COURSES SCHEME

&

SYLLABUS

FOR

M.TECH.

ENERGY TECHNOLOGY

&

MANAGEMENT

2015

M.Tech. Energy Technology and Management

Eligibility conditions

B.E/B.Tech. in any branch of engineering/technology

M.Sc. in Physics or Chemistry with Mathematics at graduation level.

Number of Seats: 20

Syllabus for TU Entrance Examination:

The entrance examination will be assessing the awareness and exposure level of the student in the following subject areas:

Analytical, quantitative and verbal aptitude; Energy resources (conventional and new/renewable); Earth and solar radiation; Units and conversions; Thermodynamics and heat transfer; Materials and energy balance; Fluid mechanics and fluid machinery; Fuels and combustion; Energy conversion technologies; Steam; Hydrogen fuel; Energy storage; Electricity and power systems; Energy crisis; Energy and environment; Energy, global warming and climate change; Energy policy and legislation; Energy conservation and management.

COURSES SCHEME & SYLLABUS FOR
M.TECH. (ENERGY TECHNOLOGY AND MANAGEMENT)

Program Objectives

- To prepare the students for successful career in the energy industry; energy regulation and management agencies; and in the academic and R&D institutions.
- To produce graduates strong in energy resources, technologies and management fundamentals, and capable in addressing the present and potential future energy problems.
- To produce energy professionals, who are sensitive to, and well aware of, the energy issues and concerns, and who can apply their specialized knowledge for the sustainable energy management.

SEMESTER – I

SR. NO.	COURSE NO.	TITLE	L	T	P	CR
1	PET106	ADVANCED THERMODYNAMICS AND HEAT TRANSFER	3	1	2	4.5
2	PET104	FLUID MECHANICS AND FLUID MACHINERY	3	1	2	4.5
3	PET103	ENERGY, ENVIRONMENT AND CLIMATE CHANGE	3	1	0	3.5
4	PET102	ENERGY POLICY AND LEGISLATION	3	0	0	3.0
5	PET101	CONVENTIONAL ENERGY TECHNOLOGIES	3	1	2	4.5
6	PET105	RENEWABLE ENERGY TECHNOLOGIES -1	3	1	2	4.5
TOTAL			**18**	**5**	**8**	**24.5**

SEMESTER – II

SR. NO.	COURSE NO.	TITLE	L	T	P	CR
1	PMA102	RESEARCH METHODOLOGY	2	0	2	3.0
2	PET201	RENEWABLE ENERGY TECHNOLOGIES -II	3	1	2	4.5
3	PET202	ELECTRICAL SYSTEMS	3	1	0	3.5
4	PET203	ENERGY CONSERVATION AND MANAGEMENT	3	1	2	4.5
5		ELECTIVE – I	3	1	2	4.5
6		ELECTIVE – II	3	1	0	3.5
TOTAL			**17**	**5**	**8**	**23.5**

ELECTIVE – I		
1	PET211	HYDROGEN FUEL AND FUEL CELL TECHNOLOGY
2	PET212	BIO-ENERGY AND TECHNOLOGIES
3	PET213	SOLAR ENERGY CONVERSION TECHNOLOGIES
ELECTIVE - II		
1	PET221	ENERGY MANAGEMENT SYSTEMS AND AUDITING
2	PET222	ELECTRICAL ENERGY AND MANAGEMENT
3	PET223	THERMAL ENERGY AND MANAGEMENT

SEMESTER – III

SR. NO.	COURSE NO.	TITLE	L	T	P	CR
1	PET391	SEMINAR	-	-	-	2.0
2	PET392	MINOR PROJECT	-	-	-	4.0
3	PET491	DISSERTATION (STARTS)	-	-	-	-
TOTAL			**-**	**-**	**-**	**6.0**

SEMESTER – IV

SR. NO.	COURSE NO.	TITLE	L	T	P	CR
1	PET491	DISSERTATION	-	-	-	12.0
TOTAL			**-**	**-**	**-**	**12.0**

Total Number of Credits: 66.0

Program Outcomes (POs)

- Understood and acquired fundamental knowledge on the science of energy and on both the conventional and non-conventional energy technologies
- Acquired the expertise and skills needed for the energy monitoring, auditing and management, and for the development, implementation, maintenance and auditing of Energy Management Systems
- Become capable of analysis and design of energy conversion systems
- Acquired skills in the scientific and technological communications, and in the preparation, planning and implementation of energy projects

PET106: ADVANCED THERMODYNAMICS AND HEAT TRANSFER

L	T	P	Cr
3	1	2	4.5

Course Objectives: The course includes fundamental principals in thermodynamics and heat transfer, and developing an intuitive understanding of thermal sciences by emphasizing the physical arguments. This course familiarises students with concepts, devices and properties used in thermal science with concepts of heat transfer, engines and refrigerators function with application of process knowledge to the analysis of complete systems.

Basic of thermodynamics and heat transfer: Review of laws of thermodynamics; Energy and entropy balances, Equilibrium criteria; Chemical potential; Fugacity; Activity; Raoult's Law; Conservation of Energy; Heat Capacity

Exergy analysis: Concept of exergy; Energy analysis for mixing and separation process of fluids, open and closed systems; Exergy analysis of power plant cycles and Refrigeration cycle; Exergy-economic analysis

Chemical equilibrium and reaction analysis: Chemical reaction and combustion; Thermochemistry; Laws of analysis for chemically reacting systems; Mass conservation and mole balance equations; chemical equilibrium; Gibbs phase rule; Henry and Raoult's law

Modes of heat transfer: Heat diffusion equations; Heat Transfer through wall; cyclinder; sphere; Conduction with heat source; Unsteady state heat transfer; Dimensionless numbers; Convection with and without phase change; Condensation and boiling; Shape factor; shape factor calculations for different bodies; radiations exchange between surfaces; Material balances with and without chemical reactions

Heat exchangers and evaporators: Design considerations of shell and tubes of heat exchangers and double pipe heat exchangers; shell-side heat transfer coefficient and pressure drop; LMTD; effectiveness-NTU methods; Fouling and its effects; Single effect and multiple effect evaporators (MEE)

Laboratory Work: Heat transfer through composite wall; Thermal conductivity of lagging material on pipe / metal rod, sphere; Performance of double pipe heat exchanger; Drop wise & film wise condensation; Heat transfer in natural and forced convection

Design project/Industry visit

Course Learning Outcomes:

The students will be able to:

1. Design and analysis of heat exchangers, evaporators with aim to improve their performance and economy
2. Able to execute the exergy analysis for understanding the given physical device and process, compute the work and heat transfer and formulate the ideal approximation to the behaviour.
3. Apply principles of heat transfer to basic engineering design systems with understanding of how processes affect the environment.

