SHIVAJI UNIVERSITY

M.Tech. in Energy Technology
Introduced from June, 2006

ADMISSION TO M. TECH. PROGRAMMES

A. Eligibility Criteria

1) The qualifying criteria for the M.Tech. course is as below.

1. Computer Science and Engineering

B.E. / B.Tech. (CSE/CT/CE/CS/IT/ Electronics/ Electrical)
M.Sc. (CS/ IT)
AMIE / IETE

2. Environmental Science and Technology

B. E. / B. Tech. (Cvil/ Chemical/ Environmental)
AMIE / IETE
M. Sc. (Environmental Science)

3. Energy Technology

B. E. / B. Tech. (Mechanical/ Automobile/ Production/ Chemical/ Electrical)
AMIE / IETE
M.Sc. (Electronics)

4. Electronics

B.E. / B. Tech. (ETC/ Electronics / Industrial Electronics)
AMIE / IETE
M. Sc. (Electronics)

B. Selection Basis :

Valid GATE Score.

Vacant seats, if any shall be filled up from the merit list prepared by conducting written test and interview by the University.

SHIVAJI UNIVERSITY
M.TECH PROGRAMMES

A. Computer Science and Engineering
B. Environmental Science and Technology
C. Energy Technology
D. Electronics.

1. Programme Duration : Two Years : Four Semesters

2. Intake : 18 per Programme

3. Programme structure and syllabus

First Year -

a. Theory Subjects :
   6 Compulsory Subjects
   4 Elective Subjects

b. Practicals for compulsory Subjects
c. Seminars - 2
d. Industrial Training – 8 weeks at the end of the First Year. (Summer)

Second Year –
a. Dissertation

4. Scheme of Marking

a.	Theory Subjects	-	1000
b.	Practicals	-	300
c.	Seminars	-	100
d.	Industrial Training	-	100
e.	Dissertation	-	500

	Total		**2000**

5. Eligibility : As per AICTE norms.

M.Tech. in Energy Technology

Course structure, scheme of evaluation (Semester-wise) and syllabus of M.Tech. programme in Energy Technology 2006-2007 in Shivaji University, Kolhapur

I) **Course Duration**: Two years four semesters, each semester of four months

II) **Course Structure:**
- (a) Theory Papers
- (b) Laboratory/ Practical training
- (c) Seminars
- (d) Industrial Training and Field Visits
- (e) Major Project

III) **Scheme of Marking**: (total marks 2000)

(a) Theory Papers	1000 marks
(b) Laboratory/ Practical training	0400 marks
(c) Major Project	0400 marks
(d) Seminars	0200 marks

IV) **Syllabus**: There are total ten theory courses consisting of six compulsory courses and four elective courses

V) **Eligibility**: B.E. / B.Tec. in mechanical,/chemical,/electronics /electrical or M.Sc. in Physics/ Electronics/Chemistry

VI) **Intake**: 25 as per AICTE rule

SHIVAJI UNIVERSITY, KOLHAPUR

M.Tech (Energy Technology)
Course Structure and Scheme of Evaluation
Semester I

Course code	Name of the subject	Teaching Scheme		Examination Scheme		Total Marks
		Lectures	Practicals	Theory	Term Work	
ETC 1-1	Energy Scenario	4	2	100	50	150
ETC 1-2	Biomass and its Conversion Technologies	4	2	100	50	150
ETC 1-3	Solar Photovoltaic Energy Conversion	4	2	100	50	150
ETE 1-1	Elective-I	4	-	100	-	100
ETE 1-2	Elective-II	4	-	100	-	100
ETL 1-1	Seminar-I	----------	2	---------	50	50
Total		20	08	500	200	700

Total hrs. 28, Total Marks 700

Semester II

Course code	Name of the subject	Teaching Scheme		Examination Scheme		Total Marks
		Lectures	Practicals	Theory	Term Work	
ETC 2-1	Solar Thermal Energy Conversion	4	2	100	50	150
ETC 2-2	Energy Management and Audit	4	2	100	50	150
ETC 2-3	Energy efficiency in thermal and electrical utility	4	2	100	50	150
ETE 2-3	Elective-III	4	-	100	-	100
ETE 2-4	Elective-IV	4	-	100	-	100
ETL 2-2	Seminar-II	----------	2	---------	50	50
Total		20	08	500	200	700

