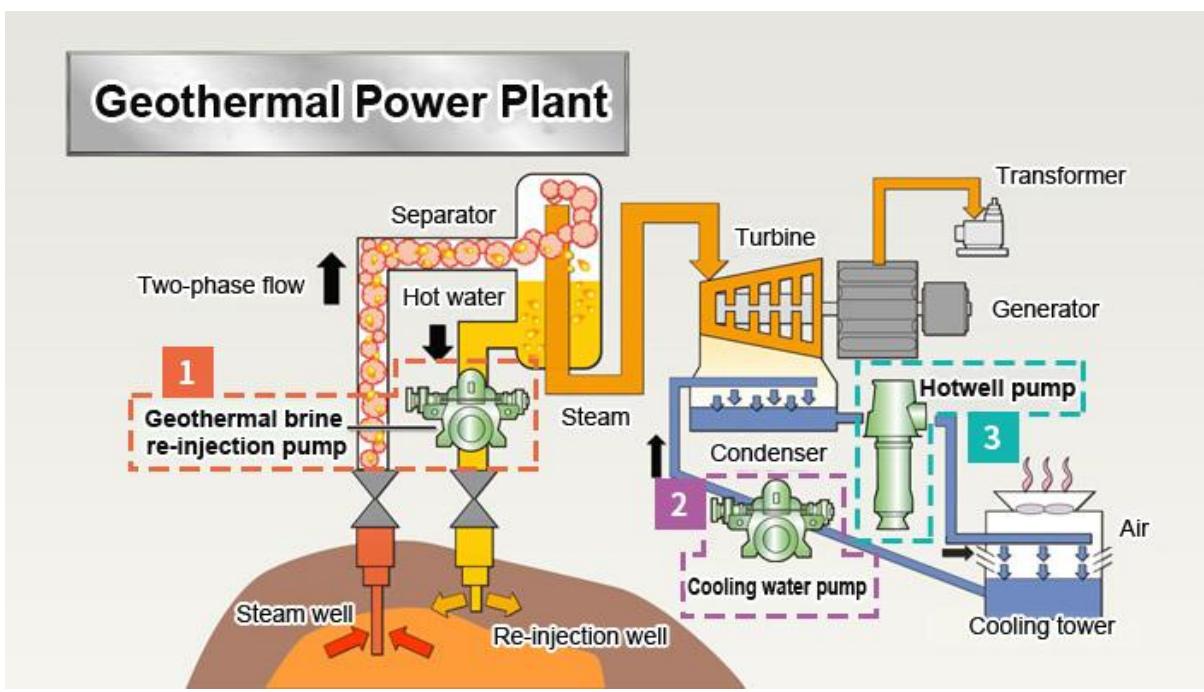
📍 Examples:

- **Puga Valley**, Ladakh (proposed)
- Mostly used in **USA, Iceland, New Zealand, Philippines**

⚡️ Uses:

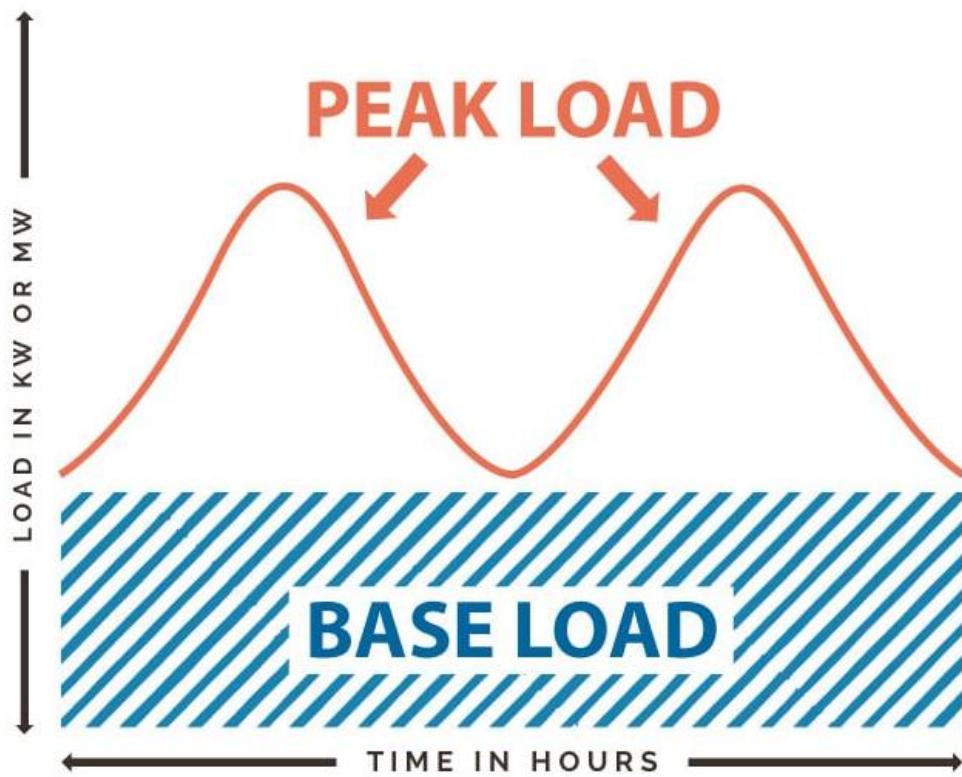
- Clean and renewable
- Limited to volcanic or hot zones

