SHIVAJI UNIVERSITY
M.TECH. (Energy Technology) PROGRAMME

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 (Open Elective*)	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
ETE 1-4	Materials and Devices for Energy Application

Elective- II Open Elective **choose from list on next page**

*Student of M.Tech. of any branch can opt this elective

Semester –I (Open Elective*)

Sr.No.	Elective-II (Open Elective*)	Branch
1	E15(V) Digital System And Testing	Electronics Technology
2	E 15 (V)Mixed Signal ASIC Design	
3	E 15 (E) Automotive Embedded Systems	
4	FTE-21: Advances in processing of dairy Technology	Food Technology
5	FTE-22: Food rheology and texture	
6	FTE-23: Advances in cereals and pulses processing technology	
7	ETE 2 Fuel and Combustion Technology	Energy Technology
8	ETE 2Solar Passive Architecture	
9	ETE 2Energy storage systems	
10	ESTE-21 Optimization Techniques	

		Environmental Science and Technology
11	ESTE-22 Design of Energy Efficient Building	
12	ESTE-23 Operational Health and Safety Management	
13	CS515 Advanced Operating Systems	Computer Sci. &Technology
14	CS515 Real Time Systems	
15	CS515 Web Engineering	

Minimum number of students for selection of Elective - 8

Maximum number of students for selection of Elective - 36 *

***Preference will be given to core branch**

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 (Open Elective*)	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
ETE 3-4	Smart Microgrids

Elective – IV **Choose from list on next page**

*Student of M.Tech. of any branch can opt this elective

Semester –II (Open Elective*)

Sr.No.	Elective-IV (Open Elective*)	Branch
1	E 25 (V) VLSI in Signal Processing	Electronics Technology
2	E25(E) High Performance Networks	
3	E 25 (E) High speed Digital Design	
4	FTE-41: Recent developments in processing of plantation crops	Food Technology
5	FTE-42: Simulation and modeling in food processing	
6	FTE-43: Project management for food processing industries	
7	ETE 4-1 Power Co-generation	Energy Technology
8	ETE 4-2 Energy modeling and project Management	
9	ETE 4-3 The New Energy Technologies	
10	ESTE-41 Operation and Maintenance of Environmental Facilities	Environmental Science and
11		

	ESTE-42 Rural Water Supply and Sanitation	Technology
12	ESTE-43 Environmental Biotechnology	
13	CS525 Geographical Information Systems	Computer Sci. &Technology
14	CS525 Artificial Intelligence and Natural Language Processing	
15	CS525 System modeling and simulation	

Minimum number of students for selection of Elective - 8

Maximum number of students for selection of Elective - 36 *

***Preference will be given to core branch**

Course Structure and Scheme of Evaluation

Shivaji University, Kolhapur Second Year M. Tech Energy Technology (Semester III)		
Sr.No	**M. Tech (Energy Technology) Semester III Pre-revised syllabus**	**M. Tech (Energy Technology) Semester III Revised syllabus**
	Teaching Scheme : P : 2 hrs/week Credits: 4	Teaching Scheme : P : 2 hrs/week Credits: 4
1	**Industrial Training**	**Industrial Training**
	Industrial Training of Eight weeks at the end of First Year, Evaluation at end of III semester on the basis given report and Presentation to concern Guide.	Industrial Training of Eight weeks at the end of First Year OR Industrial Training will be split intwo slots of four weeks during semester III. Evaluation at end of III semester on the basis given report and Presentation to concern Guide.
2	**Dissertation Phase – I**	**Dissertation Phase – I**
	Teaching Scheme : P : 5 hrs/week Credits: 10	Teaching Scheme : P : 5 hrs/week Credits: 10

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

Semester I

C-10 Research Methodology

Teaching Scheme Examination Scheme Lectures: 2 h/Week

Unit 1 Research Methodology: An Introduction. (4 h)
Objectives of Research, Types of Research, Research Methods and Methodology, Defining a Research Problem, Techniques involved in Defining a Problem

Unit 2 Research Design (6 h)
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

Unit 3 Measurement and Scaling Techniques (4 h)
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 (4 h)
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

Unit 5 Techniques of Hypotheses, Parametric or Standard Tests (4 h)
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

Unit 6Analysis of Variance and Co-variance (4 h)
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

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Interpretation and Report (1 h)

SEMESTER-I

Core Course

ETC 1-1: Energy resources and Their Utilization

Lectures: 4 h/ Week **Credits: 4**

Course Outcomes

1. Acquiring the knowledge of energy sector.
2. Analysis of energy scenario.
3. Describe the impact of energy sector on environment.

