Module 9: Power Generation

30 Important Questions and Answers

1. Sources of Energy

Q1. What are the sources of energy? How are they classified?

Ans: Sources from which useful energy is obtained. Conventional sources: coal, oil, natural gas, water (hydro) and nuclear fuels. Non-conventional sources: solar, wind, tidal, geothermal and biomass.

Q2. What is the difference between renewable and non-renewable sources?

Ans: Renewable sources are replenished naturally and will not run out (solar, wind, hydro, tidal, biomass). Non-renewable sources exist in limited stock and are used up (coal, oil, natural gas, uranium).

Q3. State the advantages and limitations of non-conventional energy sources.

Ans: Advantages: inexhaustible, clean with little pollution, low running cost and suited to remote areas. Limitations: supply depends on weather and time (intermittent), low energy density, and high initial cost per unit of power.

Q4. What are the drawbacks of fossil fuels?

Ans: Reserves are limited and will be exhausted. Burning them releases carbon dioxide, sulphur dioxide, ash and other pollutants that cause air pollution and global warming. Coal is still the main fuel for power generation in India.

2. Basics of Power Generation

Q5. What is electrical power generation? Name the stages of a power system.

Ans: Converting other forms of energy (heat, water, wind, sunlight) into electrical energy. The stages are generation, transmission, distribution and utilisation.

Q6. What are the roles of the prime mover and the alternator in a power station?

Ans: The prime mover (steam turbine, water turbine, diesel engine or gas turbine) supplies mechanical energy and rotates the rotor of the alternator. The alternator (synchronous generator) converts it into AC electrical energy at 11 kV to 33 kV, which is stepped up for transmission. Frequency f = P x N / 120.

Q7. Define connected load, maximum demand, demand factor, load factor and diversity factor.

Ans: Connected load: total rating of all connected equipment. Maximum demand: highest load in a given period. Demand factor = maximum demand / connected load. Load factor = average load / maximum demand. Diversity factor = sum of individual maximum demands / simultaneous maximum demand of the whole system (always more than 1).

Q8. A station has a maximum demand of 100 MW and supplies 43,200 MWh in 30 days. Find the load factor.

Ans: Average load = 43,200 / (30 x 24) = 60 MW. Load factor = 60 / 100 = 0.6, that is 60%.

3. Thermal Power Station

Q9. Explain the working principle of a thermal power station.

Ans: Coal is burned in a boiler to convert water into high-pressure steam. The steam drives a steam turbine coupled to an alternator. Energy conversion: chemical (fuel) to heat to mechanical to electrical energy.

Q10. Describe the flow of a thermal power station in order.

Ans: Coal handling, boiler (with superheater, economiser and air preheater), steam turbine, alternator. Exhaust steam goes to the condenser, the condensate is pumped back to the boiler by the feed pump, and ash is removed by the ash handling plant. Flue gas leaves through the chimney.

Q11. State the functions of the boiler, superheater, economiser, condenser and cooling tower.

Ans: Boiler: produces steam. Superheater: raises steam temperature above saturation. Economiser: heats feed water using flue gas. Condenser: turns exhaust steam into water. Cooling tower: cools the condenser cooling water for reuse.

Q12. What factors are considered in selecting a site for a thermal power station?

Ans: Availability and cost of coal and its transport, plenty of water for steam and cooling, ash disposal area, distance from the load centre, availability of land at low cost, good foundation soil and distance from populated areas.

Q13. State the advantages and disadvantages of thermal power stations.

Ans: Advantages: lower initial cost than hydro, less space, and can be built near the load. Disadvantages: pollution and ash, high running cost, low overall efficiency (about 30-40%), large water need and fuel transport.

4. Hydro-Electric Power Station

Q14. Explain the principle of a hydro power plant. Find the power for a flow of 10 m^3/s at 50 m head and 85% efficiency.

Ans: Water stored at height has potential energy, which becomes kinetic energy as it falls through the penstock, drives the turbine, and the alternator produces electricity. P = 9.81 x Q x H x efficiency = 9.81 x 10 x 50 x 0.85 = approx. 4170 kW.

Q15. Name the main parts of a hydro power station.

Ans: Catchment area, dam and reservoir, intake with trash rack, penstock, surge tank, water turbine, alternator, powerhouse and tailrace.

