Thermal Engineering - II

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Module 1: (15 hours)

Properties of steam: use of steam tables and Mollier chart; separating and throttling calorimeter; properties of atmospheric air; psychrometric chart; **energy scenario:** national and global; vapour and combined power cycle; Carnot vapour cycle; ideal Rankine cycle; deviations in an actual Rankine cycle; methods to increase the efficiency of Rankine cycle, reheat and regenerative cycles; open and closed feed water heaters; deaerator; co-generation; combined gas power cycles; vapour compression refrigeration cycle: ideal and actual; air refrigeration cycle; components and systems.

Module 2: (11 hours)

Steam generators: fire tube, Lancashire, locomotive and Nestler boilers; water-tube; Babcock and Wilcox and bent-tube boilers; mountings and accessories; schematic diagram of a modern steam generator; combustion equipment; overfeed and underfeed stokers; travelling-grate and spreader stokers, pulverized coal burners, cyclone furnace, fluidized-bed combustion; coal based synthetic fuels;

Steam nozzles: condition for maximum discharge, design for throat and exit areas, effect of friction, supersaturated flow.

Module 3: (13 hours)

Steam turbines: classification, impulse and reaction turbines; velocity diagrams, efficiencies, end thrust, blade height; turbine performance and governing;

condensers: surface and mixing condensers; solution of problems on evaporative cooling towers and wet cooling towers; different types of modern wet and dry cooling towers; power plant economics; load curve and load duration curve, load factor, diversity factor, capacity factor and use factor, depreciation and replacement; environmental aspects of thermal power systems; dust collectors; waste heat recovery techniques.

References:

