

### **Unit 1: Biochemical Conversion Technology**

Anaerobic digestion – biogas plants – design - operation – utilization – high rate biomethanation process – anaerobic contact process – anaerobic filter – UASB –expanded bed reactor – fluidized bed reactor – sequential bed reactor – landfills. Bioethanol – feedstock – process – utilization - composting - methods – machinery.

### **Unit 2: Thermo chemical conversion Technology**

Thermochemical degradation – Arrhenius Law. Stoichiometric air requirement - Combustion process – design of combustion system – chemistry of combustion - construction - operation - combustion zones - flame structure - stability – emissions. Cofiring of biomass – biorefinery. Incinerators - layout. Biomass gasification – chemistry of gasification – gasifiers design - gas turbine systems - applications - shaft power generation - Gas cleaning & conditioning - thermal application - performance evaluation - economics. Pyrolysis – product recovery – types - biochar – biooil – operation – recovery.

### **Unit 3: Liquid Biofuels**

Global and India scenario in biofuel - potential – options for transport fuel – impacts studies. Biofuel – biofuel crops – production – processes – properties and characteristics. Biodiesel – chemistry –raw materials – availability – preparation - production – trans esterification methods – storage methods – blending options - by-product utilization. Bioethanol production from different biomass substrates – pre-treatment techniques –product recovery systems – blending characteristics. Biofuel versus fossil fuels - Energy balance on liquid biofuels.

### **Unit 4: Solar Energy Engineering**

Solar radiation availability - radiation measurement – transmittance-absorptance - flat plate collectors and concentrating collectors - collector efficiency - heat balance – absorber plate – types - selective surfaces. Design and types of solar driers – heat and mass transfer – performance. - solar thermal power stations – principle and applications. Solar stills and ponds - types - design and performance. Photovoltaics - types – characteristics – load estimation - batteries – invertors –operation - system controls. PV system installations – standalone systems – PV powered water pumping - hybrid system – lifecycle costing - solar technologies in green buildings

### **Unit 5: Wind Energy Engineering**

Nature of wind – wind structure and measurement - wind power laws - velocity and power duration curves - aero foil - tip speed ratio - dimensionless coefficients -torque and power characteristics - power coefficients - Betz coefficient. Wind tunnel testing - axial momentum theory - momentum theory – blade element theory - strip theory - tip loss factor of HAWT rotors - taxonomy. Wind mill – types – design – materials – loads – subsystems – power curve. Upwind

and downwind systems. Stand-alone system - grid system – batteries. Wind energy storage - wind farms - wheeling and banking - testing and certification procedures.

### **Unit 6: Biochemical and Process Engineering**

Hierarchy of cellular organisation - role of microbes and enzymes. Kinetics of enzyme – catalysed reactions - enzyme substrate complex - enzyme action - Simple enzyme kinetics - Michealis - Menten equation. Growth kinetics in growth culture. Kinetics of reversible reactions. Kinetics on substrate utilization - Monod model. Immobilized enzymes – effect of immobilization. Transport phenomena in bioprocess system - gas liquid mass transfer in cellular systems - Oxygen transfer rates - mass transfer. Heat transfer in bioreactors – methods of sterilization of gases and liquids. Ideal bio reactors - multi phase bio reactors - batch, CSTR and plug flow reactors. Stoichiometry and mass balance in bioreactors. Fermentation technology – design and development of fermenters for bioconversion - pilot scale and scale up operations. Product formation and downstream processing. Economics of bioconversion - impact on environment.

### **Unit 7: Power Generation and Energy Storage**

Power generation basis – potential – types – comparison. Diesel and Gas turbine power plant - basic engine components – types – cooling system – lubricating system –combined cycle. Nuclear Power Plant - nuclear waste & its disposal. hydro power plant – classification & selection of turbines – governing mechanisms of turbine – draft tubes – micro hydro power plants. Geothermal power plants – Tidal power plants – wind power plant – solar power plant – direct energy conversion. Energy storage systems – mechanical energy storage – electrical storage – chemical storage – electromagnetic energy storage – thermal energy storage – biological storage.

### **Unit 8: Energy Auditing and Management**

Energy conservation and its importance – energy strategy for the future – energy conservation act and its features. Energy management – principles – energy audit strategy - types – detailed energy audit – steps. Energy performance – bench marking – fuel substitutions – energy audit instruments – material and energy balance. Energy efficiency in thermal utilities – methodology - performance evaluation. Energy audit in electrical utilities methodology – energy conservation opportunities in motors – efficiency – energy efficient motors - energy efficiency in compressed air system. HVAC and refrigeration system – fans and blowers – fan performance – pumps - lighting system - energy auditing and reporting in industries

### **Unit 9: Modeling and Project Management in Energy**

Model – basics - - types of models. Physical -analogy models and applications. Mathematical models – concepts - types. Methodologies in model development – variables and factors – effect and significance of variables - softwares in model formulation – testing of models. Model studies in renewable energy gadgets and heat transfer applications – moving boundary models. Economics of energy sources – Investment and Cost management in various energy

technologies. Energy action planning – project planning - project development in energy technologies – cost economics – financial analysis – sensitivity and risk analysis.