Q16. What are the types of hydro plants and turbines?

Ans: Plants: run-of-river, storage (reservoir) and pumped-storage. Turbines: Pelton wheel for high head, Francis for medium head and Kaplan for low head.

Q17. State the advantages and disadvantages of hydro power stations.

Ans: Advantages: free, clean and renewable fuel, low running cost, long life, quick start and can also give irrigation and flood control. Disadvantages: very high initial cost, depends on rainfall, long construction time and displacement of people and land.

5. Nuclear Power Station

Q18. Explain the principle of a nuclear power station.

Ans: Splitting of the nucleus of a heavy atom such as uranium-235 by a neutron (nuclear fission) releases a large amount of heat, and the neutrons released keep up a chain reaction. The heat makes steam that drives a turbine and alternator.

Q19. Name the main parts of a nuclear reactor and their functions.

Ans: Fuel (enriched or natural uranium), moderator (heavy water, graphite or water) that slows the neutrons, control rods (cadmium or boron) that absorb neutrons to control the reaction, coolant (water, heavy water, CO_2 or liquid sodium) that carries heat away, and concrete shielding.

Q20. State the advantages and disadvantages of nuclear power stations.

Ans: Advantages: a very small amount of fuel gives huge energy, no smoke or carbon dioxide, and reliable base-load power. Disadvantages: high initial cost, radioactive waste disposal, risk of accidents and the need for highly skilled staff.

6. Diesel and Gas Power Stations

Q21. Describe a diesel power station with its uses, advantages and disadvantages.

Ans: A diesel engine drives an alternator. It is used as a standby or emergency source (hospitals, hotels, buildings) and in remote areas. Advantages: quick start and stop, low initial cost, small size. Disadvantages: high fuel cost, noise, pollution and limited capacity.

Q22. Describe a gas turbine power plant.

Ans: Air is compressed, mixed with fuel (natural gas) and burned in the combustion chamber. The hot gas drives the gas turbine, which turns the alternator and the compressor. It starts quickly. In a combined-cycle plant, the exhaust heat makes steam for a steam turbine, giving much higher efficiency.

7. Solar Power Generation

Q23. Explain how a solar photovoltaic (PV) plant works.

Ans: Solar cells (silicon) convert sunlight directly into DC electricity by the photovoltaic effect. A charge controller and battery store energy, and an inverter converts DC into AC for use or for feeding the grid.

Q24. Explain solar thermal power generation.

Ans: Mirrors or concentrators (parabolic trough, solar tower or dish) focus sunlight on a receiver to heat a fluid and produce steam that drives a turbine and alternator. Solar water heaters also use this thermal principle.

Q25. State the advantages and limitations of solar power.

Ans: Advantages: free and clean, no moving parts, low maintenance, suits remote sites. Limitations: available only in daytime and in good weather, panel efficiency is low (about 15-22%), needs large area, storage and has high initial cost.

8. Wind Power Generation

Q26. Explain the working of a wind power plant and name its main parts.

Ans: Wind turns the rotor blades, which drive a generator through a gearbox. Main parts: blades, hub, nacelle, gearbox, generator, tower, yaw and pitch control and transformer. The turbine works only within a suitable wind speed range (cut-in to cut-out).

Q27. How much power is available in wind? State the advantages and limitations of wind power.

Ans: Wind power $P = 0.5 \times \text{air density} \times \text{swept area} \times v^3$, so power rises with the cube of wind speed. Advantages: free and clean, and land can still be used for farming. Limitations: intermittent, needs a windy site, noise, and bird impact.

9. Other Renewable Sources

Q28. Explain geothermal power generation.

Ans: Heat from inside the Earth (hot water and steam from wells or hot springs) drives a turbine and alternator. It gives continuous power with little pollution, but suitable sites are limited.

Q29. Explain tidal power generation.

Ans: A barrage across a bay traps sea water at high tide, and the water flows through turbines during the tide's rise and fall to turn the alternator. Output is predictable, but it needs a high tidal range, has high cost, limited sites and affects marine life.

Q30. Explain biomass and biogas power generation.

Ans: Agricultural waste, wood and cattle dung are burned, or digested in a biogas plant, to give methane-rich gas that runs a gas engine and alternator. It uses waste and is useful for villages, but needs a steady supply of raw material.