Total hrs. 28, Total Marks 700

Semester-III

Course code	Name of the subject	Evaluation		Total Marks
		Term Work	Orals	
T31	* Industrial Training	100	--	100
S32	Dissertation Phase-I	100	100	200
Total		200	100	300

* 8 Weeks at the end of First Year (summer)

Semester-IV

Course code	Name of the subject	Evaluation		Total Marks
		Term Work	Orals	
D42	Dissertation Phase-II	100	200	300

Total Marks For Four Semesters: -

Semester	I	II	III	IV	**Total**
Marks	700	700	300	300	**2000**

Elective Subjects :

Course Code	**Title of the Papers**
Elective-I	
ETE 1-1	Waste to Energy conversion
ETE 1-2	Wind Energy and Small hydropower systems
ETE 1-3	Energy efficient lighting
Elective-II	
ETE 2-1	Fuel and Combustion Technology
ETE 2-2	Solar Passive Architecture
ETE 2-3	Energy storage systems
Elective-III	
ETE 3-1	Hydrogen Technology and Fuel Cell Technology
ETE 3-2	Alternative fuels for transportation
ETE 3-3	Power Plant Engineering
Elective-IV	
ETE 4-1	Power Co-generation
ETE 4-2	Energy modeling and project management
ETE 4-3	The New Energy Technologies

Core Course

ETC 1-1: Energy Scenario

Introduction to Energy:
Definition and units of energy, power, Forms of energy, Conservation of energy, second law of thermodynamics, Energy flow diagram to the earth. Origin of fossil fuels, time scale of fossil fuels, Renewable Energy Resources, Role of energy in economic development and social transformation.

Global Energy Scene
Energy consumption in various sectors, projected energy consumption for the next century, exponential increase in energy consumption, energy resources, coal, oil, natural gas, nuclear power and hydroelectricity, impact of exponential rise in energy consumption on global economy, future energy options.

Indian Energy Scene
Commercial and non-commercial forms of energy, energy consumption pattern and its variation as a function of time, energy resources available in India, urban and rural energy consumption, nuclear energy - promise and future, energy as a factor limiting growth, need for use of new and renewable energy sources.

Environmental Impact
Environmental degradation due to energy production and utilization, Primary and secondary pollution, air, thermal and water pollution, depletion of ozone layer, global warming, biological damage due to environmental degradation. Pollution due to thermal power station and their control. Pollution due to nuclear power generation, radioactive waste and its disposal. Effect of hydroelectric power stations on ecology and environment. Effect of Hydro electric power stations on ecology and environment.

Introduction to Solar Energy
Solar Spectrum, Solar Time and angles, day length, angle of incidence on tilted surface; Sun-path diagram; Shadow angle protractor; Solar Radiation: Extraterrestrial Radiation; Effect of earth atmosphere; Estimation of solar radiation on horizontal and tilted surfaces; Measurement of Solar radiation, Analysis of Indian solar radiation data and applications.

Core Course

ETC 1-2: Biomass and its Conversion Technologies

Introduction
Origin of Biomass: Resources: Classification and characteristics; Techniques for biomass assessment; Application of remote sensing in forest assessment; Biomass estimation.

Thermochemical Conversion
Different processes: Direct combustion, incineration, pyrolysis, gasification and liquefaction; Economics of thermochemical conversion.

Biological Conversion
Biodegradation and biodegradability of substrate; Biochemistry and process parameters of biomethanation; Biogas digester types; Digester design and biogas utilisation; Chemical kinetics and mathematical modeling of biomethanation process; Economics of biogas plant with their environmental and social impacts; Bioconversion of substrates into alcohol: Methanol & ethanol Production, organic acids, solvents, amino acids, antibiotics etc.

Chemical Conversion
Hydrolysis & hydrogenation; Solvent extraction of hydrocarbons; Solvolysis of wood; Biocrude and biodiesel; Chemicals from biomass.

Power generation
Utilisation of gasifier for electricity generation; Operation of spark ignition and compression ignition engine with wood gas, methanol, ethanol & biogas; Biomass integrated gasification/combined cycles systems. Sustainable cofiring of biomass with coal. Biomass productivity: Energy plantation and power programme.

