SNS COLLEGE OF TECHNOLOGY

An Autonomous Institution

Coimbatore-35

23GET102 – Basic Civil and Mechanical Engineering

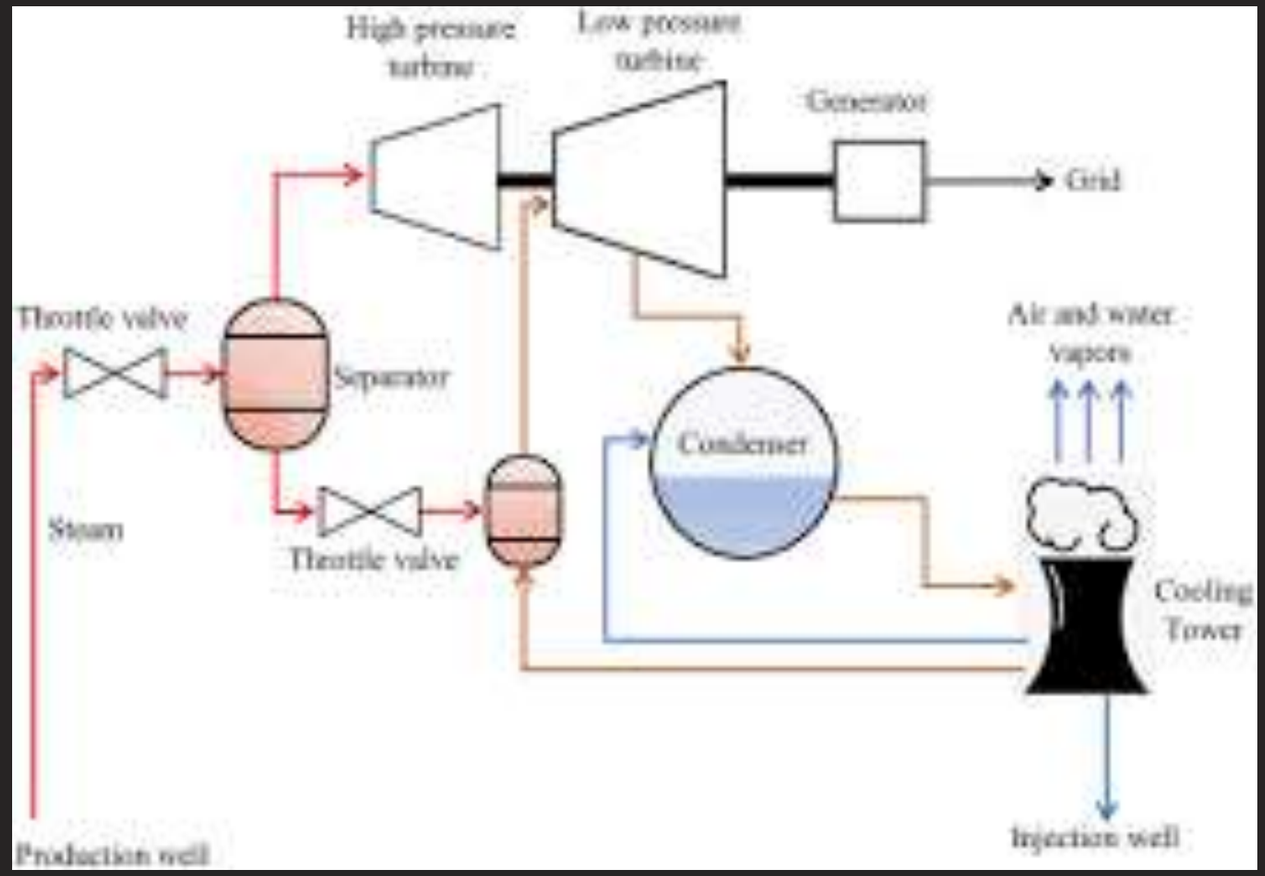
I - CST/ I SEMESTER

UNIT IV : I.C Engines and Power Plant Engineering

Topic 5 : Steam Power Plant

Steam Power Plants: Harnessing Heat to Generate Electricity

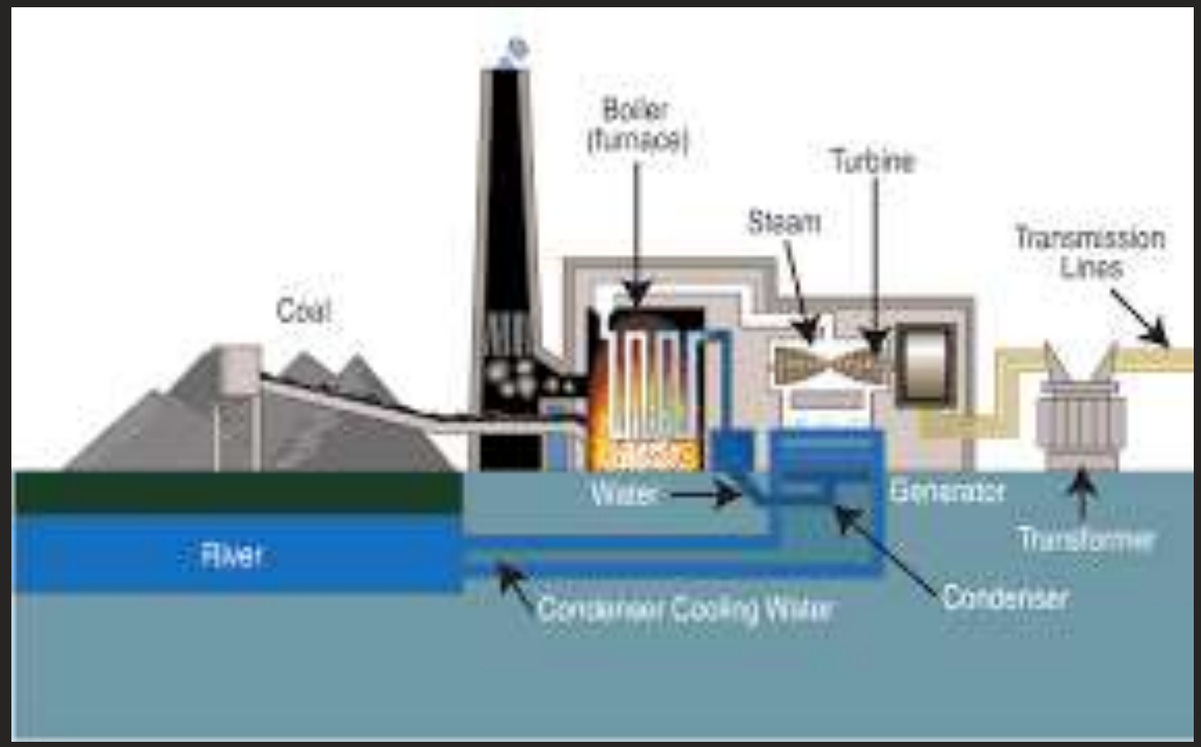
Discover how thermal energy is transformed into the electricity that powers our world through sophisticated engineering and thermodynamic principles.



What is a Steam Power Plant?

A steam power plant is a sophisticated facility that converts heat energy from various fuels into electrical energy using steam as the working fluid. These engineering marvels form the backbone of global electricity generation, particularly in regions where fossil fuels remain abundant.

The system relies on five core components working in perfect harmony: the boiler generates high-pressure steam, the turbine converts thermal energy to mechanical rotation, the generator produces electricity, the condenser returns steam to liquid, and auxiliary systems maintain optimal operation.