Recommended Books:

1. *Nag PK, Engineering Thermodynamics, Tata McGraw Hill (2008).*
2. *Sonntag RE, Borgnakke C and Van Wylen GJ, Fundamentals of Thermodynamics, John Wiley (2007).*
3. *Smith JM, van Ness H and Abbott M, Introduction to Chemical Engineering Thermodynamics, McGraw-Hill (2001)*
4. *Holman JP, Heat Transfer, McGraw-Hill (2004).*
5. *Kern DQ, Process Heat Transfer, International Student Edition, Tata McGraw-Hill (2002).*

Evaluation Scheme:

Sr. No.	**Evaluation Elements**	**Weightage (%)**
1.	MST	25
2.	EST	35
3.	Sessionals (May include Assignments/Projects/Tutorials/Quizes/Lab Evaluations)	40

PET104: FLUID MECHANICS AND FLUID MACHINERY

L	T	P	Cr
3	1	2	4.5

Course Objectives: To provide overview on fluids and fluid mechanics, to provide an understanding on the principles, design, construction and operation of hydraulic machines (flow measurement and control devices, pumps and blowers, turbines, and hydraulic and pneumatic systems).

Fluid properties and fluid mechanics basics: Properties of fluids; Hydrostatics, fluid kinematics and fluid dynamics; Pipe flow; open channel flow; Frond number, supercritical and subcritical flows and hydraulic jump; Boundary layer theory; Flow measurement; and Valves.

Compressible flow: Introduction, Thermodynamic relations, basic equation of compressible flow, Velocity of sound or pressure wave in a fluid, mach number, static and stagnation properties, area velocity relationship for compressible flows, flow of compressible fluid through orifices, venturimeter, pitot static probes.

Hydraulic turbines and flow analysis in turbines: Impacts of jets and forces exerted by jets; Turbines, and classification and types of turbines; Velocity triangle and work output for different types of turbines; Draft tube theory; Operational characteristics of hydraulic turbines and cavitation problems; Turbine design.

Pumps and blowers, and their design: Classification and types of pumps and blowers; Characteristic curves, system head capacity curves, and selection of pumps and blowers; NPSH; Design of pumps, fans and blowers.

Fluid systems and their design: Hydraulic systems and pneumatic systems and their components; Hydraulic press, hydraulic accumulator, hydraulic ram, hydraulic couplings, torque convertor, air lift pump, and gear-wheel pump; Design of hydraulic systems.

Laboratory Work: Calibration of flow meters; Determination of head losses; Performance characteristics of pumps, blowers and turbines. Mini projects on the design of pumps, blowers, turbines and hydraulic systems.

Course Learning Outcomes:

1. Capable of measurement and control of both compressible and non-compressible fluid flows
2. Knows how to analyze and design hydraulic turbines
3. Knows how to design, characterize and select pumps, fans and blowers
4. Capable of design and assembly of hydraulic systems and pneumatic systems

Recommended Books:

1. *Bansal RK, Fluid Mechanics and Hydraulics Machines, Luxmi Publishers (2010)*
2. *Fox RW, McDonald AT and Pritchard PJ, Intodution to Fluid Mechanics, Wiley & Sons Inc, (2008)*
3. *Cengel YA, Fluid Mechanics, McGraw-Hill (2008)*

Evaluation Scheme:

Sr. No.	Evaluation Elements	Weightage (%)
1.	MST	25
2.	EST	35
3.	Sessionals (May include Assignments/Projects/Tutorials/Quizes/Lab Evaluations)	40

PET103: ENERGY, ENVIRONMENT AND CLIMATE CHANGE

L	T	P	Cr
3	1	0	3.5

Course Objectives: This course provides understanding of the interrelationship of energy and environment. In addition, enhances the knowledge of basic concepts of climate change and strategies for conservation of environmental changes.

Overview: Introduction, Role of energy in economic development and social transformation: Energy and GDP, GNP and its dynamics, Impact of Energy on Economy, Energy Sources and overall energy demand and availability, Energy Consumption in various sectors and its changing pattern, Energy Security: Future Energy Options: Sustainable Development, Energy Crisis: Transition from carbon rich and nuclear to carbon free technologies.

Environmental impacts of Conventional energy technologies: Environmental implication of Fossil Fuels, CO_2 emission in atmosphere, Limitations of traditional energy technologies, Equipments used in the control of air emissions, thermal pollution and strategies for control of solid and hazardous waste from thermal power plant; Fallout from nuclear explosions – fuel processing and radioactive waste, Radioactivity risk assessment; Effect of Hydroelectric power stations on ecology and environment; Automobile pollution and its Abatement; Green belt.

Environmental impacts of Renewable energy technologies: Need for use of new and renewable energy, Criteria for the selection of new energy sources, Environmental degradation due to production and utilization by bio-energy, solar energy, tidal energy, wind energy, Geothermal energy; Power sector reforms.

Global climate change: Elements of climate; Climatic classifications; Climatic controls; Spatial and temporal patterns of climate parameters in India; Long term changes; Possible causes of climate change- External (Milankovitch variation and Solar activity) and Internal (natural and anthropogenic); Causes and consequences of global warming; ozone hole and consequence of ozone depletion; Montreal protocol; Kyoto protocol and recent conventions; Strategies for conservation of environmental changes induced by CO_2 rise; Concept of carbon sequestration; Clean Development Mechanism (CDM) and its operationalization, modalities and procedures for CDM Project.

Course Learning Outcomes:

1. Able to acquire scientific and technological understanding on the energy resources and issues associated with energy crisis.
2. Get acquainted with the environmental impacts of energy technologies.
3. Knowing the issues related to climate change and related protocols
4. Ability to learn modalities as well as procedures for CDM projects.