Core Course

ETC 1-3: Solar Photovoltaic Energy Conversion

Photovoltaic Principles
Solar Cell Physics: p-n junction: homo and heterojunctions, Metal-semiconductor interface; The Photovoltaic Effect, Equivalent Circuit of the Solar Cell, Analysis of PV Cells: Dark and illumination characteristics; Figure of merits of solar cell; Efficiency limits; Variation of efficiency with band-gap and temperature; Efficiency measurements; High efficiency cells, Types of Solar cells.

Solar Cell Fabrication Technology
Preparation of metallurgical, electronic and solar grade Silicon; Production of single crystal Silicon: Czokralski (CZ) and Float Zone (FZ) method: Procedure of masking, photolithography and etching; Design of a complete silicon, GaAs, InP solar cell; High efficiency III-V, II-VI multi-junction solar cell; a-Si-H based solar cells; Quantum well solar cell, Thermo-photovoltaics.

Solar Photovoltaic System Design
Solar cell array system analysis and performance prediction; Shadow analysis: Reliability; Solar cell array design concepts; PV system design; Design process and optimization; Detailed array design; Storage autonomy; Voltage regulation; Maximum tracking; Use of computers in array design; Quick sizing method; Array protection and trouble shooting.

SPV Applications
Centralized and decentralized SPV systems; Stand alone, hybrid and, grid connected system, System installation, operation and maintenances; Field experience; PV market analysis and economics of SPV systems.

The Recent developments in Solar cells, Role of nano-technology in Solar cells.

Core Course

ETC 2-1: Solar Thermal Energy Conversion

Radiative Properties and Characteristics of Materials
Reflection from ideal specular, ideal diffuse and real surfaces,
Selective Surfaces: Ideal coating characteristics; Types and applications; Anti-reflective coating; Preparation and characterization.
Reflecting Surfaces and transparent materials.

Flat-plate Collectors
Energy balance for Flat Plate Collectors; Thermal analysis; Heat capacity effect; Testing methods; Types of Flat Plate Collectors: Liquid Flat Plate Collectors, Air flat-plate Collectors-Thermal analysis; Evacuated tubular collectors.

Solar Thermal Energy Storage
Types: Sensible storage; Latent heat storage; Thermo-chemical storage. Design of storage system.

Concentrating Collector Designs
Classification, design and performance parameters; Tracking systems; Compound parabolic concentrators; Parabolic trough concentrators; Concentrators with point focus; Heliostats; Comparison of various designs: Central receiver systems, parabolic trough systems; Solar power plant; Solar furnaces

Solar Heating & Cooling System
Solar water heating systems, Liquid based systems for buildings, Solar air heating systems, Methods of modeling and design of Solar heating system,
Cooling requirements of buildings, Vapour absorption refrigeration cycle; Water, ammonia & lithium bromide-water absorption refrigeration systems; Solar desiccant cooling.

Performances of solar collectors
ASHRAE code; Modeling of solar thermal system components and simulation; Design and sizing of solar heating systems: f – chart method and utilizability methods of solar thermal system evaluation; Development of computer package for solar heating and cooling applications;

Solar Energy for Industrial Process Heat
Industrial process heat: Temperature requirements, consumption pattern; Applications of solar flat plate water heater & air heater for industrial process heat; Designing thermal storage; Transport of energy.

Solar Thermal Energy Systems
Solar still; Solar cooker: Solar pond; Solar passive heating and cooling systems: Trombe wall; Greenhouse technology: Fundamentals, design, modeling and applications.

ETC 2-2: Energy Management And Audit

Energy Conservation:

Energy Conservation and its Importance; Energy Strategy for the Future; The Energy Conservation Act, 2001 and its Features

Energy Management:

Definition & Objectives of Energy Management; Importance; Indian need of Energy Management; Duties and responsibilities of energy managers.

Energy Audit:

Energy Audit: Types and Methodology; Energy Audit Reporting Format; Understanding Energy Costs; Benchmarking and Energy Performance; Matching Energy Usage to Requirement; Maximising System Efficiency; Fuel and Energy Substitution; Energy Audit Instruments; Duties and responsibilities of energy auditors.