The Heart of the Plant: The Boiler

Fuel Combustion

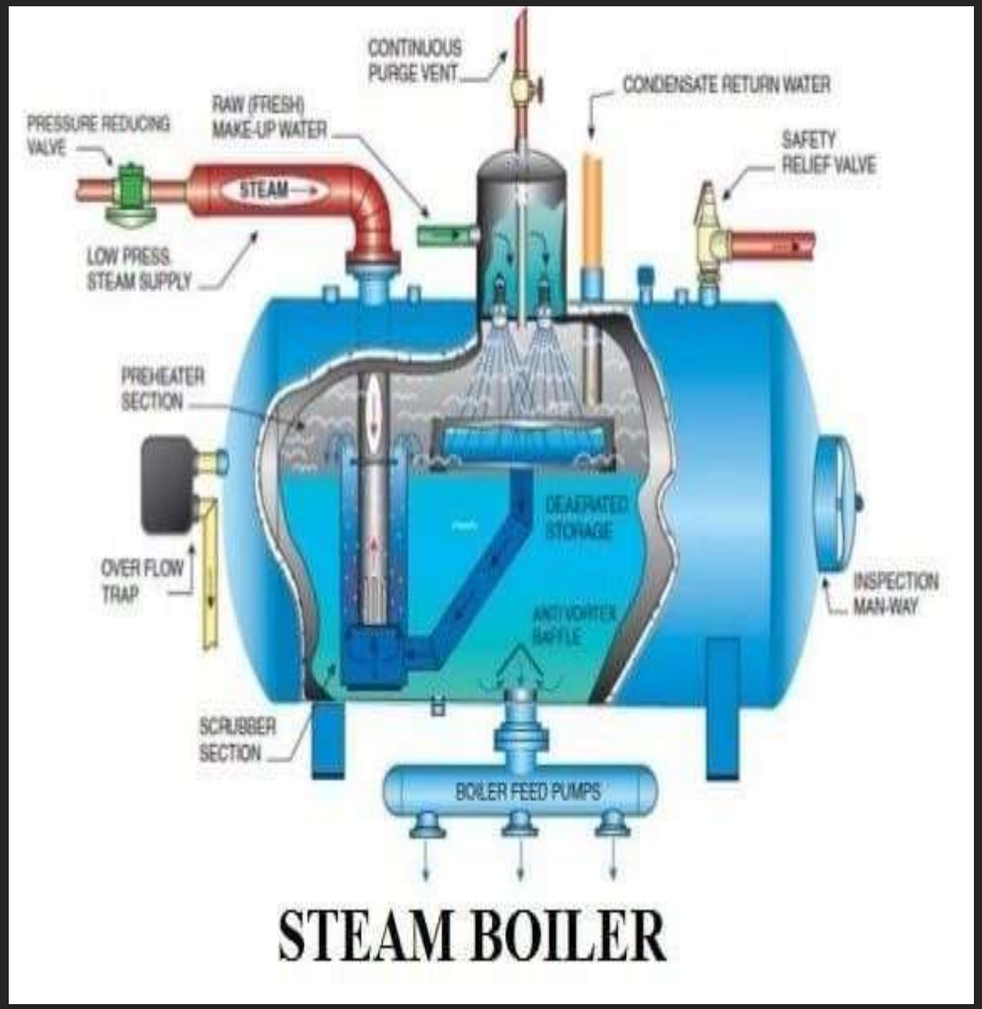
Burns coal, natural gas, oil, or biomass to generate intense heat for water conversion

Heat Transfer

Advanced designs maximize efficiency through optimized heat exchange surfaces

Fuel Flexibility

Modern boilers support multiple fuel types and co-generation applications



Advanced boiler technology has revolutionized plant efficiency, with modern designs achieving heat transfer rates that minimize fuel consumption while maximizing steam output. These systems can adapt to different fuel sources, providing operational flexibility in changing energy markets.

