

**SHIVAJI UNIVERSITY**  
**M.TECH (Energy Technology) PROGRAMMES**

**Course Structure and Scheme of Evaluation**  
**Semester I**

| Course code | Name of the Subject                         | Teaching Scheme |   |   |         |
|-------------|---------------------------------------------|-----------------|---|---|---------|
|             |                                             | L               | T | P | Credits |
|             | Research Methodology (Audit)                | 2               | - | - | -       |
| ETC 1-1     | Energy Scenario                             | 4               | - | - | 4       |
| ETC 1-2     | Biomass and its Conversion Technologies     | 4               | - | - | 4       |
| ETC 1-3     | Solar Photovoltaic Energy Conversion        | 4               | - | - | 4       |
| ETE 1-1     | Elective-I                                  | 3               | - | - | 3       |
| ETE 1-2     | Elective-II                                 | 3               | - | - | 3       |
| ETC 1-4     | Energy Scenario Lab                         | -               | - | 2 | 1       |
| ETC 1-5     | Biomass and its Conversion Technologies Lab | -               | - | 2 | 1       |
| ETC 1-6     | Solar Photovoltaic Energy Conversion Lab    | -               | - | 2 | 1       |
| ETL 1-1     | Seminar-I                                   | -               | - | 2 | 2       |
|             | Total                                       | 20              | 0 | 8 | 23      |

Total hrs. 28, Total Marks 700

**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         |

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**Course Structure and Scheme of Evaluation**  
**Semester II**

| Course code | Name of the Subject                                     | Teaching Scheme |   |   |         |
|-------------|---------------------------------------------------------|-----------------|---|---|---------|
|             |                                                         | L               | T | P | Credits |
| ETC 2-1     | Solar Thermal Energy Conversion                         | 4               | - | - | 4       |
| ETC 2-2     | Energy Management and Audit                             | 4               | - | - | 4       |
| ETC 2-3     | Energy efficiency in thermal and electrical utility     | 4               | - | - | 4       |
| ETE 2-3     | Elective-III                                            | 3               | - | - | 3       |
| ETE 2-4     | Elective-IV                                             | 3               | - | - | 3       |
| ETC 2-4     | Solar Thermal Energy Conversion Lab                     | -               | - | 2 | 1       |
| ETC 2-5     | Energy Management and Audit Lab                         | -               | - | 2 | 1       |
| ETC 2-6     | Energy efficiency in thermal and electrical utility Lab | -               | - | 2 | 1       |
| ETL 2-2     | Seminar-II                                              | -               | - | 2 | 2       |
|             | Total                                                   | 18              | 0 | 8 | 23      |

Total hrs. 28, Total Marks 700

**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            |

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**T 31 Industrial Training:**

**Teaching SchemeExamination Scheme**

**Contact hrs : 2 Hrs./Week/student**

**Credit: 4**

**Course Structure and Scheme of Evaluation**  
**Semester III**

| Course code | Name of the subject              | Teaching Schemes |   |     |         |
|-------------|----------------------------------|------------------|---|-----|---------|
|             |                                  | L                | T | P   | Credits |
| T31         | * Industrial Training            | -                | - | **2 | 4       |
| S32         | Dissertation Phase-I             | -                | - | **5 | 10      |
|             | Total                            | -                | - | 5   | 14      |
|             | Total Contact hours per week = 7 |                  |   |     |         |

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

\*\* Average contact hours/week/student

8 Weeks at the end of First Year and as a part of evaluation at the end of third semester student should submit the report for the 8 week industrial training and give presentation to the concern guide, concern guide should spare 2hrs/week/student

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**Course Structure and Scheme of Evaluation**  
**Semester IV**

| Course code | Name of the subject   | Evaluation |   |   |         |
|-------------|-----------------------|------------|---|---|---------|
|             |                       | L          | T | P | Credits |
| D42         | Dissertation Phase-II | -          | - | 5 | 20      |
|             | Total                 | -          | - | 5 | 20      |
|             |                       |            |   |   |         |

**SHIVAJI UNIVERSITY**  
**M.TECH (Energy Technology) PROGRAMMES**

**Semester I**

**C-10 Research Methodology**

**Teaching Scheme Examination Scheme**

**Lectures: 2 Hrs./Week**

**Unit 1 Research Methodology: An Introduction.**

Objectives of Research, Types of Research, Research Methods and Methodology, Defining a Research Problem, Techniques involved in Defining a Problem