1. Y. A. Cengel and M. A. Boles, *Thermodynamics - An engineering approach*, 4th ed., Tata McGraw Hill, 2005.

2. M. M. El-Wakil, *Power Plant Engineering*, 1st ed. McGraw Hill, 1985.

3. W. A. Vopat and B. G. A. Skrotzki, *Power Station Engineering and Economy*. Tata McGra Hill, 1999.

4. P. K. Nag, *Power Plant Engineering*, 4th ed. McGraw Hill, 2017.

5. W. F. Stoecker and J.W. Jones, *Refrigeration & Air Conditioning*, 2nd ed. McGraw Hill, 1983.

6. C. P. Arora, *Refrigeration & Air Conditioning*, 3rd ed. McGraw Hill, 2008

Course outcomes

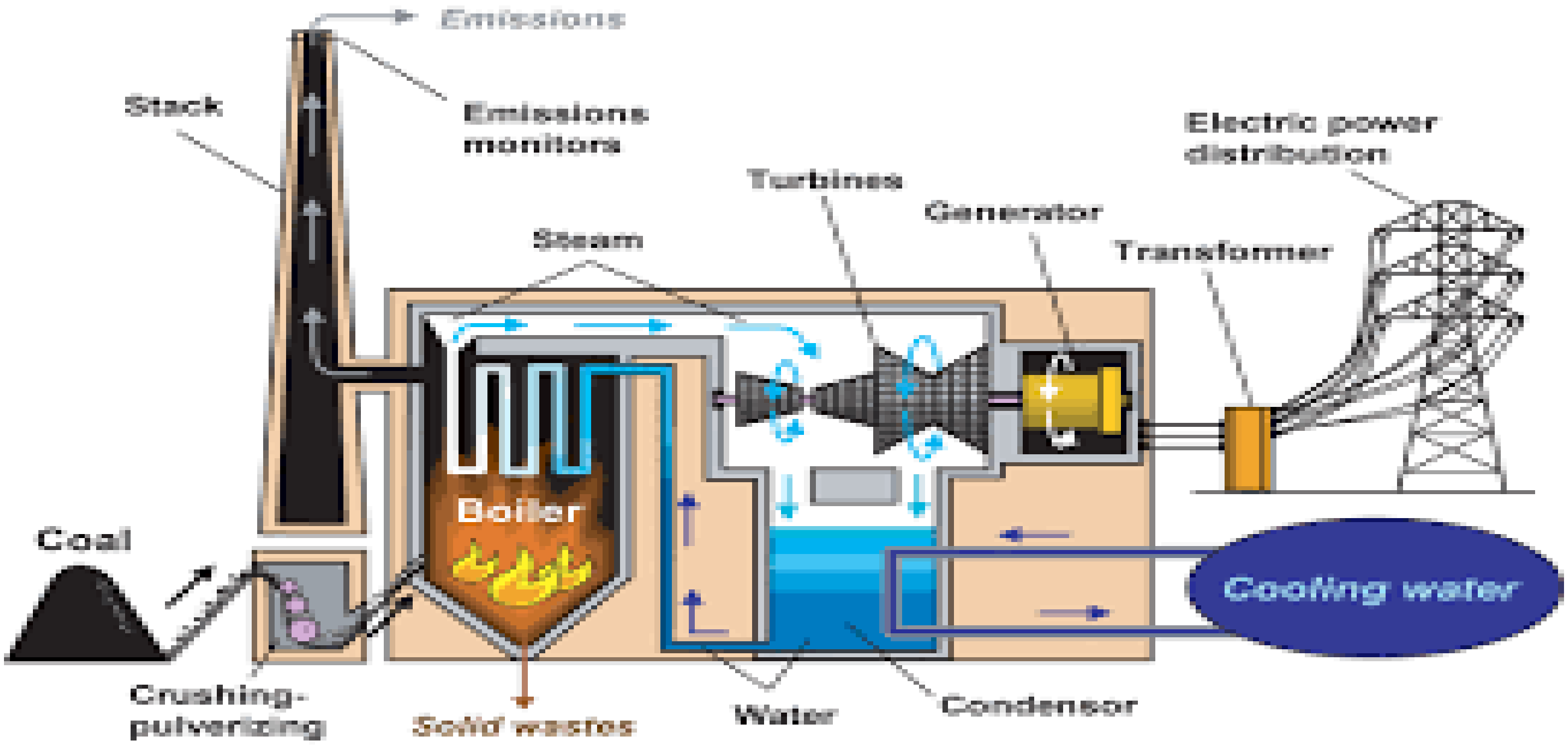
CO1: Apply thermodynamic cycles to steam power plant and refrigeration systems.

CO2: Develop thermal refinement methods for performance improvement of steam power plant.

CO3: Analyse the components of steam power plant and refrigeration systems.

CO4: Acquire knowledge on pollution control methods.

STEAM POWER PLANT



Energy Scenario of India

- Installed power capacity of India as on 9-1-2019 (3,57,875 MW) :

- Coal – 58.3%
- Gas – 7.6%
- Oil – 0.3%
- Hydel – 13.6%
- Nuclear – 2%
- RES – 18.2%