From Steam to Electricity: Turbine & Generator

High-Pressure Steam Entry

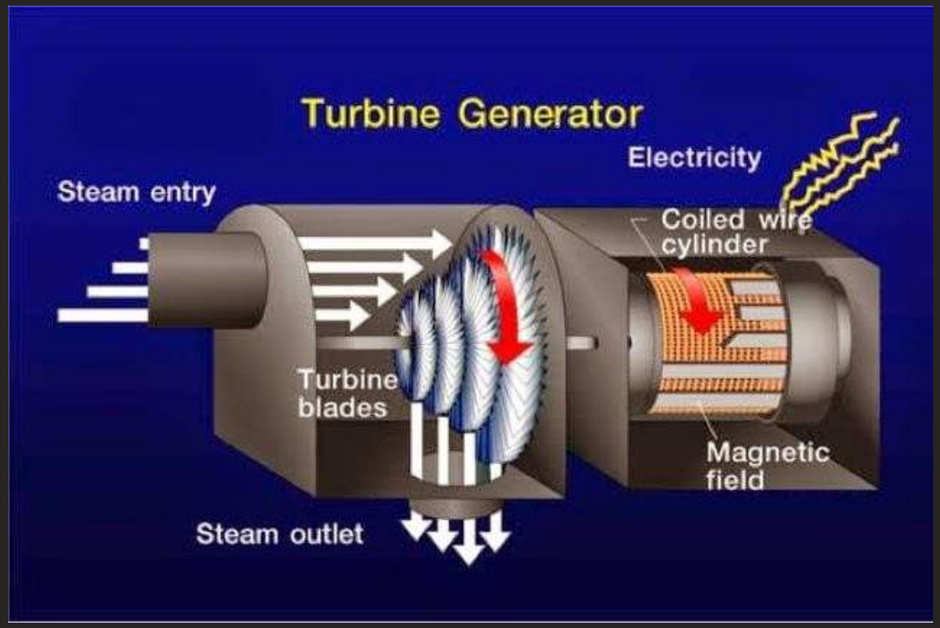
Superheated steam enters at extreme pressure and temperature

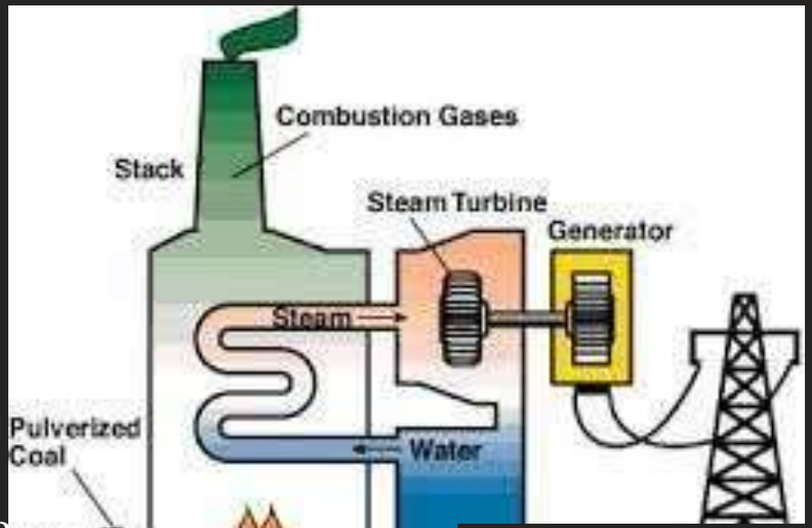
Energy Conversion

Steam expands through precision-engineered turbine blades, spinning the shaft

Electricity Generation

Generator converts mechanical rotation into electrical power via electromagnetic induction





Multi-stage turbines featuring high, intermediate, and low-pressure sections extract maximum energy from steam as it expands and cools, achieving remarkable thermodynamic efficiency.

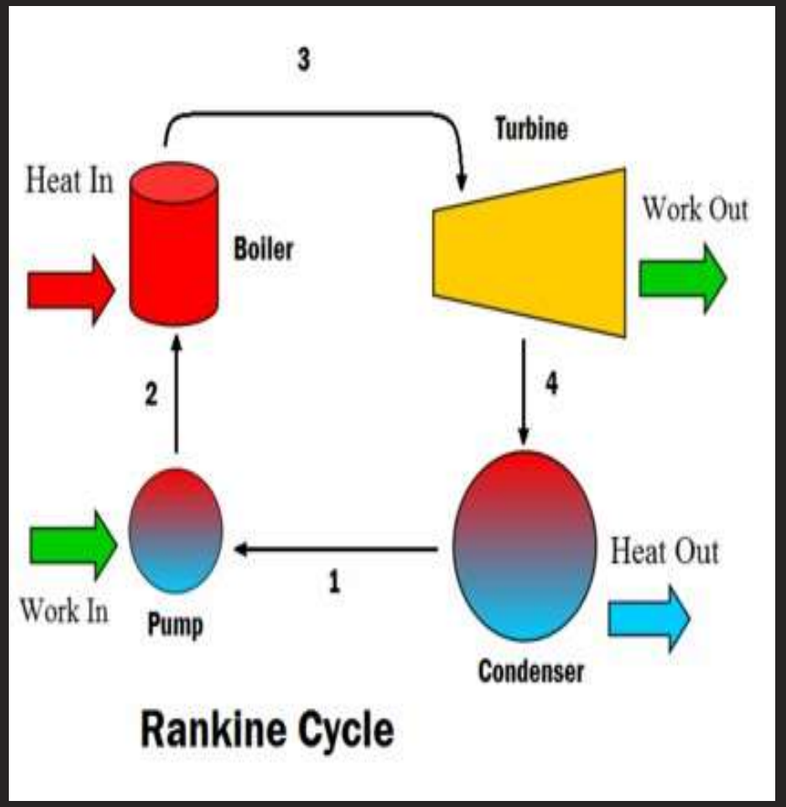
The Rankine Cycle: The Thermodynamic Backbone