Material and Energy Balance:

Basic Principles; The Sankey Diagram and its Use; Material Balances; Energy Balances; Method for Preparing Process Flow Chart; Facility as an Energy System; How to Carryout Material and Energy (M & E) Balance.

Energy Action Planning

Key elements; Force field analysis; Energy policy purpose, perspective, contents, formulation, ratification; Organizing the management: location of energy management, top management support, managerial function, accountability; Motivation of employees: Information system-designing barriers, strategies; Marketing and communicating: Training and planning.

Energy Monitoring And Targeting:

Definition; Elements of Monitoring & Targeting System; A Rationale for Monitoring, Targeting and Reporting; Data and Information Analysis; Relating Energy Consumption and Production; CUSUM; Case Study.

Global Environmental Concerns:

Global Environmental Issues; Ozone Layer Depletion; Global Warming; Loss of Bio-Diversity; Climate Change Problem and Response; The Conference of the Parties (COP); Prototype Carbon Fund (PCF); Sustainable Development.

Electrical Energy Management

Supply side: Methods to minimize supply-demand gap, renovation and modernization of power plants, reactive power management, HVDC, and FACTS. Demand side: conservation in motors, pumps and fan systems; energy efficient motors.

Thermal energy Management

Energy conservation in boilers, steam turbines and industrial heating systems; Application of FBC; Cogeneration and waste heat recovery; Thermal insulation; Heat exchangers and heat pumps; Building Energy Management.

Course Code

ETC 2-3: Energy Efficiency In Thermal & Electrical Utilities

Boilers
Introduction; Boiler Systems; Boiler Types and Classifications; Performance Evaluation of Boilers; Boiler Blowdown; Boiler Water Treatment; Energy Conservation Opportunities;Case Study.

Steam System
Introduction; Properties of Steam; Steam Distribution; Steam Pipe Sizing and Design; Proper Selection, Operation and Maintenance of Steam Traps; Performance Assessment Methods for Steam Traps; Energy Saving Opportunities

Furnaces
Types and Classification of Different Furnaces; Performance Evaluation of a Typical Furnace General Fuel Economy Measures in Furnaces; Case Study

Insulation And Refractories
Purpose of Insulation; Types and Application; Calculation of Insulation Thickness; Economic Thickness of Insulation(ETI); Simplified Formula for Heat Loss Calculation; Refractories; Properties of Refractories; Classification of Refractories; Typical Refractories in Industrial Use; Selection of Refractories; Heat Losses from Furnace Walls.

FBC Boilers
Introduction; Mechanism of Fluidised Bed Combustion; Types of Fluidised Bed Combustion Boilers; Retrofitting of FBC Systems to Conventional Boilers; Advantages of Fluidised Bed Combustion Boilers.

Waste Heat Recovery
Introduction; Classification and Application; Benefits of Waste Heat Recovery; Development of a Waste Heat Recovery System; Commercial Waste Heat Recovery Devices.

Electric Motors
Introduction; Motor Types; Motor Characteristics; Motor Efficiency; Motor Selection; Energy Efficient Motors; Factors Affecting Energy Efficiency and Minimising Motor Losses in Operation; Rewinding Effects on Energy Efficiency; Speed Control of AC Induction Motors; Motor Load Survey: Methodology.

Compressed Air System
Introduction; Compressor Types; Compressor Performance; Compressed Air System Components; Efficient Operation of Compressed Air Systems; Compressor Capacity Assessment; Checklist for Energy Efficiency in Compressed Air System.

HVAC And Refrigeration System
Introduction; Types of Refrigeration System; Common Refrigerants and Properties; Compressor Types and Application; Selection of a Suitable Refrigeration System; Performance Assessment of Refrigeration Plants; Factors Affecting Performance and Energy Efficiency of Refrigeration Plants; Energy Savings Opportunities.

FANS AND BLOWERS
Introduction; Fan Types; Fan Performance Evaluation and Efficient System Operation; Fan Design and Selection Criteria; Flow Control Strategies; Fan Performance Assessment; Energy Saving Opportunities.

Pumps And Pumping System
Pump Types; System Characteristics; Pump Curves; Factors Affecting Pump Performance; Efficient Pumping System Operation; Flow Control Strategies; Energy Conservation Opportunities in Pumping Systems.