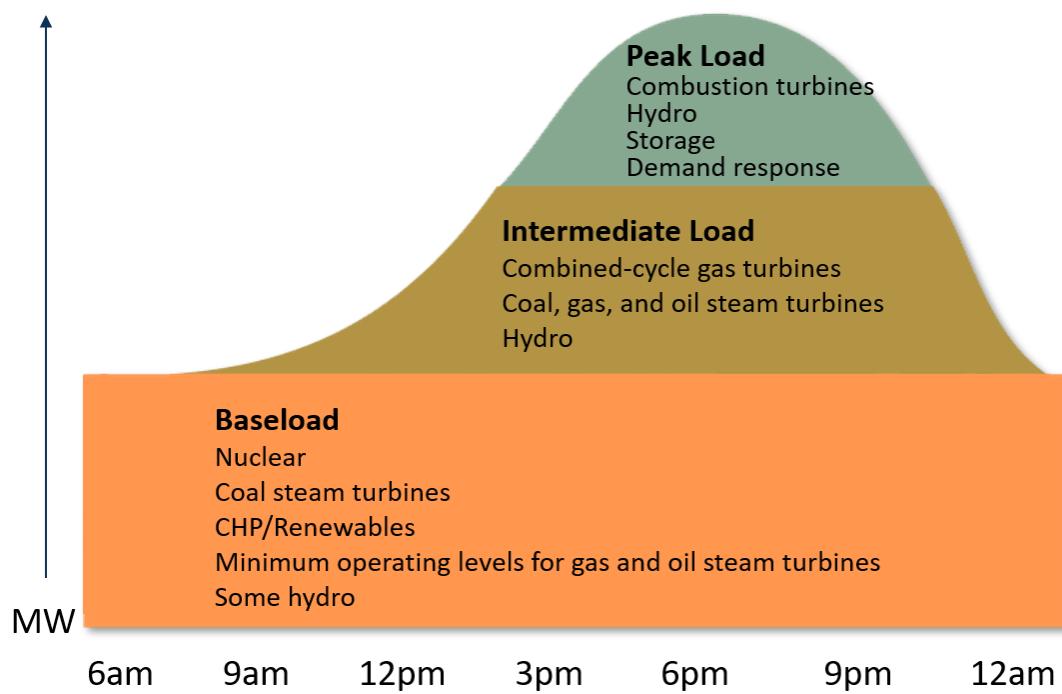




B. Based on Operation:

- **Base Load Plants** – Run continuously to meet regular demand (e.g. Thermal, Nuclear)
- **Peaking Plants** – Operate only during peak electricity demand (e.g. Hydro, Diesel)





3 c. Based on Location:

- **Onshore Plants** – Built on land (e.g., coal, solar farms)



- **Offshore Plants** – Built at sea (mostly wind farms)



📌 Each type has its own advantages, limitations, and environmental impact.