Water Pumping

Condensed water is pressurized and prepared for heating

Condensation

Exhaust steam cools back to liquid, enabling water reuse



Heat Addition

Water transforms into high-pressure superheated steam in the boiler

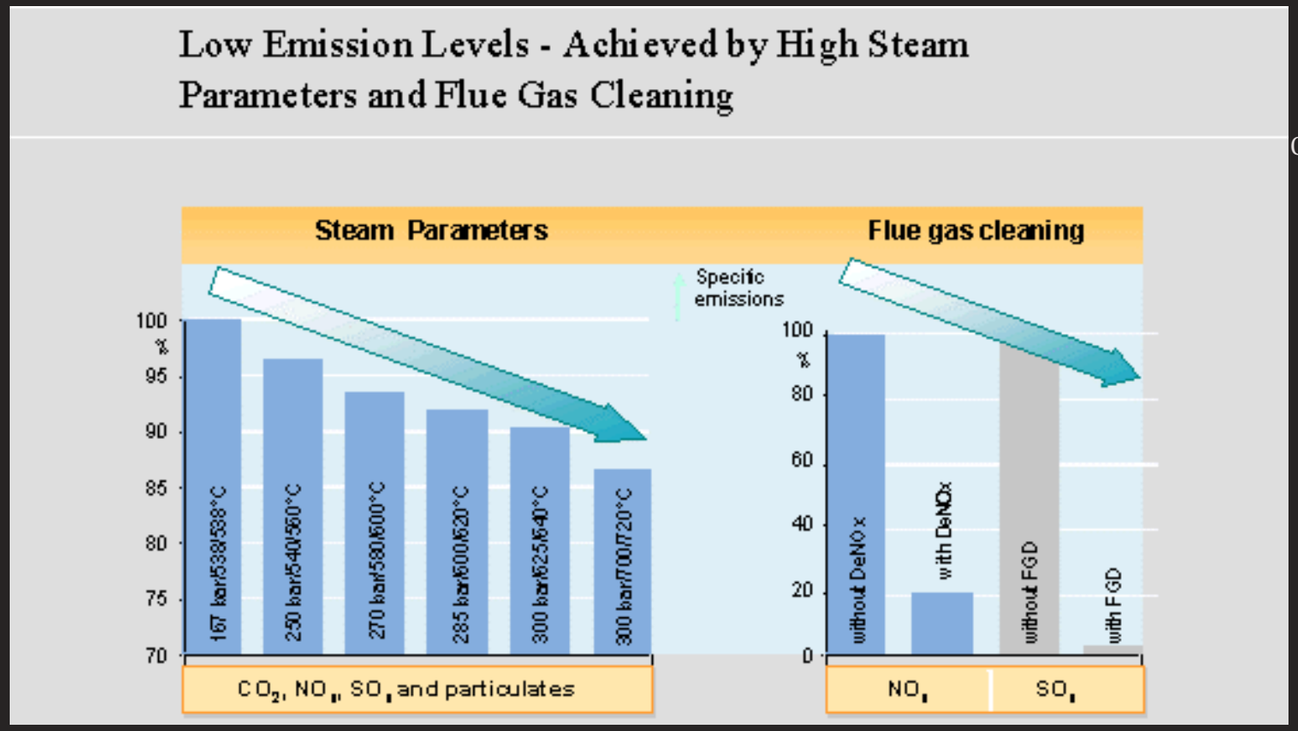
Work Extraction

Steam expands through turbine stages, producing mechanical power

The condenser plays a crucial role in maintaining cycle efficiency by creating vacuum conditions that allow maximum energy extraction. Feedwater heaters use extracted turbine steam to preheat incoming water, reducing fuel requirements and boosting overall plant performance.