Cooling Towers
Introduction; Cooling Tower Performance; Efficient System Operation; Flow Control Strategies; Energy Saving Opportunities in Cooling Towers.

DG Set System
Introduction; Selection and Installation Factors; Operational Factors; Energy Performance Assessment of DG Sets; Energy Savings Measures for DG Sets.

Energy Efficient Technologies In Electrical Systems
Maximum Demand Controllers; Automatic Power Factor Controllers; Energy Efficient Motors; Soft Starter; Variable Speed Drives; Energy Efficient Transformers; Electronic Ballasts; Energy Efficient Lighting Controls.

Elective Course

ETE 1-1: Waste to Energy Conversion

Solid Waste
Definitions: Sources, types, compositions; Properties of Solid Waste; Municipal Solid Waste: Physical, chemical and biological property; Collection, transfer stations; Waste minimization and recycling of municipal waste

Waste Treatment & Disposal
Size Reduction: Aerobic composting, incineration; Furnace type & design; Medical / Pharmaceutical waste incineration; Environmental impacts; Measures of mitigate environmental effects due to incineration; Land Fill method of solid waste disposal; Land fill classification; Types, methods & siting consideration; Layout & preliminary design of land fills: Composition, characteristics, generation; Movement and control of landfill leachate & gases; Environmental monitoring system for land fill gases.

Energy Generation From Waste
Types: Biochemical Conversion: Sources of energy generation, Industrial waste, agro residues; Anaerobic Digestion: Biogas production; Types of biogas plants, Community biogas plants;
Thermo-chemical conversion: Sources of energy generation, Gasification; Types of gasifiers; Industrial applications of gasifiers; Environment benefits of biochemical and thermo-chemical conversion, Briquetting; Utilization and advantages of briquetting;

Bio-diesel
History, Production methods of Bio-diesel: Transesterification, Fuel quality, standards and properties, Availability of Raw materials for bio-diesel, Applications, Bio-diesel potential in India.

Elective Course

ETE 1-2: Wind Energy & Small Hydropower Systems

Introduction
Wind energy conversion principles; General introduction; Types and classification of WECS; Power, torque and speed characteristics.

WECS Design
Aerodynamic design principles; Aerodynamic theories; Axial momentum, blade element and combine theory; Rotor characteristics; Maximum power coefficient; Prandlt's tip loss correction.

Design of Wind Turbine
Wind turbine design considerations; Methodology; Theoretical simulation of wind turbine characteristics; Test methods.

Wind Energy Application
Wind pumps: Performance analysis, design concept and testing; Principle of WEG; Stand alone, grid connected and hybrid applications of WECS; Economics of wind energy utilization; Wind energy in India; Case studies, Environmental Impacts of Wind Farms.

Small Hydropower Systems
Overview of micro, mini and small hydro systems; Hydrology; Elements of pumps and turbine; Selection and design criteria of pumps and turbines; Site selection and civil works; Speed and voltage regulation; Investment issues load management and tariff collection; Distribution and marketing issues: case studies; Potential of small hydro power in North East India.

Wind and hydro based stand-alone hybrid power systems.

Elective Course

ETE 1-3: Energy Efficient Lighting

Introduction
Need for Energy Management programme; Illumination requirements for various tasks Activities/Locations; Basic Terms in Lighting System and Features

System Elements
Light Sources, Luminaries, Ballasts; Lamp Types and their Features

Methodology of Lighting System, Day lighting, lighting system controls, system maintenance, operating schedule, psychology of changeover. Lighting energy management in buildings: Case Studies Some Good Practices in Lighting

Light Emitting Diodes
Principle, working and Fabrication of Light emitting diodes, Materials development, status of R and D in light emitting diodes

Fiber Optics
Types of Fibers, fabrication technology, Materials development for fiber optic, Transmission losses, Use of fiber in lighting

Solid State Lighting
Florescence, Phosphorescence, Electroluminescence, development of electroluminescent materials and thin film devices, solid state display devices

Elective course

ETE 2-1: Fuel & Combustion Technology

Introduction
Types of fuels: Solid, liquid and gaseous fuels; Properties of fuels: Coal, liquid fuels, gaseous fuels and agro-residues.