**4hrs.**

**Unit 2 Research Design**

Need for Research Design, Features of Good Design, Different Research Designs, Basic Principles of Experimental Designs, Sampling Design, Steps In Sampling Design, Types of Sampling Design, Sampling Fundamentals, Estimation, Sample size Determination, Random sampling

**6hrs.**

**4hrs.**

**Unit 3 Measurement and Scaling Techniques**

Measurement in Research, Measurement Scales, Scales, Sources in Error, Techniques of Developing Measurement Tools, Scaling, Meaning of Scale, Scale Construction Techniques

**Unit 4 Methods of Data Collection and Analysis**

Collection of Primary and Secondary Data, Selection of appropriate method, Data Processing Operations, Elements of Analysis, Statistics in Research, Measures of Dispersion, Measures of Skewness, Regression Analysis, Correlation

**4hrs.**

**4hrs.**

**Unit 5 Techniques of Hypotheses, Parametric or Standard Tests**

Basic concepts, Tests for Hypotheses I and II, Important parameters, Limitations of the tests of Hypotheses, Chi-square Test, Comparing Variance, as a non-parametric Test, Conversion of Chi to Phi, Caution in Using Chi-square test

**4hrs.**

**Unit 6 Analysis of Variance and Co-variance**

ANOVA, One way ANOVA, Two Way ANOVA, ANOCOVA, Assumptions in ANOCOVA, Multivariate Analysis Technique, Classification of Multivariate Analysis, factor Analysis, R-type Q Type Factor Analysis, Path Analysis

**Interpretation and Report**

**1hrs.**

**SHIVAJI UNIVERSITY**  
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**SEMESTER-I**

**Core Course**

**ETC 1-1: Energy Scenario**

**Lectures : 4 hrs/ Week**

**Credits : 4**

**Unit -1** 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.

**6hrs.**

**Unit -2** 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.

**7hrs.**

**Unit -3** 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

**6hrs.**

**Unit -4** 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.

**7hrs.**

**Unit – 5** 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's atmosphere; Estimation of solar radiation on horizontal and tilted surfaces; Measurement of Solar radiation.

**6hrs.**

**Unit -6** Analysis of Indian solar radiation data and applications.

**7hrs.**

**SHIVAJI UNIVERSITY**  
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**SEMESTER-I**

**ETC 1-2: Biomass and its Conversion Technologies**

**Lectures : 4 hrs/ Week**

**Credits : 4**

**Unit -6 1 Introduction**

Origin of Biomass: Resources: Classification and characteristics; Techniques for biomass assessment; Application of remote sensing in forest assessment; Biomass estimation. **6hrs.**

**Unit -2 Thermochemical Conversion**

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

**7hrs.**

**Unit -3 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 **6hrs.**

**Unit -64 Chemical Conversion**

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

**Unit -5 Power generation**

**7hrs.**

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.

**Unit -6 Biomass productivity: Energy plantation and power programme.**

**6hrs.**

**7hrs.**

**SHIVAJI UNIVERSITY**  
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**SEMESTER-I**

**ETC 1-3: Solar Photovoltaic Energy Conversion**

**Lectures : 4 hrs/ Week**

**Credits : 4**

**Unit -1** 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,

**6hrs.**

**Unit -2** Types of Solar cells.

Solar Cell Fabrication Technology

Preparation of metallurgical, electronic and solar grade Silicon; Production of single crystal Silicon: Czochralski (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.

**7hrs.**

**Unit -3** 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.

**6hrs.**

**Unit -4** SPV Applications

Centralized and decentralized SPV systems; Stand alone, hybrid and, grid connected system, System installation, operation and maintenances; Field experience;

**7hrs.**

**Unit – 5** PV market analysis and economics of SPV systems.

**6hrs.**

**Unit – 6** The Recent developments in Solar cells, Role of nano-technology in Solar cells.

**7hrs.**

**SHIVAJI UNIVERSITY**  
**M.TECH (Energy Technology) PROGRAMMES**

**SEMESTER-I**

**Elective Course**

**ETE 1-1: Waste to Energy Conversion**

**Lectures : 3 hrs/ Week**

**Credits : 3**

**Unit -1 Solid Waste**

Definitions: Sources, types, compositions; Properties of Solid Waste; Municipal Solid Waste.