Efficiency & Innovation

Supercritical and Ultra-Supercritical Plants



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Supercritical Pressure

Operating above 22.12 MPa enables higher efficiency

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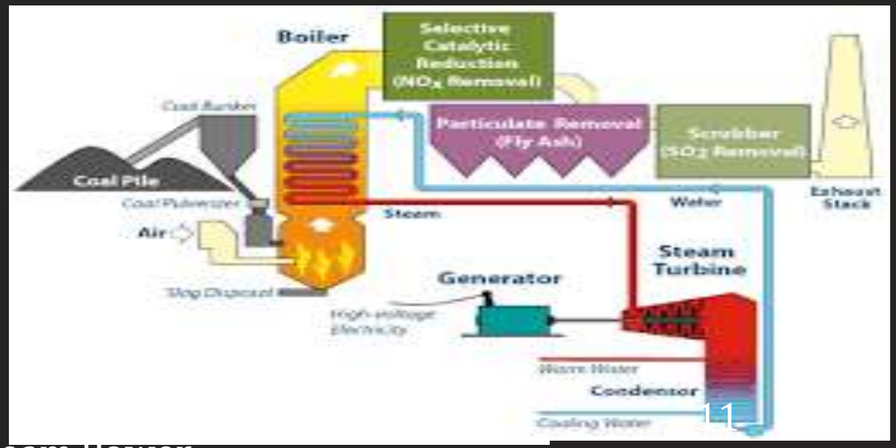
Ultra-Supercritical Pressure