Solid Fuels
Coal; Family, origin, classification of coal; Analysis and properties; Action of heat on coal; Gasification; Oxidation; Hydrogenation and liquefaction of coal; Efficient use of solid fuels; Manufactured fuels; Agro fuels; Solid fuel handling; Properties related to combustion, handling, and storage

Liquid Fuels
Origin and classification of petroleum; Refining; Properties & testing of petroleum products; Various petroleum products; Petroleum refining in India; Liquid fuels from other sources; Storage and handling of liquid fuels.

Gaseous Fuels
Types of gaseous fuels: natural gases, methane from coal mines, manufactured gases, producer gas, water gas, biogas, refinery gas, LPG; Cleaning and purification of gaseous fuels.

Combustion of fuels
Stoichiometry and thermodynamics; Combustion stoichiometry: Combustion thermodynamics, Combustion of Oil; Combustion of Coal; Combustion of Gas; Draft System; burners; Fluidized bed combustion process. Combustion Controls

Stoichiometry
Stoichiometry relations; Estimation of air required for complete combustion; Estimation of minimum amount of air required for a fuel of known composition; Estimation of dry flue gases for known fuel composition; Calculation of the composition of fuel & excess air supplied, from exhaust gas analysis; Dew point of products; Flue gas analysis (O2, CO2, CO, NOx, SOx).

Burner Design and Furnaces
Ignition: Concept, auto ignition, ignition temperature; Burners: Propagation, various methods of flame stabilization; Basic features and design of burners for solid, liquid, and gaseous fuels; Furnaces: Industrial furnaces, process furnaces, batch & continuous furnaces; Advantages of ceramic coating; Heat source; Distributions of heat source in furnaces; Blast furnace; Open hearth furnace, Kilns; Pot & crucible furnaces; Waste heat recovery in furnaces: Recuperators and regenerators; Furnace insulation; Furnace heat balance computations; Efficiency considerations.

Elective Course

ETE 2-2: Solar Passive Architecture

Introduction
Introduction to architecture; Architecture as the art of science of designing buildings; Building science and its significance; Energy management concept in building

Thermal Analysis And Design For Human Comfort
Thermal comfort; Criteria and various parameters; Psychometric chart; Thermal indices, climate and comfort zones; Concept of sol-air temperature and its significance; Calculation of instantaneous heat gain through building envelope; Calculation of solar radiation on buildings; building orientation; Introduction to design of shading devices; Overhangs; Factors that effects energy use in buildings; Ventilation and its significance; Air-conditioning systems; Energy conservation techniques in air-conditioning systems

Passive Cooling And Heating Concepts
Passive heating concepts: Direct heat gain, indirect heat gain, isolated gain and sunspaces; Passive cooling concepts: Evaporative cooling, radiative cooling; Application of wind, water and earth for cooling; Shading, paints and cavity walls for cooling; Roof radiation traps; Earth air-tunnel.

Heat Transmission In Buildings
Surface co-efficient: air cavity, internal and external surfaces, overall thermal transmittance, wall and windows; Heat transfer due to ventilation/infiltration, internal heat transfer; Solar temperature; Decrement factor; Phase lag. Design of daylighting; Estimation of building loads: Steady state method, network method, numerical method, correlations; Computer packages for carrying out thermal design of buildings and predicting performance.

Bioclimatic Classification
Bioclimatic classification of India; Passive concepts appropriate for the various climatic zones in India; Typical design of selected buildings in various climatic zones; Thumb rules for design of buildings and building codes.

Energy Efficient Landscape Design
Modification of microclimatic through landscape element for energy conservation; Energy conservation through site selection, planning, and design; Siting and orientation.

Elective Course

ETE 2-3: Energy Storage Systems

Energy Storage
Need of energy storage; Different modes of Energy Storage.
Potential energy: Pumped hydro storage; KE and Compressed gas system: Flywheel storage, compressed air energy storage; Electrical and magnetic energy storage: Capacitors, electromagnets; Chemical Energy storage: Thermo-chemical, photo-chemical, bio-chemical, electro-chemical, fossil fuels and synthetic fuels. Hydrogen for energy storage. Solar Ponds for energy storage

Electrochemical Energy Storage Systems
Batteries: Primary, Secondary, Lithium, Solid-state and molten solvent batteries; Lead Lead acid batteries; Nickel Cadmium Batteries; Advanced Batteries. Role of carbon nano-tubes in electrodes.