Recommended books:

1. *Brown CE, World Energy Resources: Charles E. Brown, Springer (2002).*
2. *Tiwari GN, Renewable Energy Resources: Basic Principles and Applications Narosa Publishing House (2005).*
3. *Dayal M, Renewable Energy Environment and Development, Konark Publisher(1998).*

Evaluation Scheme:

Sr. No.	Evaluation Elements	Weightage (%)
1.	MST	30
2.	EST	45
3.	Sessionals (May include Assignments/Projects/Tutorials/Quizes/Lab Evaluations)	25

PET102: ENERGY POLICY AND LEGISLATION

L	T	P	Cr
3	0	0	3.0

Course Objectives: This course provides insight into processes, institutions and major developments in the energy policy of India. Further, this course covers regulations associated with energy policy and implications in future energy demand. Subsequently, student's skills in critical thinking and reasoning about energy policy issues to be developed.

Definitions of terms: Conventions, protocols, policy, law, act and rule, administrative and legal interpretations, codes and specifications.

Overview: Energy scenario of India; Carbon emissions, meeting the growing energy demands and providing access to everyone, Pricing mechanisms and producer and consumer subsidies, Energy imports and import dependence of India; Overview of energy legislation of India; Overview of energy policies and plans of the Govt. of India.

Energy sectors, departments and ministries of India: Power sector and Ministry of Power; Coal sector and Ministry of Coal; Oil & gas sector and Ministry of Petroleum and Natural Gas; Renewable Energy sector and Ministry of New and Renewable Energy; Nuclear sector and Department of Atomic Energy.

Key energy acts and rules made thereunder: The energy conservation Act, 2001; The Electricity Act, 2003; The Atomic Energy Act, 1962; The Coalmines (conservation & development) Act, 1974; Other legislation concerning power, coal, oil & gas, renewable energy, nuclear energy sectors.

Institutional structures of energy administration in India: ONGC, State Electricity Boards; Atomic Energy Agency, etc.

Energy policies and plans: Integrated energy policy, 2008; National policy on bio-fuels; Strategic plan for new and renewable energy sector for the period of 2011-2017; 5 year plans and their impacts on energy sector; National action plan for climate change.

Energy management systems: ISO 50001: 2011.

Course Learning Outcomes:

Following the successful completion of this course, the students will be able to:

1. Interpret various energy acts in India.
2. Critically review the Indian energy policy with respect to future energy demand.
3. Form an opinion about subsidies given in different energy sectors and defend their position.
4. Evaluate the performance of state owned energy companies and recommend measures to improve the performance.
5. Analyze the impact of 5 year plans in the energy sector
6. Formulate plans for implementing energy management systems.

Recommended books:

1. *India: Energy policy, laws and regulations handbook, Volume-1: Strategic information and renewable energy. International business publications, USA. 2010.*
2. *Naseem M, Energy Law in India, Kluwer Law International BV, The Netherlands (2011).*

Evaluation Scheme:

Sr. No.	Evaluation Elements	Weightage (%)
1.	MST	30
2.	EST	50
3.	Sessionals (May include Assignments/Projects/Tutorials/Quizes/Lab Evaluations)	20

PET101: CONVENTIONAL ENERGY TECHNOLOGIES

L	T	P	Cr
3	1	2	4.5

Course Objectives: This course enables to understand various conventional energy technologies including fossil fuel based nuclear and hydro power plants; fuel types and their combustion phenomenon and energy efficiency analysis of steam, gas, nuclear, combined cycle and hydroelectric power plants. In addition, develops skills to assess and select suitable conversion devices, components and equipments.

Fuels and combustion: Fossils fuels; Fuel properties; Fuel combustion and combustion technologies; Combustion equations (stoichiometric and non-stoichiometric), analysis of products of combustion, conversion of volumetric and gravimetric analysis; and Fluidized bed combustion system.

Thermal energy: Thermal energy and thermal power stations; Vapour power cycles; Boiler systems, Types of boilers; Fuel handling systems; Ash handling; Treatment and conditioning of boiler feed water; Degasifiers and Deaerators; Conditioning of cooling waters; **S**team properties and steam calculations; Pressure reducing systems.

Turbines and IC engine: Steam turbines; Turbine losses and efficiencies; Condensers and cooling towers; Cogeneration and back-pressure turbines; Gas Turbines; Combined cycle power plants and analysis; IGCC plant and binary vapour cycles; Internal combustion engine based power plants - DG sets.

Nuclear energy: Nuclear energy – potential, challenges and opportunities; Nuclear fuels; Nuclear fusion and fission technologies; Breeder technology; Nuclear fuel enrichment; Nuclear reaction control.

Nuclear reactors: Components of nuclear reactors, fuel cladding, moderators, coolants, control rods, Nuclear reactor types; Recent developments in nuclear reactors; Nuclear wastes and their management; and Reactor safety and safety measures.

Hydropower: Importance and potential of hydro-electric power; Hydropower - merits and demerits; Types of hydroelectric power plants; Run-of-the-river power plants; Components of a hydroelectric power plant; Classification of modern water turbines; Torque - power and efficiency; and Power house safety requirements.

Laboratory Work: Field visit of thermal power plant, determination of dryness fraction, cooling tower, evaluation of brake power, brake thermal efficiency, brake specific fuel consumption and heat balance sheet.

Course Learning Outcomes:

1. Gaining comprehensive knowledge on principal of operation, construction and working of various conventional power plants equipment and components.
2. Gaining appropriate knowledge on energy conversion device principles, operation and performance evaluation.

3. Ability to identify, track and solve various combustion problems and evaluate theoretically the performance of various components involved in thermal power plants.
4. Becoming aware of the appropriate technologies used in the power plants for waste management and integration of the thermal energy management system for enhancement in performance.

Recommended Books:

1. *Wakil M, Power Plant Engineering, McGraw Hill. (2004)*
2. *Nag PK, Power Plant Engineering, Tata McGraw Hill Ltd. (2010)*
3. *Bansal PK, Fluid Mechanics & Hydraulic Machines, Luxmi Publishers, (2012)*

Evaluation Scheme:

Sr. No.	Evaluation Elements	Weightage (%)
1.	MST	25
2.	EST	35
3.	Sessionals (May include Assignments/Projects/Tutorials/Quizes/Lab Evaluations)	40

PET105: RENEWABLE ENERGY TECHNOLOGIES -I

L	T	P	Cr
3	1	2	4.5

Course Objectives: This course provides an understanding of solar energy systems and wind energy resources, with scientific examinations of the energy field and emphasis on their technology and management.

Overview of new and renewable energy resources: Introduction to renewable energy technologies; CDM and sustainable energy; Direct energy conversion Devices-Thermionic, thermoelectric, MHD generator.