**6hrs.**

**Unit -2** Physical, chemical and biological property; Collection, transfer stations; Waste minimization and recycling of municipal waste

**7hrs.**

**Unit -3 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.

**6hrs.**

**Unit -4** Layout & preliminary design of land fills: Composition, characteristics, generation; Movement and control of landfill leachate & gases; Environmental monitoring system for land fill gases.

**7hrs.**

**Unit – 5 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;

**6hrs.**

**Unit -6 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.

**7hrs.**

**SHIVAJI UNIVERSITY**  
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**SEMESTER-I**

**ETE 1-2: Wind Energy & Small Hydropower Systems**

**Lectures : 3 hrs/ Week**

**Credits : 3**

**Unit -1** Introduction

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

**6hrs.**

**Unit -2** WECS Design

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

**7hrs.**

**Unit -3** Design of Wind Turbine

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

**6hrs.**

**Unit - 4** 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.

**7hrs.**

**Unit -5** 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;.

**6hrs.**

**Unit -6** Potential of small hydro power in North East India. Wind and hydro based stand-alone hybrid power systems.

**7hrs.**

**SHIVAJI UNIVERSITY**  
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**SEMESTER-I**

**ETE 1-3: Energy Efficient Lighting**

**Lectures : 3 hrs/ Week**

**Credits : 3**

**7hrs.**

**Unit -1** Introduction

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

**6hrs.**

**Unit -2** 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.

**7hrs.**

**Unit -3** Lighting energy management in buildings: Case Studies Some Good Practices in  
Lighting

**6hrs.**

**Unit -4** Light Emitting Diodes

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

**7hrs.**

**Unit -5** Fiber Optics

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

**Unit -6** Solid State Lighting

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

**SHIVAJI UNIVERSITY**  
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**SEMESTER-I**

**ETE 2-1: Fuel & Combustion Technology**

**Lectures : 3 hrs/ Week**

**Credits : 3**

**Unit -1** Introduction

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

**6hrs.**

**Unit -2** 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

**7hrs.**

**Unit -3** 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.

**6hrs.**

**Unit -4** 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.

**7hrs.**

**Unit -5** 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 (O<sub>2</sub>, CO<sub>2</sub>, CO, NO<sub>x</sub>, SO<sub>x</sub>).

**6hrs.**

**Unit -6** 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.

**7hrs.**

**SHIVAJI UNIVERSITY**  
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**SEMESTER-I**

**ETE 2-2: Solar Passive Architecture**

**Lectures : 3 hrs/ Week**

**Credits : 3**

**6hrs.**

**Unit -1 Introduction**

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

**7hrs.**

**Unit -2 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

**6hrs.**

**Unit -3 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.

**7hrs.**

**Unit -4 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.

**Unit -5 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.

**6hrs.**

**Unit -6 Energy Efficient Landscape Design**

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

**7hrs.**

**SHIVAJI UNIVERSITY**  
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**SEMESTER-I**

**ETE 2-3: Energy Storage Systems**

**Lectures : 3 hrs/ Week**

**Credits : 3**

**6hrs.**

**Unit -1**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

**7hrs.**

**Unit -2** 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.

**Unit -3** 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.

**6hrs.**

**Unit -4** 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.

**7hrs.**

**Unit - 5**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.

**6hrs.**

**Unit -6** 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.

**7hrs.**

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**SEMESTER-I**

**ETC 1-4 Energy Scenario Lab**

**Practical : 2hrs/week**

**Credit :1**

A performance based on Experiments, or assignment or Visit report

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**SEMESTER-I**

**ETC 1-5 Biomass and its Conversion Technologies Lab**

**Practical : 2hrs/week**

**Credit :1**

A performance based on Experiments, or assignment or Visit report

**SHIVAJI UNIVERSITY**  
**M.TECH (Energy Technology) PROGRAMMES**

**SEMESTER-I**

**ETC 1-6 Solar Photovoltaic Energy Conversion Lab**

**Practical : 2hrs/week**

**Credit :1**

A performance based on Experiments, or assignment or Visit report

**SHIVAJI UNIVERSITY**  
**M.TECH (Energy Technology) PROGRAMMES**

**SEMESTER-II**

**ETC 2-1: Solar Thermal Energy Conversion**

**Lectures : 4    hrs/ Week**

**Credits : 4**

**Unit – 1** 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.

**6hrs.**

**Unit – 2** 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.

**7hrs.**

**Unit -3** Solar Thermal Energy Storage

Types: Sensible storage; Latent heat storage; Thermo-chemical storage. Design of storage system.