Magnetic and Electric Energy Storage Systems
Superconducting Magnet Energy Storage(SMES) systems; Capacitor and Batteries: Comparison and application; Super capacitor: Electrochemical Double Layer Capacitor (EDLC), principle of working, structure, performance and application, role of activated carbon and carbon nano-tube.

Sensible Heat Storage
SHS mediums; Stratified storage systems; Rock-bed storage systems; Thermal storage in buildings; Earth storage; Energy storage in aquifers; Heat storage in SHS systems; Aquifers storage.

Latent Heat Thermal Energy Storage
Phase Change Materials (PCMs); Selection criteria of PCMs; Stefan problem; Solar thermal LHTES systems; Energy conservation through LHTES systems; LHTES systems in refrigeration and air-conditioning systems; Enthalpy formulation; Numerical heat transfer in melting and freezing process.

Some Areas of Application of Energy Storage
Food preservation; Waste heat recovery; Solar energy storage; Green house heating; Power plant applications; Drying and heating for process industries.

Elective Course

ETE 3-1: Hydrogen Technology and Fuel Cell Technology

Hydrogen Energy
Hydrogen: Its merit as a fuel; Applications

Hydrogen Production Methods
Production: from fossil fuels, electrolysis, thermal decomposition, photochemical, photocatalytic, hybrid;

Hydrogen Storage Methods
Storage: Metal hydrides, Metallic alloy hydrides, Carbon nano-tubes; Sea as the source of Deuterium.

Fuel Cell: Basics
Fuel cell definition, difference between batteries and fuel cells, fuel cell history, components of fuel cells, principle of working of fuel cell, performance characteristics of fuel cells, efficiency of fuel cell, fuel cell stack, fuel cell power plant: fuel processor, fuel cell power section, power conditioner, Advantages and disadvantages of fuel cell power plant.

Types of Fuel Cells
Fuel cell types: alkaline fuel cell, , polymer electrolyte fuel cell, phosphoric acid fuel cell, molten carbonate fuel cell, solid oxide fuel cell, Geometries of solid oxide fuel cells: planar, tubular, Types of solid oxide fuel cells: High temperature, intermediate temperature ,Single chamber solid oxide fuel cells, Problems with fuel cells, applications of fuel cells.

Description of some commercially available fuel cell stacks, overview on research activities on fuel cells in world, Research and development related to fuel cell development in India.

Elective Course

ETE 3-2: Alternative Fuels for transportation

An introduction to hydrocarbon fuels - their availability and effect on Environment.
Gasoline and Diesel self ignition characteristics of the fuel, octane number, cetane number.

Alternative fuels - Liquid and Gaseous Fuels. Physico-chemical characteristics.
Alternative Liquid Fuels. Alcohol fuels - Ethanol & Methanol. Fuel composition, Fuel Induction techniques, fumigation, emission of oxygenates, applications to engines and automotive conversions.

Biodiesel formulation techniques, transesterification, application in diesel engines. CME (Di-methyl ether), properties Fuel injection consideration

General introduction to LPG and LNG. Compressed Natural Gas components, mixtures and kits, fuel supply system and emission studies and control. Hydrogen combustion characteristics, flashback control techniques, safety aspects and system development, NOx emission control.

Biogas, Producer gas and their characteristics, System development for engine application.

Elective Course

ETE 3-3: Power Plant Engineering

Introduction:
Choice of power generation; Load & Load duration curves; Load factor; Diversity factor; Load deviation curve; Load management; Number and size of generating unit; Cost of electrical energy; Tariff-Power factor improvement.

Thermal Power Stations
Types of thermal power plants; elements of thermal power plant: Boiler, superheater, economiser, condenser, combustion chamber, gas loops and turbines etc., Site selection of Steam power plant, Principles of Electric Power station. General lay out. Instrumentation and control

Gas Turbine Power plant
Types, Open and close cycle gas turbines; Components of the plant, Plant lay out, Combined cycle power plant

Hydropower Plant
Mass curve and storage capacity; Classification; Components; Turbines- Characteristics and their selection; Governor; Plant layout and design; Auxiliaries; Underground, automatic, remote controlled, and pumped storage plants.

