XE-I Energy Science

Section 1: Energy Resources and Conversion Technologies

Fossil energy resources: R/P ratio, estimation of reserves, unconventional fossil resources (coal bed methane, shale gas, gas hydrates, frozen methane), peak oil theory.

Nuclear energy resources: Energy-mass relation, nuclear reaction conservation laws, binding energy and Q-values, radioactive decay, fission and fusion.

Solar thermal systems: Solar radiation distribution and measurement, solar geometry, optical efficiency, thermal efficiency, energy conversation for solar thermal collectors, flat plate collectors, evacuated tube collectors, solar air heaters, concentrating collectors.

Solar photovoltaic (PV) systems: I-V characteristics, efficiency, fill factor, series and parallel connections, sizing of PV systems (load factor, days of autonomy, battery size, inverter size, PV array size), maximum power point tracking.

Biomass: Biomass resources, biomass composition, characterisation, conversion methods (pyrolysis, gasification, steam reforming), biofuels.

Wind energy conversion systems: Wind resource analysis, types and characteristics of wind turbines, Betz limit, wind turbine motor design considerations, blade profile, wind energy generators.

Hydropower: Hydro resources, hydro power plants, turbines (Pelton, Kaplan, Francis), small hydro systems.

Section 2: Energy Storage, Economics, Environment, and Efficiency

Energy storage systems: Batteries (capacity, C-rate, state of charge, state of health, depth of discharge, energy and power densities); conservation of energy and mass for thermal energy storage, pumped hydro storage, and compressed air storage; charging, discharging, and round-trip efficiency.

Economic analysis of energy systems: Simple Payback Period, Time Value of Money, Discount rate, Present Worth Factor, Capital Recovery Factor, Life Cycle Costing, Internal Rate of Return, Net Present Value, Annual Worth, Cost of Saved Energy, Levelized Cost of Energy.

Environmental impacts of energy use: Air pollution (SO_x, NO_x, CO, particulates), greenhouse gas emissions and their sources, emission factors and inventories.

Energy management: Energy auditing (methodology, analysis of past trends plants data), electrical systems (demand side management, power factor correction), motor efficiency testing, energy efficient motors, lighting (lighting levels, efficient options, fixtures, daylighting, timers), thermal and mechanical systems (insulation, compressors, pumps, boiler, heating and cooling systems).