Solar energy: Solar radiation, components and spectral distribution; Sun-earth geometry and basic earth-sun angles; Factors governing availability of solar energy on the earth; Estimation of average daily global solar radiation; Radiation instruments and radiation measurement – pyranometers and pyrheliometers; Fate of solar radiation in the atmosphere and on the earth.

Solar energy collectors: Stationary collectors – flat plate collectors and evacuated tube collectors; Sun tracking concentrating collectors – parabolic trough collectors, Fresnel collectors, parabolic dish reflectors, Heliostat filled collectors.

Solar energy applications: Passive and active solar water heating systems; Solar space heating and cooling; Solar buildings; Greenhouses; Solar cooling by adsorption systems, absorption systems and by absorption refrigeration systems; Solar cookers and solar driers; Solar desalination systems.
Solar thermal power systems: Solar thermal power generation schemes; Central receiver power plants (solar power towers); Solar chimney power plants; Dish sterling systems; Solar ponds, Thermal analysis of solar power plants.

Photovoltaic systems: Semiconductors; Photovoltaic panels; Types of photovoltaic technologies; Equipment related to photovoltaic technology – batteries, invertors, charge controllers, maximum power point tracking; size of PV system, PV applications; Concentrating photovoltaic systems; Hybrid photovoltaic/thermal systems.

Wind energy basics: Potential of Wind energy in India; Wind energy developments in India; Wind energy resources - assessment and selection of prospective wind energy sites. Wind farms; Environmental impact of wind turbine power plant; Wind diesel hybrid systems; Solar-wind hybrid systems; Wind pumps; Environmental impacts of wind farms.

Wind energy technologies and design: Wind energy conversion technologies and types; Design of wind turbine; Control systems; Planning and design of wind farms; Feasibility study and technology assessment – cost benefit analysis of wind energy projects; Installation and commissioning of WECS; Grid integration of WECS.

Laboratory Work: Performance characteristics of solar flat plate collector, solar stand PV system, solar water heating system, wind turbine system, field visits.

Course Learning Outcomes:

Following the successful completion of this course, the students will be able to:

1. Design, develop and assess solar thermal systems including solar cooker, solar dryer, solar cooler and solar heater.
2. Evaluate the potential of solar and wind energy at a given location.
3. Build a model of wind turbine system and evaluate its performance characteristics under varying experimental conditions.
4. Justify the selection of solar and wind energy systems for a given location based on economics.

Recommended Books:

1. *Goswami DY, Krieth F and Krieder JF, Principles of Solar Engineering, second edition, Taylor and Francis Inc. (2000)*
2. *Tiwari GN, Solar Energy, NarosaPublisers, (2002).*
3. *Garg HP and Prakash J, Solar Energy – Fundamentals and Applications, Tata McGraw-Hill, (2004).*
4. *Manwell JF and Roger AL, Wind Energy: Theory, Design and Applications, Wiley Inc., (2008).*

Evaluation Scheme:

Sr. No.	Evaluation Elements	Weightage (%)
1.	MST	25
2.	EST	35
3.	Sessionals (May include Assignments/Projects/Tutorials/Quizes/Lab Evaluations)	40

PMA102: RESEARCH METHODOLOGY

L	T	P	Cr
2	0	2	3.0

Course Objectives: Ability to elaborate the concept of distribution function. Ability to distinguish between a discrete and continuous random variable and discuss transformation of one-dimensional, two-dimensional variables. Develop potential towards problem solving using analysis of variance techniques. Able to compute and interpret Karl Pearson's correlation coefficient and Spearman's rank correlation coefficient. Able to constitute random block design, Latin square design, and derive their probability distributions

Introduction: Nature and objectives of research, Study and formulation of research problem, Scope and formulation of hypothesis, Preparation and presentation of research and project proposals, Selection of thrust research.

Introduction to Statistical Analysis: Measures of Central Tendency and Dispersion, Mean, Median, Mode, Range, Mean deviation, Standard Deviation.

Random Variables and Probability Distribution: Definition, Distributions, Functions, Mathematical Expectation, Binomial, Poisson, Geometric, Negative bionomial, Exponential, Normal and log-normal distributions.

Hypothesis Testing: Tests of Significance based on normal, t and chi-square distributions, Analysis of variance technique.

Linear Regression and Correlation: Linear regression, least square principle and fitted models, Karl Pearson's correlation coefficient, Rank Correlation, Lines of regression.

Design of Experiments: Completely randomized design, Random block design, Latin square design, Statistical analysis and variances of estimates, Analysis of covariance.

Laboratory Work: Implementation of statistical techniques using statistical packages *viz*., SPSS, Mathematica including evaluation of statistical parameters and data interpretation, Regression Analysis, Covariance, Hypothesis testing and analysis of variance.

Course Learning Outcomes:

1. Acquiring skills for formulating research problems and hypotheses to be tested, and for the preparation and presentation of research/project proposals.
2. Obtaining the knowledge of probability and data distribution functions and becoming capable of estimating mathematical expectations.
3. Acquiring the skills of regression and correlation analysis, development of statistical models, and calibration, validation and use of the models.
4. Becoming capable of design of experiments for investigations and hypotheses testing relating to research problems and projects.
5. Getting acquainted with the commercially available software packages for the statistical data analysis.

Recommended Books:

1. *Dowdy S, Wearden S and Chilko D. Statistics for Research, Wiley Series (2004).*
2. *Walpole RE, Myers RH, Myers SL. and Ye K. Probability and Statistics for Engineers and Scientists, Pearson Education (2002).*

Evaluation Scheme:

Sr. No.	Evaluation Elements	Weightage (%)
1.	MST	25
2.	EST	35
3.	Sessionals (May include Assignments/Projects/Tutorials/Quizes/Lab Evaluations)	40

PET201: RENEWABLE ENERGY TECHNOLOGIES-II

L	T	P	Cr
3	1	2	4.5

Course Objectives: This course provides knowledge, understanding and application oriented skills on biomass, ocean, tidal and geothermal energy sources and relevant technologies towards their effective utilization for meeting energy demand. Furthermore, develops clear understanding of these technologies to be able to select an appropriate type of plant for given energy requirements.

Biomass energy: Biomass energy resources – types and potential; Energy crops.

Biomass energy technologies: Biomass characterization (proximate and ultimate analysis); Biomass pyrolysis and gasification; Biofuels – biodiesel, bioethanol, Biobutanol; Algae and biofuels; Hydrolysis & hydrogenation; Solvent extraction of hydrocarbons; Pellets and bricks of biomass; Biomass based thermal power plants; Biomass as boiler fuel; Social, economic and ecological implications of biomass energy.