Unit - 1: Introduction to Energy: (10 h)

Definition and units of energy and power, forms of energy, conversion of energy, second law of thermodynamics, origin of fossil fuels, time scale of fossil fuels, renewable energy resources, role of energy in economic development and social transformation, Human Development Index of UNO.

Unit - 2 Global Scene (10 h)

Energy resources - coal, oil, natural gas, uranium and hydroelectricity, energy resources and their geographical distribution, energy consumption in various sectors, projected energy consumption for the twenty first century, impact of rise in energy consumption on global economy, large power plants, energy consumption in some important countries, energy exports, future energy options, role in brief, of International Atomic Energy Agency.

Unit - 3 Indian Scene (10 h)

Commercial and non-commercial forms of energy, energy consumption pattern and its variation as a function of time, energy resources available in urban and rural sector, nuclear energy - promise and future, energy as a factor limiting growth, need for use of renewable energy resources, state wise energy utilization, energy independence, large power projects.

Unit - 4 Environmental Impact (10 h)

Environmental degradation due to energy production and utilization, primary and secondary pollution-air, thermal and water, depletion of ozone layer, global warming, biological damage due to environmental degradation, pollution due to thermal power stations and their control, pollution due to nuclear power generation, radioactive waste management, effect of hydro-electric power stations on ecology and environment, global warming and its effects - summary of UNFCCC studies.

References-

1. Energy for a sustainable world: Jose Goldenberg, Thomas Johansson, A.K.N.Reddy, Robert Williams (Wiley Eastern).

2. Energy policy, B.V.Desai (Weiley Eastern),

3. Modeling approach to long term demand and energy implication : J.K.Parikh.

4. Energy Policy and Planning : B.Bukhootsow.

5. TEDDY Year Book Published by Tata Energy Research Institute (TERI),

6. World Energy Resources : Charles E. Brown, Springer2002.

7. 'International Energy Outlook' -EIA annual Publication

8. Heat and Thermodynamics – M.W. Zemansky (McGraw Hill Publication)

9. Principles of Energy Conversion: A.W. Culp (McGraw Hill International edition.)

10. World Energy Council - latest edition

11. Ministry of Power - Govt. of India - Energy Statistics - latest edition

SEMESTER-I

ETC 1-2: Biomass and its Conversion Technologies

Lectures: 4 h/ Week **Credits: 4**

Course Outcomes

1. Acquiring the knowledge of biomass energy.
2. Understanding Biomass as an renewable energy and its importance with respect to environment protection
3. To design bio-energy systems.

Unit - 1 Introduction (5 h)

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

Unit-2 Thermo-chemical Conversion (7 h)

Different processes: Direct combustion, incineration, pyrolysis, gasification and liquefaction; Economics of Thermo-chemical conversion. biomass processing, briquetting, pelletisation, biomass stoves, biomass carbonization, production of syngas from biomass.

Unit -3 Biological Conversion (10 h)

Biodegradation and biodegradability of substrate; Biochemistry and process parameters of bio-methanation; Biogas digester types; Digester design and biogas utilization; Chemical kinetics and mathematical modeling of bio-methanation 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 activated sludge process, plug flow reactors, anaerobic fixed film reactor, UASB reactor, anaerobic fluidized bed reactor, estimation of methane yield, anaerobic digestion system for MSW, Vermi-composting,

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Unit -4 Chemical Conversion (6 h)

Hydrolysis & hydrogenation; Solvent extraction of hydrocarbons; Solvolysis of wood; Bio-crude and biodiesel; Chemicals from biomass. Bio CNG: biogas to green vehicle fuel; anaerobic digestion; Bio gas opportunities: Landfill gas, agricultural and industrial wastewater and additional sources of methane.