Nuclear Power Plant
Basic principles, Elements of Nuclear power plant, Nuclear reactor and fuels, Hazards due to Nuclear power plants, Nuclear Instrumentation.

Diesel-electric Power Plant
Working principle, Elements of the plant, Starting and stopping; Efficiency and Heat balance; Plant layout.

Elective Course

ETE 4-1: Power Cogeneration

Need for Cogeneration, Principle of Cogeneration, Technical Options for Cogeneration, Classification of Cogeneration Systems, Factors Influencing Cogeneration Choice, Important Technical Parameters for Cogeneration, Prime Movers for Cogeneration, Typical Cogeneration Performance Parameters, Relative Merits of Cogeneration Systems.

Cogeneration alternatives, Gas turbine Steam turbine, Diesel engine, Bottoming cycles. Industry/ utility cogeneration, Thermodynamic evaluation, Technoeconomic evaluation, Environmental evaluation. Cogeneration in sugar and steel industry, Case Studies

Elective Course

ETE 4-2: Energy Modeling & Project Management

Introduction
Basic concept of econometrics and statistical analysis; The 2-variable regression model; The multiple regression model; Tests of regression coefficients and regression equation; Econometric techniques used for energy analysis and forecasting with case studies form India; Operation of computer package

Input – Output Analysis
Basic concept of Input-output analysis; concept of energy multiplier and implication of energy multiplier for analysis of regional and national energy policy; Energy and environmental Input - Output analyses using I-O model

Energy Modeling
Interdependence of energy-economy-environment; Modeling concept, and application, Methodology of energy demand analysis; Methodology for energy forecasting; Sectoral energy demand forecasting; Interfuel substitution models; SIMA model, and I-O model for energy policy analysis; Simulation and forecasting of future energy demand consistent with macroeconomic parameters in India; Energy Economics and Policies: National and Sectoral energy planning; Integrated resource planning; Energy pricing

Project Evaluation & Management
Financial analysis: Project cash flows, time value of money, life cycle approach & analysis, conception, definition, planning, feasibility and analysis; Project appraisal criteria; Risk analysis; Project planning matrix; Aims oriented project planning; Social cost benefit analysis. Network analysis for project management; Time estimation; Critical path determination; PERT, CPM and CERT; Fuzzy logic analysis; Stochastic based formulations; Project evaluation techniques; Funds planning; Project material management, evaluation & analysis; Implementation and monitoring; Performance indices; Case studies.

Elective Course

ETE 4-3: New Energy Technologies

Introduction:
Development in the field of superconductivity, Basic parameters of superconductivity, Types of superconductors, BCS theory, Meissner Effect, Josephson effect in Superconductors.

High T_c Superconductors
Cuprate Superconductors; La, Y, Bi, Tl and Hg based superconductors, Intermetallic MgB_2 superconductor crystal structure and superconducting properties, conduction mechanism.

Synthesis of High T_c superconductors
Introduction, Different methods of synthesis of High T_c superconductors; electrodeposition, electrophoretic method, spray pyrolysis technique, solid state reaction method, screen printing, Pulse laser deposition method (PLD), Powder in tube method (PIT), combustion method, sol -gel method, Electrodeposition of alloys; DC electrode position, Mechanism of electrodeposition, Post deposition treatments.

Applications of Superconductors in Energy
Superconducting wires and their characteristics, High field magnets for production of energy by magnetic fusion, Energy generation-Magnetohydrodynamics (MHD), energy storage, electric generators and role of superconductors.

Large scale applications of superconductors
Electric power transmission, Applications of superconductor in the magnetism and medicine-Magnetic Resonance Imaging (MRI), Superconducting Quantum Interference Devices (SQUID).

Experimental Techniques
Low temperature resistivity measurements; Four probe and Vander Paw resistivity technique, AC and DC susceptibility measurements, SQUID measurements, Different types of cryostat, Closed cycle refrigerators system

SAWANT S. P. / BIRJE S. R./ Jr. Cl.

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