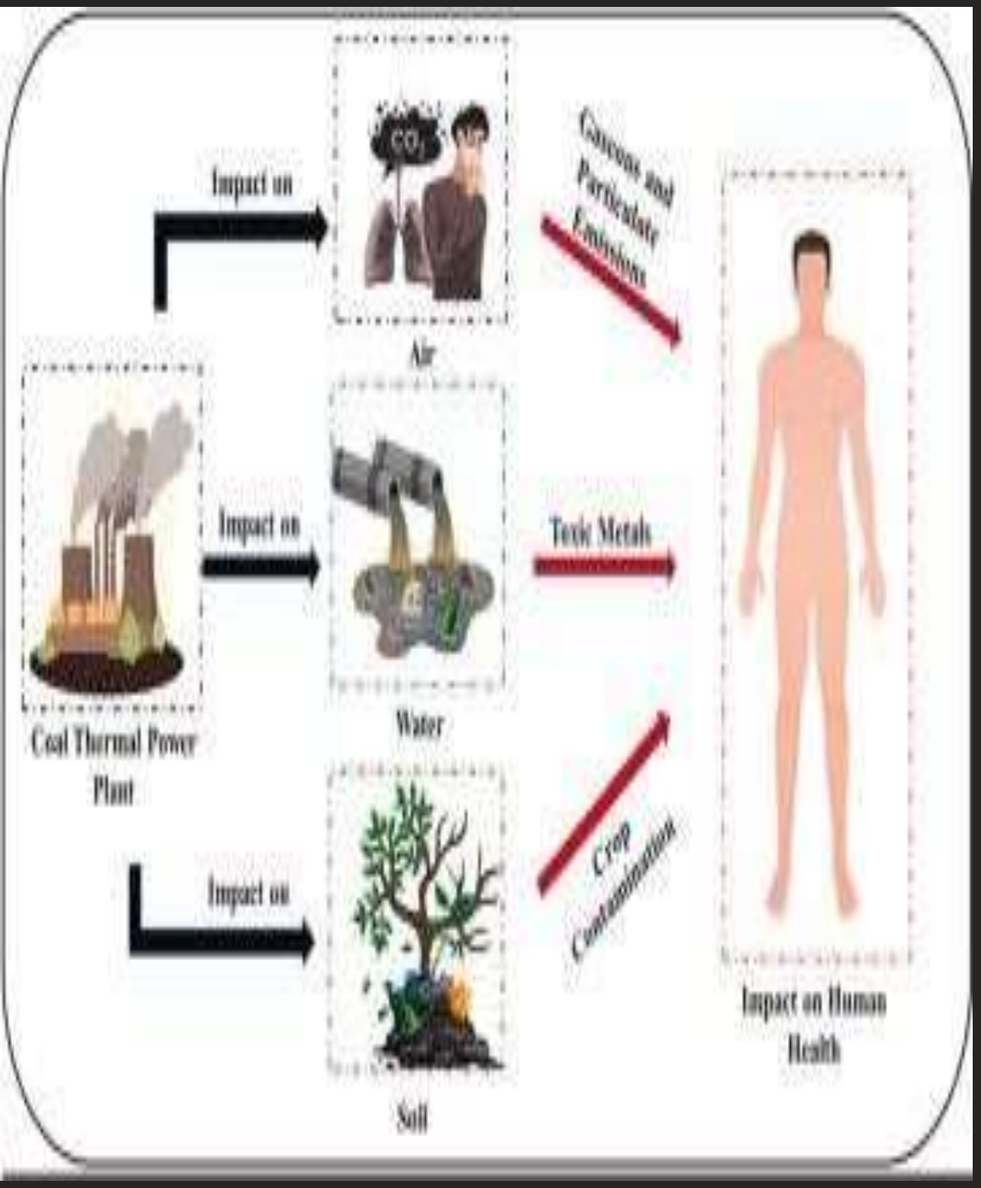
Advanced plants exceed 25 MPa and 593°C

45%

Thermal Efficiency

Ultra-supercritical plants achieve industry-leading efficiency





Environmental Considerations

Air Quality Control

Advanced scrubbers, electrostatic precipitators, and selective catalytic reduction systems remove sulfur dioxide, particulates, and nitrogen oxides from exhaust gases.

Waste Heat Management

Cooling towers and water-based systems manage thermal discharge. Cogeneration captures waste heat for district heating or industrial processes.

Emissions Reduction

Fuel switching, efficiency improvements, and carbon capture technologies help minimize greenhouse gas footprints and support climate goals.

Modern environmental controls represent significant investments but are essential for regulatory compliance and corporate sustainability commitments. The integration of these systems demonstrates that thermal power generation can evolve toward cleaner operation.