Unit -5 Power generation (6 h)

Utilization 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. Biomass renewable energy program of central govt. and state government Regulations, policies, feed in tarrif policies, grid injection, hybrid systems, and cost economics. (6 h)

Text Books –

1. Non-conventional energy sources by G.D. Rai, Khanna Publishers

2. Solar Energy: Principles of Thermal Collection and Storage by S,P Sukhatme, Tata McGraw Hill

3. Solar Engineering of Thermal processes, J.A.Duffie and W.A.Beckman, 2ndedition, John Wiley, New York, 1991.

4. Handbook of Biogas Technology, Prattek Shilpkar & Deepti Shilpkar

References -

1. Fuel Cells by Bockris and Srinivasan; McGraw Hill.

2. Solar Energy: Fundamentals and Applications by H.P. Garg& Jai Prakash, Tata McGraw Hill.

3. Wind Power Technology, Joshua Earnest, PHI Learning, 2014

4. Non Conventional Energy Resources by S. Hasan Saeed and D. K. Sharma, S. K. Kataria& Sons.

5. Renewable Energy Sources, J W Twidell& Anthony D. Weir. ELBS Pub.

6. Energy Conversion Systems, R D Begamudre, New Age International (P) Ltd., Publishers, New Delhi ,2000.

7. Principles of Solar Engineering, D.Y.Goswami, F.Kreith and J.F.Kreider, Taylor and Francis, Philadelphia, 2000.

8. Solar Photovoltaics: Fundamentals, Technologies and Applications, C S Solanki, 2nd Edition, PHI Learning, 2013

9. Biomass Regenerable Energy, D. D. Hall and R. P. Grover, John Wiley, New York,1987.

10. Wind and Solar Power Systems, Mukund R Patel, CRC Press, 1999.

11. Wind Energy Explained: Theory, Design and Application, J F Manwell, J.C.McGowan, A.L.Rogers, John Wiley and Sons, May 2002.

12. Magneto Hydrodynamics by Kuliovsky and Lyubimov, Addison

SEMESTER-I

ETC 1-3: Solar Photovoltaic Energy Conversion

Lectures: 4 h/ Week **Credits: 4**

Course Outcomes

1. Acquire the knowledge of Solar PV system.
2. Characterization of Solar PV System.
3. Design the Solar PV System.
4. Market Analysis & Techno-economical feasibility of Solar PV System

Unit -1 Introductions to Solar Energy (8 h)

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

Unit-2 Photovoltaic Principles (8 h)

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, various types of solar cells.

Unit -3 Solar Photovoltaic System Design (9 h)

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.

Unit -4 Performance evaluation of SPV systems (8 h)

Plant load factor, PV array efficiency evaluation, Inverter efficiency tests, balance of material (BOM), energy loss calculations, system efficiency loss calculations, solar PV system component standards and testing standards

Unit – 5 Market analysis and economics of SPV system (7 h)

Various business models for sale of PV electricity, Feed in tariff, regulatory provisions and central/ states solar PV policy, The Recent developments in Solar cells, Role of nano-technology in Solar cells.

Text Books –

1. Solar photovoltaic –Chetan Singh Solanki

2.Principles of solar cells and application - Martin A. Green

References-

1. Solar Electricity Handbook-2015 Edition, by Michael Boxwell, Greenstream Publishing Ltd.

2. Solar Energy Engineering: Processes and Systems by Prof. Soteris Kalogirou

3. Solar Photovoltaic Basics by Sean White

4. Code and Practices for Grid Connected Grid Connected Solar Photovoltaic Systems by IET

SEMESTER-I

Elective Course

ETE 1-1: Waste to Energy Conversion

Lectures: 3 h/ Week **Credits: 3**

Course Outcomes

1) Acquiring the knowledge of Waste to Energy Conversion.
2) Analysis of Waste to Energy Conversion.
3) Describe the impact of Waste to Energy Conversion

Unit -1 Solid Waste (6 h)
Definitions: Sources, types, compositions; Properties of Solid Waste; Municipal Solid Waste.

Unit -2 Physical, chemical and biological property; Collection, transfer stations; Waste minimization and recycling of municipal waste (6 h)

Unit -3 Waste Treatment & Disposal (7 h)
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.

Unit -4 Layout & preliminary design of landfills (6 h)
Composition, characteristics, generation; Movement and control of landfill leachate & gases; Environmental monitoring system for land fill gases.

Unit – 5 Energy Generation from Waste (7 h)
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;

Unit -6 Bio-diesel (6 h)
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.