💡 1.4 Future Trends in Power Generation

1. Renewable Energy Growth

- Solar parks, wind farms, biomass
- **Floating solar panels** (placed on lakes)

2. Energy Storage Systems

- Batteries (Li-ion, sodium-ion)
- **Pumped hydro** storage during low demand

3. Smart Grid Technologies

- Monitors supply and demand in real-time
- Reduces blackout chances 🧠 ⚡

4. AI & IoT Applications

- Predictive maintenance
- Remote monitoring & control

5. Hydrogen Fuel Development

- Green hydrogen can replace fossil fuels
- India's National Hydrogen Mission under process 

 Future = Digital, Clean, Efficient, & Decentralized 

📍 **1.5 General criteria for selection of site for different type of power plant.**

📌 **Why Site Selection is Important?**

Proper site selection ensures:

- Lower operational cost
- Better plant efficiency
- Minimal environmental damage

Key Criteria:

1. **Fuel Availability** – Near to coal mines, gas pipelines, or renewable source
2. **Water Supply** – Essential for thermal and nuclear cooling
3. **Load Center Proximity** – Closer to cities/industries saves on transmission cost
4. **Transport Access** – Rail, road, or waterway access for equipment and fuel
5. **Land Availability** – Flat, stable land with enough area
6. **Environmental Impact** – Away from wildlife or urban zones
7. **Legal Clearances** – Must comply with pollution norms, zoning laws

📌 **Example Locations:**

- **Thermal:** Durgapur, Singrauli (coal belt)
- **Hydro:** Tehri, Sardar Sarovar (river valleys)
- **Nuclear:** Kalpakkam, Kudankulam (coastal for water cooling)

 A wrong site = high costs, pollution, legal trouble 



Suggestion Paper

✍ Short Questions (2–3 Marks)

1. Define a power plant.
2. Write two advantages of hydro power plant.
3. What is the function of a generator in a power plant?
4. List two renewable sources of energy.
5. Mention any two power-producing states in India.
6. What is a base-load power plant?
7. State two future trends in power generation.
8. Write two factors considered in site selection of thermal power plant.
9. Differentiate between onshore and offshore power plants.
10. Name two smart technologies used in modern power systems.

📝 Long Questions (5–7 Marks)

1. Explain the basic working of a thermal power plant with a neat sketch.
2. Describe the power scenario of India and the world.
3. Classify power plants based on energy source and explain with examples.
4. What are the major trends in future power generation?
5. List and explain general criteria for selection of power plant site.
6. Compare thermal, hydro and nuclear power plants in terms of cost, fuel, and setup.
7. Explain the block diagram of electricity generation process in any one type of power plant.
8. Describe India's energy mix and how it's changing over time.

9. Why is smart grid technology important in the future of power systems?

10. Describe in brief the working of solar and wind power plants.

MCQ Sheet

1. Which of the following is NOT a renewable energy source?

a) Solar

b) Wind

c) Coal

 c) Coal

2. India is the _____ largest electricity producer in the world.

a) First

b) Second

c) Third

d) Fifth

3. The generator in a power plant converts:

a) Chemical energy to mechanical energy

b) Mechanical energy to electrical energy

c) Mechanical to electrical

d) Heat to kinetic energy

4. Which of the following is a base load plant?

a) Diesel plant

b) Gas plant

c) Thermal plant

d) None

5. A solar power plant uses:

- a) Photovoltaic cells
- b) Diesel fuel
- c) Uranium rods

👉 **a) Photovoltaic cells**

6. Ujjwal Bharat Abhiyan is related to:

- a) Road safety
- b) Power sector reforms
- 👉 **b) Power sector reforms**
- d) Oil import reduction

7. Smart grid system helps in:

- a) Pollution control
- b) Real-time monitoring
- c) Load forecasting
- 👉 **b) Real-time monitoring**

8. Which state in India has the highest solar power capacity?

- a) Odisha
- 👉 **b) Rajasthan**
- c) Bihar
- d) Kerala

9. National Hydrogen Mission aims to promote:

- a) Coal production
- 👉 **b) Nuclear power**

c) Green hydrogen energy

d) Biomass export

10. Which of these is a future trend in power generation?

a) Manual grids

b) Floating solar

c) Floating solar

d) Coal imports