Waste to energy: Agricultural residues and wastes including animal wastes; industrial wastes; municipal solid wastes; Incinerators, gasifiers and digestors.

Ocean wave and tidal energy: Introduction to tidal and ocean wave energy; Potential sources in India; Understanding of wave and current movements for tapping of energy; Estimation of energy – Maximum and minimum power ranges; Different wave energy conversion devices; Principles of tidal power generation; Components of a tidal power plant; Current technologies and future challenges in the wave, tidal stream and barrage energy production; Coastal impacts of marine based energy.

Ocean energy: OTEC Principles and technologies; Lambert's law of absorption; Major problems and operational experience; Future scope, potential and assessment of ocean thermal energy sources and conversion technologies.

Geothermal energy: Geothermal energy sources – types and potential; Physico-chemical features of geothermal reservoirs; Direct and indirect uses of geothermal energy resources; Geothermal energy conversion technologies; High temperature geothermal power plants; Environment impacts.

Mini and micro hydel power plants: Pumped storage power plants; Siting and design of mini and micro hydro power plants; Ecological and environmental concerns and impacts of hydroelectric power.

Unconventional energy resources: Unconventional oil/gas resources, shale gas, coal bed methane.

Laboratory Work: Biogas operated dual fuel engine, biodiesel production process, gasifier based dual fuel engine, methane production and anaerobic digestion process, pyrolysis, field visits.

Course Learning Outcomes:

Following the successful completion of this course, the students will be able to:

1. Access the socio-economic impact of biomass energy.
2. Formulate protocol to convert agricultural waste into energy.
3. Estimate energy generated from sources like ocean based, geothermal and mini hydro system.
4. Build and evaluate mini hydro power plants.
5. Solve supply and environmental problems associated with the unconventional oil and gas energy resources.

Recommended Books:

1. *Dickson MH, Geothermal Energy: Utilization and Technology, UNESCO (2005)*
2. *Charlier RH, Ocean Energy: Tidal and Tidal Power, R.H. Charlier, Springer-Verlag (2004)*
3. *Sorenson B. Renewable Energy, Elsevier (2010).*
4. *Rao S, Parulekar BB. Energy Technology: Non-conventional, Renewable and Conventional, Khanna Pub. (2005).*
5. *Fay JA, Golomb DS. Energy and Environment, Oxford University Press (2002)*

Evaluation Scheme:

Sr. No.	Evaluation Elements	Weightage (%)
1.	MST	25
2.	EST	35
3.	Sessionals (May include Assignments/Projects/Tutorials/Quizes/Lab Evaluations)	40

PET202: ELECTRICAL SYSTEMS

L	T	P	Cr
3	1	0	3.5

Course Objectives: This course provides an intensive introduction to the AC electric system, AC system losses and power factor correction, operation and control of power system, relaying and protection of transmission lines with emphasis on their technology and applications.

Overview of Electrical System: Introduction to power generation, transmission and distribution, review of AC system fundamentals.

Power Factor Correction: Concept of power factor and reactive power, causes and effects of low power factor, advantages of improved power factor, energy saving by power factor improvement through capacitor, synchronous generator and STATCOM.

Operation and Control of Power System: Synchronous machine operation and capability analysis, governing systems, automatic generation control, automatic voltage regulator, hydro, and steam turbine modelling, power system stabilizer, economic operation of thermal units.

Power System Harmonics and Filters: Problem of harmonics in power system, sources of harmonics, computation and measurement of harmonics, performance measures, and harmonic mitigation.

Relaying and Protection and Substation practices: Fault calculation, circuit breakers, isolators, fuses and connectors, types of circuit breakers; relaying elements, relay types and characteristics, protection of power system components, numerical relays, grounding and earthing.

Course Learning Outcomes:
At the end of the course, the student shall be able to -

1. Explain the concepts of AC electric system.
2. Apply power factor correction for energy saving by capacitor and STATCOM.
3. Estimate the harmonics and apply mitigation through STATCOM.
4. Comprehend the operation and control of power system, power system protection and substation practices.

Recommended Books:

1. *Nagrath IJ and Kothari DP, Power System Engineering, Tata McGraw–Hill (2007).*
2. *Wadhwa CL, Electrical Power Systems, New Age International (P) Limited, Publishers (2008).*
3. *Gupta BR, Power System Analysis and Design, S. Chand (2009).*
4. *Pabla AS, Electric Power Distribution, McGraw Hill (2008).*
5. *Mukherjee PK and Chakravorty S, Electrical Machines, Dhanpat Rai (2004).*
6. *Nagrath IJ and Kothari DP, Electric Machines, Tata McGraw Hill (2004).*

Evaluation Scheme:

Sr. No.	Evaluation Elements	Weightage (%)
1.	MST	30
2.	EST	45
3.	Sessionals (Quizzes, Assignments, Tutorials)	25

PET203: ENERGY CONSERVATION AND MANAGEMENT

L	T	P	Cr
3	1	2	4.5

Course Objectives: To understand and appreciate the energy crisis and environmental concerns associated with the energy management, and the importance of energy conservation, to acquire the skills of energy efficiency analysis and energy management in the routinely used thermal and electrical energy systems, to understand the energy conservation and management technologies and strategies.

Introduction: Overview of non-renewable energy resources, and new and renewable energy resources; Overview of energy technologies; Energy crisis and environmental concerns; Principles of energy conservation and management.

Energy conservation and management in thermal systems: Fuels and combustion; Boilers, Internal combustion engines and furnaces; Waste heat recovery systems; Turbines and DG sets; Steam system and condensate systems; Insulation; Heat exchangers; Cooling towers and circulating cooling water systems.

Energy conservation and management in electrical systems: Electrical motors and drives; Pumps, Fans and Blowers; Air compressors and compressed air systems; Buildings and space heating and lighting systems; HVAC systems.

Energy management: Supply side and demand side energy management; Energy monitoring and auditing; Energy management systems.

Laboratory Work: Energy monitoring and auditing; Energy Plus Simulation software.

Course learning outcomes:

1. Awareness on the energy crisis and environmental concerns and on the importance of energy efficiency, conservation and management
2. knowing the techniques and having the skills for the energy conservation and management in the thermal energy systems
3. knowing the techniques and having the skills for the energy conservation and management in the electrical energy systems
4. Basic knowledge on energy monitoring and auditing, and on the energy management systems
5. Exposure to the most used energy planning and management softwares.