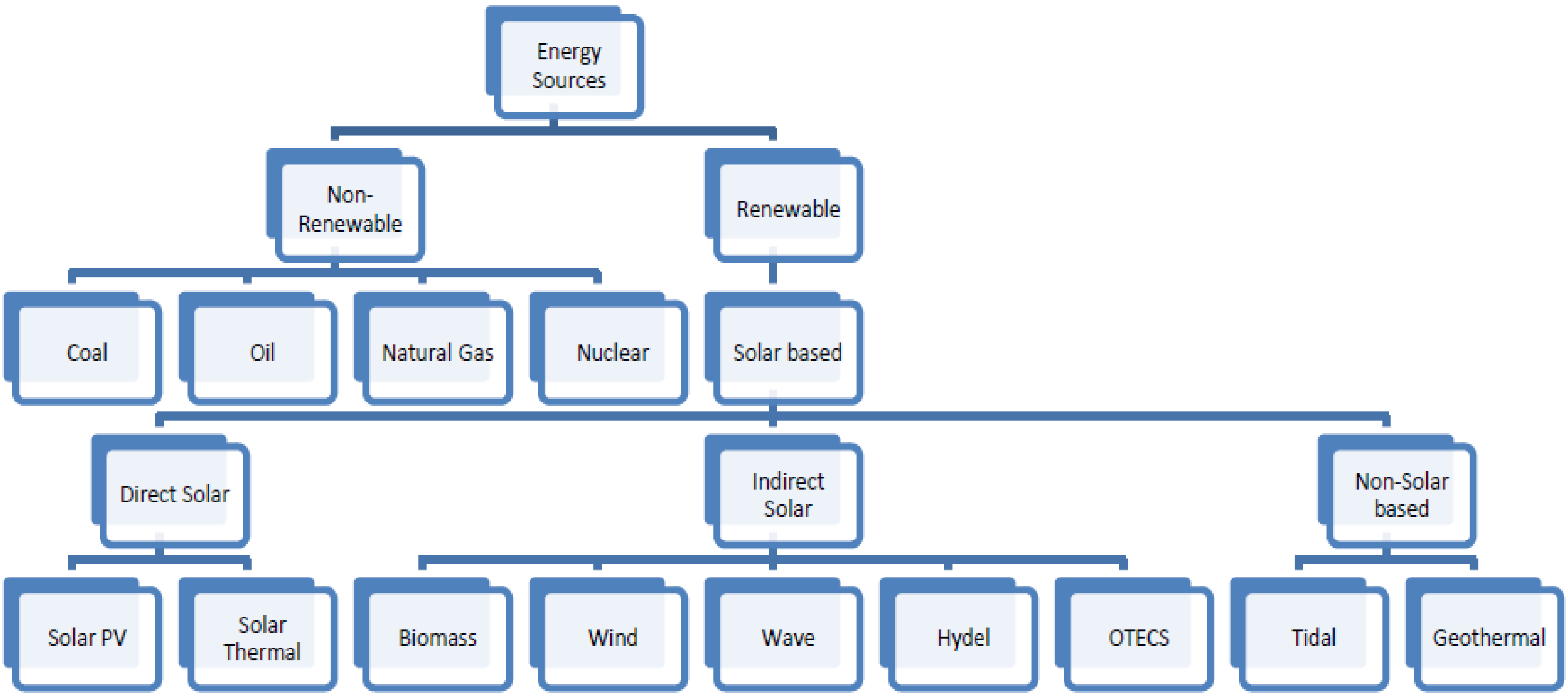
Different shares:

- State sector – 24.4%
- Central sector – 31.1%
- Private Sector – 44.5%

- CO_2 Emissions per kWh energy :
- Coal - 0.98 kg/kWh
- Gas – 0.52 kg/kWh
- Oil – 0.77 kg/kWh

- Advantage of nuclear power:
- 1 kg of coal generates 8 kWh of heat where as 1 kg of uranium 235 generates 2,40,00000 kWh heat by fission

CLASSIFICATION OF ENERGY RESOURCES



Types of Steam power plants

- 1. Central power stations :
  - Power generated is for **general sale**
  - Also called **Condensing** power plants
- 2. Captive power stations / Co- Generation plants :
  - Power generated is for **industries internal usage**
  - Also called **Non – Condensing type**

Steam power plant

- It is a heat engine
- It is an external combustion engine

- Definition of IC and EC engines

- Definition of IC Engine:

  Examples: SI and CI Engines

  Definition of EC Engine:

  Example: Steam power plant and closed cycle gas turbine power plant (CCGTPP)

- Steam is an important medium of producing mechanical energy.

- Steam has the following advantages:

  It can be raised from **water which is available in abundance,**

  It does **not react much with the materials of the equipment** of power plant and

  It is **stable at the temperature** required in the plant.

- Steam is used to drive steam engines, steam turbines etc.

- Steam power station is most suitable where coal is available in abundance.
- Thermal electrical power generation is one of the major method.
- Out of total power developed in India about **66% is thermal based.**

A steam power plant must have following equipments :