**6hrs.**

**Unit -4** 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

**7hrs.**

**Unit -5** 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.

**6hrs.**

**Unit -6** 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;

**7hrs.**

**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.

**SEMESTER-II**

**SHIVAJI UNIVERSITY**  
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**ETC 2-2: Energy Management And Audit**

**Lectures : 4    hrs/ Week**

**Credits : 4**

**Unit -1 Energy Conservation:**

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

**6hrs.**

**Unit -2 Energy Management:**

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

**7hrs.**

**Unit -3 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.

**6hrs.**

**Unit -4 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.

**7hrs.**

**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.

**Unit -5 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.

**6hrs.**

**Unit -6 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.

**7hrs.**

**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.

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**SEMESTER-II**

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

**Lectures : 4    hrs/ Week**

**Credits : 4**

**Unit -1 Boilers**

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

**6hrs.**

**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

**Unit -2 Furnaces**

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

**7hrs.**

**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.

**Unit -3 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.

**6hrs.**

**Unit -4 Waste Heat Recovery**

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

**7hrs.**

**Unit -5 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.

**6hrs.**

**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.

**SHIVAJI UNIVERSITY**  
**M.TECH (Energy Technology) PROGRAMMES**

**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.

**Unit -6 DG Set System**

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

**6hrs.**

**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.

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**SHIVAJI UNIVERSITY**  
**M.TECH (Energy Technology) PROGRAMMES**

**SEMESTER-II**

**Elective Course**

**ETE 3-1: Hydrogen Technology and Fuel Cell Technology**

**Lectures : 3 hrs/ Week**

**Credits : 3**

**Unit -1 Hydrogen Energy**

**6hrs.**

Hydrogen: Its merit as a fuel; Applications

**Unit -2 Hydrogen Production Methods**

**7hrs.**

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

**Unit -3 Hydrogen Storage Methods**

**6hrs.**

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

**Unit -4 Fuel Cell: Basics**

**7hrs.**

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.

**Unit -5 Types of Fuel Cells**

**6hrs.**

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.

**Unit -6 Research and development related to fuel cell development in India.**

**7hrs.**

**SHIVAJI UNIVERSITY**  
**M.TECH (Energy Technology) PROGRAMMES**

**SEMESTER-II**

**ETE 3-2: Alternative Fuels for transportation**

**Lectures : 3    hrs/ Week**

**Credits : 3**

**Unit -1** An introduction to hydrocarbon fuels - their availability and effect on Environment. Gasoline and Diesel self ignition characteristics of the fuel, octane number, cetane number. **6hrs.**

**Unit -2** 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. **7hrs.**

**Unit -3** Biodiesel formulation techniques, transesterification, application in diesel engines. CME (Dimethyl ether), properties Fuel injection consideration

**Unit -4** 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. **7hrs.**

**Unit -5** Biogas, Producer gas and their characteristics.

**Unit -6** System development for engine application. **6hrs.**

**7hrs.**

**SHIVAJI UNIVERSITY**  
**M.TECH (Energy Technology) PROGRAMMES**

**SEMESTER-II**

**ETE 3-3: Power Plant Engineering**

**Lectures : 3    hrs/ Week**

**Credits : 3**

**Unit -1** 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.

**6hrs.**

**Unit -2** 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

**7hrs.**

**Unit -3** Gas Turbine Power plant

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

**6hrs.**

**Unit -4** 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.

**7hrs.**

**Unit -5** Nuclear Power Plant

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

**6hrs.**

**Unit -6** Diesel-electric Power Plant

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

**7hrs.**

**SHIVAJI UNIVERSITY**  
**M.TECH (Energy Technology) PROGRAMMES**

**SEMESTER-II**

**ETE 4-1: Power Cogeneration**

**Lectures : 3    hrs/ Week**

**Credits : 3**

**6hrs.**

**Unit -1** Need for Cogeneration, Principle of Cogeneration.

**Unit -2** Technical Options for Cogeneration,  
Classification of Cogeneration Systems.

**7hrs.**

**Unit -3** Factors Influencing Cogeneration Choice, Important Technical Parameters for  
Cogeneration.

**6hrs.**

**Unit -4** Prime Movers for Cogeneration, Typical Cogeneration Performance Parameters, Relative  
Merits of Cogeneration Systems.