Recommended Books:

1. *Practical guide to energy conservation – a ready reckoner on energy conservation measures; Petroleum Conservation Research Association (2009).*
2. *Indian Energy Board-2012; World Energy Council.*
3. *Reay DA, Industrial energy conservation; Pergamon Press (1979).*
4. *White LC, Industrial Energy Management and Utilization; Hemisphere Publishers; (1988).*
5. *Eastop TD and Croft DR, Energy Efficiency for Engineers and Technologists; Longman- Scientific and Technical Series (1988).*

Evaluation Scheme:

Sr. No.	Evaluation Elements	Weightage (%)
1.	MST	25
2.	EST	35
3.	Sessionals (May include Assignments/Projects/Tutorials/Quizes/Lab Evaluations)	40

PET211: HYDROGEN FUEL AND FUEL CELL TECHNOLOGY

L	T	P	Cr
3	1	2	4.5

Course Objectives: The objective of the course is to provide comprehensive and logical knowledge of hydrogen production, storage and utilization. In addition, provides an understanding of various fuel cell technologies.

Introduction of hydrogen energy systems: Properties of hydrogen as fuel, Hydrogen pathways introduction-current uses, general introduction to infrastructure requirement for hydrogen production, storage, dispensing and utilization, and hydrogen production plants.

Hydrogen production processes: Thermal-Steam reformation, thermo chemical water splitting, gasification-pyrolysis, nuclear thermal catalytic and partial oxidation methods. Electrochemical-Electrolysis, photo electro chemical, Biological-Anaerobic digestion, fermentation micro-organism, PM based electrolyser.

Hydrogen storage: Physical and chemical properties, general storage methods, compressed storage-composite cylinders, glass micro sphere storage, zeolites, metal hydride storage, chemical hydride storage and cryogenic storage, carbon based materials for hydrogen storage.

Hydrogen utilization: Overview of hydrogen utilization, IC Engines, gas turbines, hydrogen burners, power plant, domestic cooking gas, marine applications, hydrogen dual fuel engines.

Fuel cells: History – principle - working - thermodynamics and kinetics of fuel cell process – performance evaluation of fuel cell – comparison on battery Vs fuel cell, Types of fuel cells – AFC, PAFC, SOFC, MCFC, DMFC, PEMFC, microbial fuel cells, relative merits and demerits.

Applications of fuel cells: Fuel cell usage for domestic power systems, large scale power generation, Automobile, Space, economic and environmental analysis on usage of hydrogen and fuel cell. Future trends in fuel cells, portable fuel cells, laptops, mobiles, submarines.

Hydrogen safety: Hydrogen safety aspects, backfire, pre-ignition, hydrogen emission NOx control techniques and strategies, Hydrogen powered vehicles.

Laboratory Work: Hydrogen production via biological process, electrolysis, hydrogen operated SI and CI engine etc, field visits

Course Learning Outcomes:
Following the successful completion of this course, the students will be able to:

1. Evaluate the performance of fuel cells under different operating conditions.
2. Select and defend appropriate fuel cell technology for a given application.
3. Design and develop suitable hydrogen storage system to be used along with fuel cell system.
4. Minimize environmental hazards associated with the use of hydrogen storage and fuel cell technology.

Recommended Books:

1. *Sorenson B, Hydrogen and Fuel Cells: Emerging Technologies and Applications, Bent Sorenson, Academic Press (2005).*
2. *Hordeski MF, Hydrogen and Fuel Cells: Advances in Transportation and Power, The Fairmont Press, Inc. (2009)*
3. *Busby RL, Hydrogen and Fuel Cells: A Comprehensive Guide, Penn Well Books (2005).*

Evaluation Scheme:

Sr. No.	Evaluation Elements	Weightage (%)
1.	MST	25
2.	EST	35
3.	Sessionals (May include Assignments/Projects/Tutorials/Quizes/Lab Evaluations)	40

PET212: BIO-ENERGY AND TECHNOLOGIES

L	T	P	Cr
3	1	2	4.5

Course Objectives: This course provides an understanding of the processes for converting biomass feed-stocks to fuels by various approaches. In addition, develops potential to evaluate technical and economic feasibility and sustainability of energy production from biomass.

Biomass resources and biomass properties: biomass definition, classification, availability and estimation of availability, consumption and surplus biomass, energy plantations. Potential of biomass and assessment.

Thermo chemical conversion: Direct combustion, incineration, pyrolysis and gasification; Biomass stoves, improved chulha and designs; Design, construction and operation of biomass combustors including incinerators; biomass fired boilers and types; Biomass pyrolysis – types, manufacture of charcoal, manufacture of pyrolytic oils and gases; Design, construction and operation of pyrolysis units; Biomass gasification – types, gasifier burner arrangement for thermal heating, gasifier engine arrangement for electrical power; Design, construction and operation of gasifiers.

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: Production of methanol & ethanol, organic acids, solvents, amino acids, antibiotics etc.

Chemical conversion: Hydrolysis and hydrogenation; Solvent extraction of hydrocarbons; Bioethanol; Chemicals from biomass.

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.

Waste to energy Introduction to Energy from waste - classification of waste as fuel – agro based, forest residue, industrial waste, MSW – conversion devices – incinerators, gasifiers, digestors, Environmental monitoring system for land fill gases, Environmental impacts; Measures to mitigate environmental effects due to incineration.

Laboratory work: Biogas operated dual fuel engine, soxhlet solvent oil extraction process, biodiesel production process, gasifier based dual fuel engine, methane production and anaerobic digestion process etc.

Course Learning Outcomes:

1. Able to understand and assess the biomass resource, appropriate conversion technology for the given biomass resource and end use.
2. Able to evaluate the cost-benefit of various biomass energy conversion processes.
3. Able to identify remedies/potential solutions to the supply and environmental issues associated with biomass based energy resources.

4. Describe the challenges/risks involved in the waste disposal and able to identify appropriate waste management technique to handle and turn waste to energy.