Challenges & Future Outlook

Current Challenges

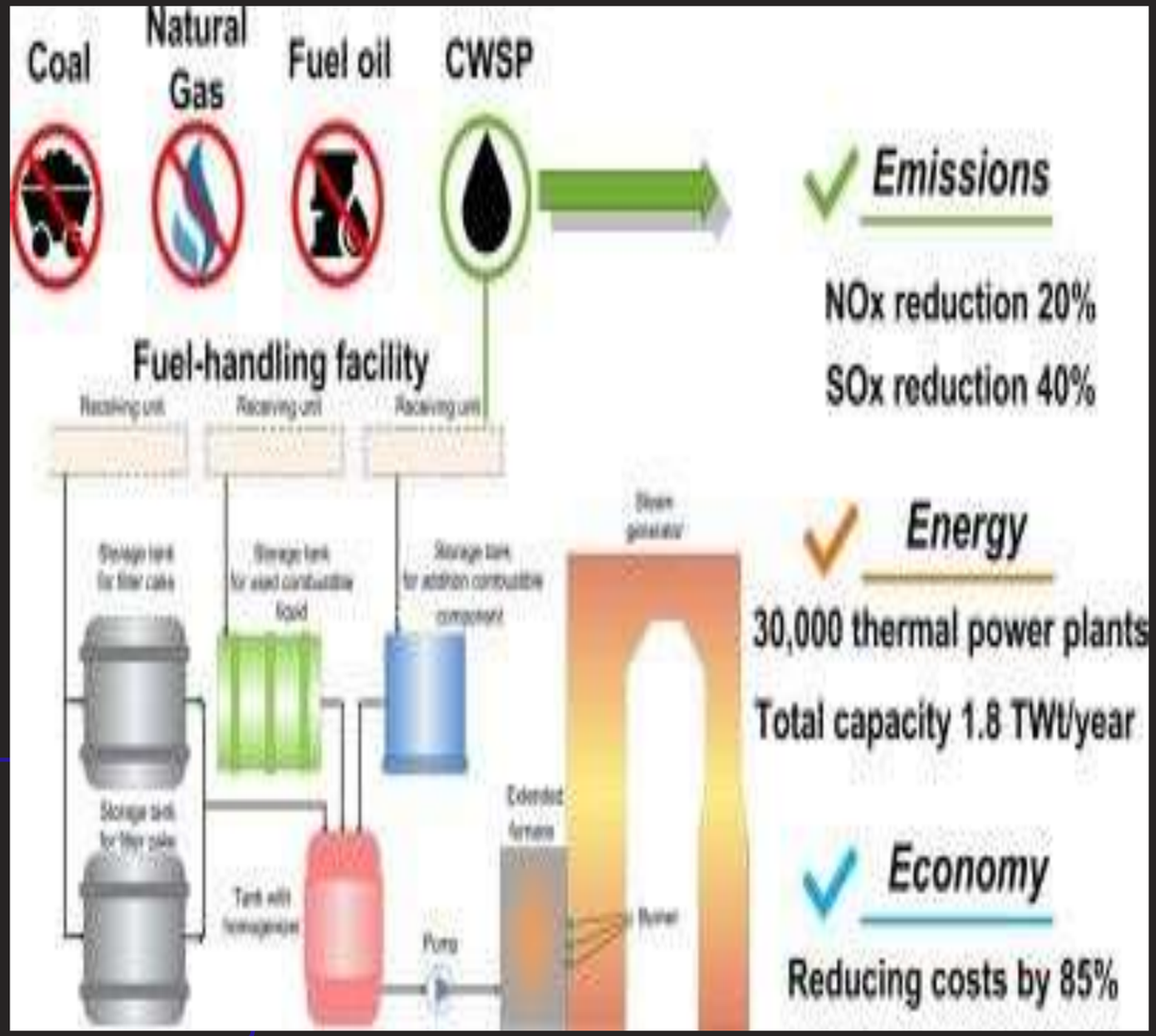
High maintenance costs, aging infrastructure, and operational complexity require continuous investment. Competition from renewable energy sources and natural gas plants creates market pressure.

Emerging Trends

- Integration with renewable energy for hybrid systems
- Supercritical CO_2 cycles for compact, efficient designs
- Digital twins and AI-driven plant optimization
- Flexible operation to support grid balancing

Path Forward

Continued innovation focuses on boosting efficiency beyond 50%, reducing emissions through carbon capture, and ensuring reliable baseload power as energy systems transition toward sustainability.



Assessment- Quiz

1. The Hidden Path PuzzleQuestion:Steam leaves the boiler at 500°C and 10 MPa and eventually returns to the boiler as condensate at 50°C.You must identify the missing step in this flow:Boiler → ? → Condenser → Feed Pump → BoilerWhich component fits the "?" and why?Answer: Turbine

   Explanation:

   The turbine is where steam expands to produce mechanical (shaft) work before it goes to the condenser. So the correct sequence is:

   Boiler → Turbine → Condenser → Feed Pump → Boiler

2. The Efficiency EnigmaQuestion:A turbine produces 300 MW of power. The heat supplied by the boiler is 900 MW.If condenser efficiency drops (exhaust steam temperature rises), which efficiency metric decreases most — boiler, turbine, or overall plant — and why?Answer:✅ Overall Plant Efficiency decreases

.Explanation: A higher condenser temperature means higher back pressure on the turbine, reducing expansion and work output. Boiler efficiency is mostly unchanged, but turbine output — and thus total plant efficiency — falls.

References

https://www.youtube.com/watch?v=IdPTuwKEfmA&t=62s

https://www.youtube.com/watch?v=-MTfFvSMrRM&list=PLwdnzlV3ogoXZIxDYHM3aavBr5E8kDvH8

https://www.youtube.com/watch?v=Z0auqiqfDyA&list=PLwdnzlV3ogoXZIxDYHM3aavBr5E8kDvH8&index=5