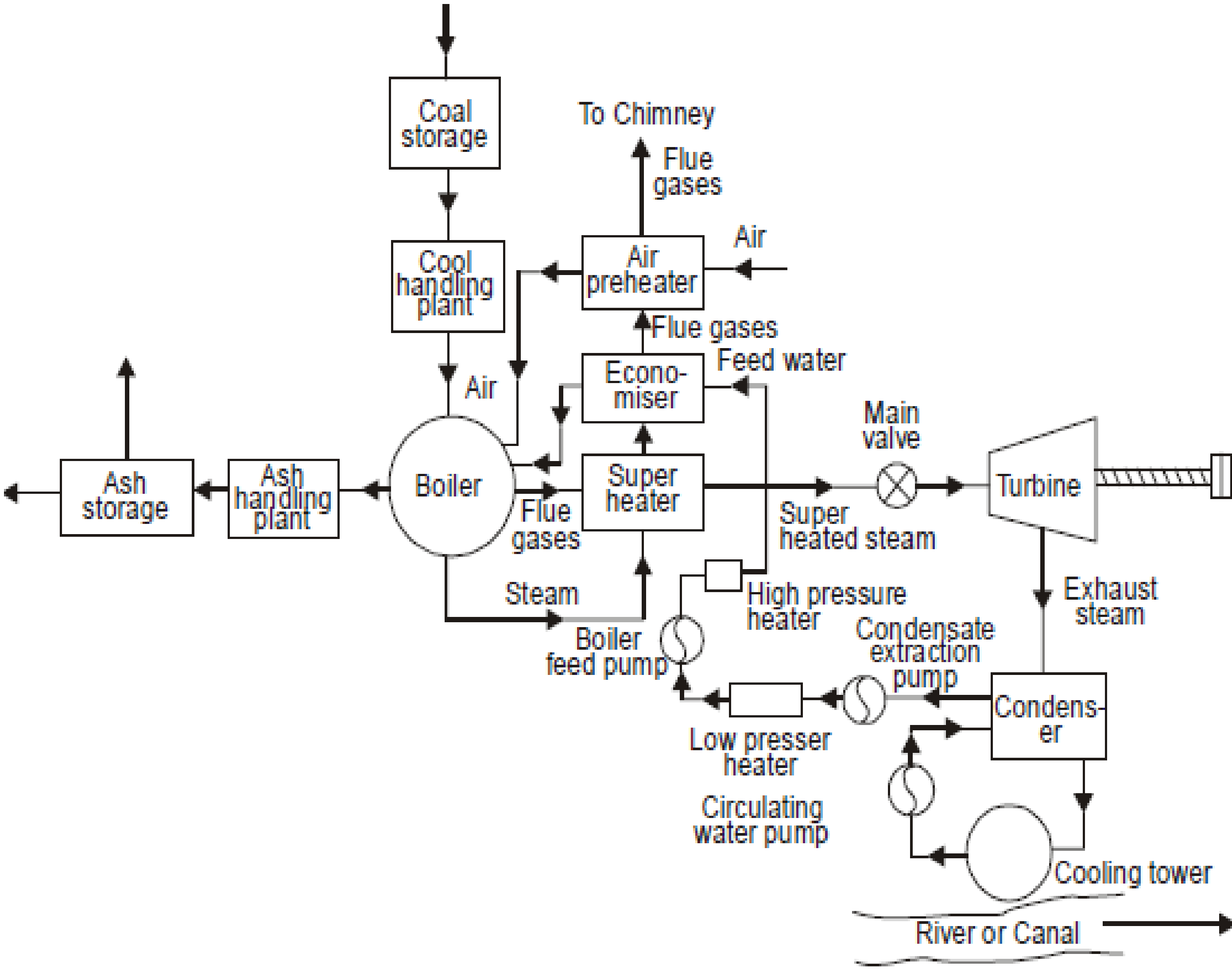


Fig. 4.1. Steam Power Plant.

A steam power plant must have following equipments :

1. A furnace to burn the fuel.

2. Steam generator or boiler containing water.
   Heat generated in the furnace is utilized to convert
   water in steam.

3. Main power unit such as an engine or turbine to use the heat of steam and perform work.

4. Piping system to convey steam and water.

The flow sheet of a thermal power plant consists of the following four main circuits :

(*i) Feed water and steam flow circuit*

(*ii) Coal and ash circuit*

(*iii) Air and gas circuit*

(*iv) Cooling water circuit.*

- A steam power plant using steam as working substance works basically on Rankine cycle.

- Steam is generated in a **boiler,** expanded in the **prime mover**, condensed in the **condenser** and fed into the **boiler** again.