Recommended books:

1. *Capareda S, Introduction to biomass energy conversion, CRC Press (2013).*
2. *Lorenzini G and Biserni C, Solar Thermal and Biomass Energy, WIT Press (2012).*
3. *Brown RC and Stevens C, Thermo-chemical Processing of Biomass: Conversion into Fuels, Chemicals and Power, Wiley and Sons (2011).*

Evaluation Scheme:

Sr. No.	Evaluation Elements	Weightage (%)
1.	MST	25
2.	EST	35
3.	Sessionals (May include Assignments/Projects/Tutorials/Quizes/Lab Evaluations)	40

PET213: SOLAR ENERGY CONVERSION TECHNOLOGIES

L	T	P	Cr
3	1	2	4.5

Course Objectives: This course provides a detailed knowledge of solar energy measurement techniques and harvesting solar energy potential through solar energy conversion systems. In addition, develops skills in critical thinking and reasoning about issues associated direct and indirect use of solar energy.

Solar radiation and availability: Introduction, Solar radiation, components and spectral distribution; Fate of solar radiation in the atmosphere and on the earth; Radiation instruments and radiation measurement – pyranometers and pyrheliometers; Sun-earth geometry and basic earth-sun angles; Solar time and equation of time; Duration of sunshine hours and angle of incidence of solar radiation; Factors governing availability of solar energy on the earth; Estimation of average daily global solar radiation.

Solar energy collectors: Stationary collectors – flat plate collectors, compound parabolic collectors and evacuated tube collectors; Sun tracking concentrating collectors – parabolic trough collectors, Fresnel collectors, parabolic dish reflectors, Heliostat filled collectors.

Solar water heating systems: Passive solar water heating systems – Thermal siphon systems, Integrated collector storage systems; Active solar water heating systems – Direct circulation systems, Indirect water heating systems, Air heating systems, Heat pump systems, and pool heating systems; Heat storage systems – air system and liquid system thermal storage, and Thermal analysis of storage systems; Module and array design; Solar water heater performance evaluation.

Solar space heating and cooling: Thermal load estimation; Passive space heating design; Service hot water and space heating; Air systems and water systems for solar space heating and cooling; Industrial process heat generation – air and water systems; Solar steam generation systems; Heat pump systems; Solar buildings; Greenhouses; Solar cooling by adsorption systems.

Solar cookers and solar driers: Types of solar cookers; Solar box type solar cooker; SK type solar cooker (parabolic); Solar steam cooking system; Solar bowl cooking concentrators; Classification of solar dryers; Active and passive solar energy dryers.

Solar desalination: Thermal desalinization process and exergy analysis; Direct collection systems - solar stills and types, basin type solar stills, performance of solar stills; indirect collection systems – multistage flash process, multiple effect boiling process (humidification –dehumidification distillation); Vapour compression, reverse osmosis and electro-dialysis processes.

Photovoltaic systems: Semiconductors; Photovoltaic panels; Types of photovoltaic technologies; Equipment related to photovoltaic technology – batteries, invertors, charge controllers, peak power trackers; Design aspects of photovoltaic systems; Concentrating photovoltaic systems; Hybrid photovoltaic/thermal systems.

Solar thermal power systems: Solar thermal power generation schemes; Parabolic trough solar power generating systems; Central receiver power plants (solar power towers); Solar

chimney power plants; Dish sterling systems; Solar ponds, design aspects of solar thermal devices, Thermal analysis of solar power plants.
Design and modelling of solar energy systems: F-chart method and program; Modelling and simulation of solar energy systems; Artificial intelligence in solar energy systems.

Laboratory Work: Performance characteristics of solar flat plate collector, solar standalone PV system, solar water heating system, field visit of solar park etc.

Course Learning Outcomes:
Following the successful completion of this course, the students will be able to:

1. Predict the performance of solar energy systems by building suitable mathematical models.
2. Analyze solar thermal systems using Exergy formulations.
3. Construct and operate standalone solar PV systems.
4. Evaluate the choice of solar collector for a given application.
5. Estimate average global solar radiation at a given place.

Recommended Books:

1. *Kalogirou S, Solar Energy Engineering: Processes and Systems, Academic Press, USA (2009).*
2. *Sukhatme SP, Solar Energy: principles of Thermal Collection and Storage, Tata McGraw-Hill (1996).*
3. *Tiwari GN, Solar Energy-Fundamentals, Design, Modelling & Applications, Narosa (2009)*
4. *Garg HP and Prakash J, Solar Energy fundamentals & Applications, Tata Mc-Graw Hill (2000).*

Evaluation Scheme:

Sr. No.	Evaluation Elements	Weightage (%)
1.	MST	25
2.	EST	35
3.	Sessionals (May include Assignments/Projects/Tutorials/Quizes/Lab Evaluations)	40

PET221: ENERGY MANAGEMENT SYSTEMS AND AUDITING

L	T	P	Cr
3	1	0	3.5

Course Objectives: To provide understanding on the structure and functioning of energy management systems, to train the students on the energy analysis of organizations and development of energy baseline, to train the students on the development, implementation and maintenance of energy management systems, to train the students on the auditing of energy management systems.

Introduction: Energy resources; Environment, climate change and sustainability.

Energy management: Energy management in organizations; Energy efficiency and energy conservation; Environmental impacts, including greenhouse gas emissions, of Energy; Legal and other requirements applicable to the energy management.

Energy monitoring, measurement and analysis: Energy performance indicators; Energy monitoring devices and instruments; Energy monitoring, measurement and analysis.

Energy analysis: Energy review; Development of energy baseline and energy plans.

Energy management systems: Management systems approach for energy management in organizations; Energy management systems and requirements of ISO 50001; Development, implementation, maintenance and improvement of energy management systems.

Auditing and certification of energy management systems: ISO 19011 and internal and second party auditing of energy management systems; ISO 17021 and third party auditing and management system certification/registration.

Case study: Energy management system auditing case study.

Course Learning Outcomes:

1. knows the energy management systems and their essential elements
2. Able to develop, implement and maintain Energy Management Systems in organizations
3. Able to carry out Energy Management Systems Auditing
4. Able to carry out energy analysis of organizations and development of energy baseline

Recommended Books:

1. *ISO 19011: 2011- Guidelines for auditing management systems.*
2. *ISO 17021: 2011 - Conformity assessment — Requirements for bodies providing audit and certification of management systems.*
3. *ISO 50001: 2011 - Energy management systems — Requirements with guidance for use.*
4. *Thumann and W.J. Younger: Handbook of energy audits, Fairmont Press, Georgia, USA (2003).*
5. *Bureau of energy efficiency, New Delhi, India: Guide Book - National certificate examination for energy management and energy audit, 2005 (Book I - General aspect of energy management and energy audit; Book II - Energy efficiency in thermal utilities; Book III - Energy efficiency in electrical utilities; and Book IV - Energy performance assessment for equipment & utility systems).*

Evaluation Scheme:

Sr. No.	Evaluation Elements	Weightage (%)
1.	MST	30
2.	EST	45
3.	Sessionals (May include Assignments/Projects/Tutorials/Quizes/Lab Evaluations)	25

PET222: ELECTRICAL ENERGY AND MANAGEMENT

L	T	P	Cr
3	1	0	3.5

Course Objectives: To provide understanding of typical electrical energy powered utilities and services of industrial facilities and organizations, carry out energy analysis and make the student aware of the techniques and practices for the conservation and management of electrical energy. Furthermore, train the student on the electrical energy analysis of organizations for identifying the opportunities and options for the conservation and management of electrical energy.