Text Books –

1. Waste to Energy Conversion Technology by Klinghoffer & Castaldi .

2. Energy Conversion by D. Yogi Goswami, Frank Kreith.

References -

1. Municipal Solid Waste to Energy Conversion Processes: Economic, Technical, and Renewable Comparisons by Gary C. Young

2. Waste-to-Energy, Second Edition: Technologies and Project Implementation by Marc J. Rogoff**.**

3. Municipal Solid Waste Incineration: Requirements for a Successful Project by T. Rand and J. Haukohl , U Marxen

SEMESTER-I

ETE 1-2: Wind Energy & Small Hydropower Systems

Lectures: 3 h/ Week **Credits: 3**

Course Outcomes

1. Acquire the knowledge of WESH system.
2. Characterization of WESH System.
3. Design the WESH System.
4. Market Analysis & Techno-economical feasibility of WESH System.

Unit -1 Introduction (6 h)

Wind energy conversion principles; General introduction; Types and classification of WECS; Power, torque and speed characteristics, Wind resource map of India, screening probable sites and various indicators involved, instrumentation, wind speed measurement, Micrositing of wind turbines, site identification, wind mast installation, Annual Energy Output estimation Uncertainties in estimation, Probabilities of Estimation

Unit -2 WECS Design (7 h)

Aerodynamic design principles, Aerodynamic theories; (2-D, 3-D aerodynamics), Axial momentum, blade element and combine theory; Rotor characteristics; Maximum power coefficient; Prandlt's tip loss correction.

Unit -3 Design of Wind Turbine (6 h)

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

Unit – 4 Wind Energy Application (7 h)

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.

Unit-5 Wind Power Project Planning and Structuring (5 h)

Bank ability of Projects, Promoters, Financing, Balance Sheet, Non Recourse or Project Finance, Leasing, Taxation Issues Electricity off Take Arrangements & Structures; PPA with utility, Captive, Group Captive, Open Access & Merchant Sale and concerned government regulations and policies

Unit-6 Project Contracts (4 h)

Wind Turbine Supply Contracts, Works Contracts, E&C Contract, O&M Contract, Introduction to WASP, Wind Farmer.

Unit -7 Small Hydropower Systems (6 h)

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.

Text Books –

1. Non-conventional energy sources by G.D. Rai, Khanna Publishers

2.Wind Energy by spingers –Erich Hau

3.Renewable Energy Focus – Handbook by Elsevier

References-

1. Wind Energy Engineering, Pramod Jain, The McGraw-Hill Companies, Inc

2. Advanced Renewable Energy Sources,By G. N. Tiwari, Rajeev Kumar Mishra

3. Renewable Energy Engineering and Technology: principles and practice edited by V. V. N. Kishore

SEMESTER-I

ETE 1-3: Energy Efficient Lighting

Lectures : 3 h/ Week **Credits : 3**

Course Outcomes

1. Acquire the knowledge of Energy Efficient Lighting System (EELS).
2. Characterization of EELS.
3. Design the EELS.
4. Market Analysis & Techno-economical feasibility of EELS

Unit -1 Introduction (6 h)

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

Unit -2 System Elements (7 h)

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.

Unit -3 Lighting energy management in buildings: (6 h)

Case Studies Some Good Practices in Lighting

Unit -4 Light Emitting Diodes (7 h)

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

Unit -5 Fiber Optics (6 h)

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

Unit -6 Solid State Lighting (7 h)

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

Text Books –

1.Lighting Retrofit and Relighting: A Guide to Energy Efficient Lighting by James R. Benya ,Donna J. Leban,Willard L. Warren

2.Green Lighting by Brian Clark Howard ,Seth Leitman,William Brinsky

3. Lighting Retrofit and Relighting: A Guide to Energy Efficient Lighting by James R. Benya, Donna J. Leban, Willard L. Warren

References-

1. Lighting Design Basics by Mark Karlen, James R. Benya, Christina Spangler

2. Lighting Controls Handbook by Craig DiLouie

3. Lighting & Controls: Transitioning to the Future by Stan Walerczyk

4. Fundamentals of Lighting by by Susan M. Winchip

SEMESTER-I

ETE 2-1: Fuel & Combustion Technology

Lectures: 3 h/ Week **Credits: 3**

Course Outcomes

1. Characterization of different types of the fuels.
2. Analysis & applications of thermodynamics and combustion of fuels.
3. Applications, designs and thermal performance evaluation of combustion systems

Unit -1 Introduction (6 h)

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

Unit -2 Solid Fuels (7 h)

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

Unit -3 Liquid Fuels (6 h)

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.