**7hrs.**

**Unit -5** Cogeneration alternatives, Gas turbine Steam turbine, Diesel engine, Bottoming cycles.  
Industry/ utility cogeneration.

**6hrs.**

**Unit -6** Thermodynamic evaluation, Technoeconomic evaluation,  
Environmental evaluation. Cogeneration in sugar and steel industry, Case Studies

**7hrs.**

**SHIVAJI UNIVERSITY**  
**M.TECH (Energy Technology) PROGRAMMES**

**SEMESTER-II**

**ETE 4-2: Energy Modeling & Project Management**

**Lectures : 3    hrs/ Week**

**Credits : 3**

**Unit -1 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 from India; Operation of computer package

**6hrs.**

**Unit -2 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

**7hrs.**

**Unit -3 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.

**6hrs.**

**Unit -4 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**

**7hrs.**

**Unit -5 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.

**6hrs.**

**Unit -6 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.**

**7hrs.**

**SHIVAJI UNIVERSITY**  
**M.TECH (Energy Technology) PROGRAMMES**

**SEMESTER-II**

**ETE 4-3: New Energy Technologies**

**Lectures : 3    hrs/ Week**

**Credits : 3**

**Unit -1** Introduction:

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

**6hrs.**

**Unit -2** 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.

**7hrs.**

**Unit -3** 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, Pos deposition treatments.

**6hrs.**

**Unit -4** 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.

**7hrs.**

**Unit -5** 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).

**6hrs.**

**Unit -6** 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

**7hrs.**

**SHIVAJI UNIVERSITY**  
**M.TECH (Energy Technology) PROGRAMMES**

**SEMESTER-II**

ETC 2-4 Solar Thermal Energy Conversion Lab

**Practical : 2hrs/week**

**Credit :1**

A performance based on Experiments, or assignment or Visit report

**SHIVAJI UNIVERSITY**  
**M.TECH (Energy Technology) PROGRAMMES**

**SEMESTER-II**

ETC 2-5 Energy Management and Audit Lab

**Practical : 2hrs/week**

**Credit :1**

A performance based on Experiments, or assignment or Visit report

**SHIVAJI UNIVERSITY**  
**M.TECH (Energy Technology) PROGRAMMES**

**SEMESTER-II**

ETC 2-6 Energy efficiency in thermal and electrical utility Lab  
**Practical : 2hrs/week** **Credit :1**

A performance based on Experiments, or assignment or Visit report

**SHIVAJI UNIVERSITY**  
**M.TECH (Energy Technology) PROGRAMMES**

**Semester-III**

**T 31 Industrial Training:**

**Teaching SchemeExamination Scheme**

**Contact hrs : 2 Hrs./Week/student**

**Credit: 4**

8 Weeks at the end of First Year and as a part of evaluation at the end of third semester student should submit the report for the 8 week industrial training and give presentation to the concern guide, concern guide should spare 2 hrs/week/student

**SHIVAJI UNIVERSITY**  
**M.TECH (Energy Technology) PROGRAMMES**

**Semester-III & IV**  
**S 32 and D 42 Dissertation Project Phase I & II**

The student shall be allowed to submit the dissertation phase I report only after the completion of minimum 50% work of the total project with intermediate /partial results of the dissertation project to the concern guide and the dissertation phase II report only after the full-fledge demonstration of his /her work to the concerned guide. Assessment of the dissertation shall be based on design & implementation aspects, documentation & presentation skills, utility of the dissertation work & publications based on the same.

For the dissertation phase I and phase II concern guide should guide to each student minimum for 2 hrs per week till the final submission of the dissertation of the concern student.

**NOTE : Structure of M. Tech. Energy Technology is only converted into credit system without any changes in the syllabus. So equivalent subjects are denoted**