Electrical energy: Electrical energy source and supply scenario; Electrical energy and greenhouse gas (GHG) emissions; Supply side management of electrical energy; Regulatory provisions relating to electrical energy supply and management; Electricity pricing, and rebate and penalty schemes applicable to electrical energy.

Concepts of distribution system: Electrical power system and its components; Rectifiers and transformers, and energy losses; Power regulation panels and distribution systems and losses; Capacitors and power factor regulation; Electrical load management and demand control; Environmental concerns of electrical power systems.

Electrical furnaces and heaters: Types and classification of furnaces; performance evaluation of a furnace; furnace efficiency testing; fuel economy measures for furnaces.

Motors and drives: Losses in induction motors, Motor efficiency, Factors affecting motor performance, Rewinding and motor replacement issues, energy efficient motors, variable speed and variable frequency drives.

Pumps, fans and blowers: Saving potential, Fans, Blowers and pumps- Types, Performance evaluation, Efficient system operation, Flow control strategies and energy conservation opportunities.

Lighting, heating/cooling and ventilation systems: Air Handling Units; Luminance requirements and choice of lighting; Electrical energy conservation avenues; natural lighting and passive systems for ventilation.

Compressed air system: Compressed air systems and their energy and environmental analysis; Types of air compressors and efficiencies, and efficient operation of compressors; Capacity assessment, Leakage test Factors affecting the performance and efficiency.

HVAC and refrigeration System: Vapor compression refrigeration cycle, Refrigerants, Coefficient of performance, Factors affecting refrigeration and air conditioning system performance and savings opportunities, Vapor absorption refrigeration system: Working principle, Types and comparison with vapor compression system.

Case study: Electrical energy auditing and management case study.

Course Learning Outcomes:

At the end of the course, the students shall be able to:

1. Explain the typical electrical energy powered machinery and equipment of organizations, especially the industrial units.
2. Apply tools and techniques and the management practices for the conservation and management of electrical energy in organizations.
3. Apply techniques and skills of electrical energy analysis and identification of opportunities and options for electrical energy conservation and management.

Recommended Books:

1. *Abbi Y P and Jain S, Handbook on Energy Audit and Environment Management, Teri Bookstore (2006).*
2. *Diwan P, Energy Conservation, Pentagon Press (2008).*
3. *Doty S, and Wayne C. Turner, Energy Management Handbook; The Fairmont Press, Inc. (2009).*
4. *Younger, W., Handbook of Energy Audits, CRC Press (2008).*
5. *Bureau of Energy Efficiency, New Delhi, India: Guide Book (Book III –IV) - National certificate examination for energy management and energy audit (2005).*

Evaluation Scheme:

Sr. No.	Evaluation Elements	Weightage (%)
1.	MST	30
2.	EST	45
3.	Sessionals (May include Assignments/Projects/Tutorials/Quizes/Lab Evaluations)	25

PET223: THERMAL ENERGY AND MANAGEMENT

L	T	P	Cr
3	1	0	3.5

Course Objectives: This course provides basic understanding on combustion of fuels, generation and conversion of thermal energy, and on the typical thermal energy utilities including boilers and steam system, thermic fluid systems and cooling water systems. In addition, develops skill on performance evaluation of different boilers and energy conversion devices.

Boilers: Boiler types and classification; Steam boilers, hot water boilers and thermic fluid boilers; Boiler system and components (ID and FD fans, furnace, boiler, economizer, air preheater, heat recovery unit, air pollution control devices and stacks); Boiler feed water and boiler water treatment; Boilers operation and control and boiler blowdowns; direct and indirect boiler efficiency estimation; and energy conservation opportunities in boilers.

Cogeneration: Principle and need of cogeneration; Classification of cogeneration systems; technical options for cogeneration; Steam turbines and gas turbines; and Parameters of cogeneration performance.

Steam and condensate system: Properties of steam; Steam supply and condensate recovery systems and their components; Steam and condensate system design; Pressure reducing systems; Steam traps and vents; and Energy losses in steam and condensate system and energy saving opportunities.

Furnaces: Types and classification of furnaces; Furnace system and components; Energy performance evaluation of furnaces; Pollution control devices and energy recovery systems for furnaces; and Fuel economy measures for furnaces.

Insulation and refractories: Purpose, types and applications of insulation; Heat loss calculations and design of insulation thickness; Properties, types and applications of refractories; Heat loss calculations, selection and design of refractories.

Cooling towers and circulating cooling water systems: Circulating cooling water system and components; performance evaluation of cooling tower and circulating cooling water system; Conditioning of cooling water and management of cooling tower blowdowns.

Case study: Thermal energy auditing and management case study.

Course Outcomes:

1. Having basic understanding of combustion process and knowledge of on-site thermal energy generation systems.
2. Gaining knowledge on performance enhancement minimising energy losses using cogeneration, various thermal power plant sub-systems and insulation. Becoming aware of the structure and functioning of thermal energy systems of industrial units and organizations.
3. Aquiring skills on thermal energy auditing and analysis of energy losses in power plant.

4. Student acquiring the techniques and skills of thermal energy analysis and identification of opportunities and options for the thermal energy conservation and management.

Recommended books:

1. *Thumann A and Younger WJ, Handbook of Energy Audits, Fairmont Press, Georgia, USA (2003).*
2. *Bureau of Energy Efficiency, New Delhi, India: Guide Book (Book II) - National certificate examination for energy management and energy audit (2005).*
3. *Doty S, and Wayne C. Turner, Energy Management Handbook; The Fairmont Press, Inc. (2009)*

Evaluation Scheme:

Sr. No.	Evaluation Elements	Weightage (%)
1.	MST	30
2.	EST	45
3.	Sessionals (May include Assignments/Projects/Tutorials/Quizes/Lab Evaluations)	25