Unit -4 Gaseous Fuels (7 h)

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.

Unit -5 Combustion of fuels (6 h)

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

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

Unit -6 Burner Design and Furnaces (7 h)

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.

References –

1.Modern Petroleum Technology, Vol 1, Upstream, Ed. by Richard A. Dave, IP, 6th ed., John Wiley & Sons. Ltd.

2.Modern Petroleum Technology, Vol 2, Downstream, Ed. by Alan G. Lucas, IP, 6th ed., John Wiley & Sons. Ltd.

3.Combustion, Irvin Glassman, 2nd ed., Academic Press.

4.Modern Petroleum Refining Processes, B.K. Bhaskar Rao, 4th ed., Oxford & IBH Publishing Co. Pvt. Ltd.

5.Report on the project "Coal Combustion Study", sponsored by Tata Tron and Steel Company Ltd., Jamshedpur.

6.Fuels Combustion and Furnaces, John Griswold, Mc-Graw Hill Book Company Inc.

7.Fuels and Combustion, Samir Sarkar, 3rd. ed Universities Press.

8.Petroleum Refinery Engineering, W.L. Nelson, 4th ed. Mc-Graw Hill Book Company.

SEMESTER-I

ETE 2-2: Solar Passive Architecture

Lectures: 3 h/ Week **Credits: 3**

Course Outcomes

1. Apply the principles of energy systems for SPA..
2. Design & demonstrate SPA technologies.
3. Integration of renewable energy in passive design

Unit -1 Introduction (4 h)

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

Unit -2 Thermal Analysis and Design For Human Comfort (8 h)

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

Unit -3 Passive Cooling and Heating Concepts (7 h)

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, Introduction and use of different building simulation software for modeling of air conditioned spaces such as VISDOE, EPLUS etc. Introduction to green campus, Solar cities and smart cities

Unit -4 Heat Transmission in Buildings (8 h)

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 day lighting; 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 (6 h)

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.

Unit -6 (7 h)

Introduction and use of different building simulation software for modeling of buildings spaces such as TRNSYS, ECOTECT etc. Introduction to certification of the buildings for building energy performance like USGBC/IGBC/GRIHA/LEED and ECBC

Text Book –

1. Energy conscious building by J.K. Nayak ,J.A. Prajapati

References-

1. Solar radiation and day lighting- Dube, Muner, Tiwari
2. Passive solar architecture :Heating,cooling,ventilation,day lighting and more using natural flows – David Bainbridge, Ken Haggard
3. The solar house: Passive heating and cooling – Daniel D Chiras
4. Solar energy fundaments and modeling techniques – Zekai sen
5. Energy performance of buildings – George Baird
6. Energy and climate change– David Coley

SEMESTER-I

ETE 2-3: Energy Storage Systems

Lectures: 3 h/ Week **Credits: 3**

Course Outcomes

1) Characterization of energy storage system.
2) Describe various energy storage materials & systems.
3) Demonstrate performance evaluation of various electrical & thermal energy storage systems.

Unit -1 Energy Storage (6 h)

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

Unit -2 Electrochemical Energy Storage Systems (7 h)

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 (6 h)

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.

Unit -4 Sensible Heat Storage (7 h)

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.

Unit - 5 Latent Heat Thermal Energy Storage (6 h)

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.

Unit -6 Some Areas of Application of Energy Storage (7 h)

Food preservation; Waste heat recovery; Solar energy storage; Green house heating; Power plant applications; Drying and heating for process industries.

Text Books –

1.Energy Storage 2010th Edition by Robert A. Huggins

2.Energy Storage: Fundamentals, Materials and Applications 2nd ed. 2016 Edition by Robert Huggins

References-

1. Thermal Energy Storage Technologies for Sustainability: Systems Design by S. Kalaiselvam, R. Parameshwaran

2. Hybrid Hydrogen Systems: Stationary and Transportation Applications by Said Al-Hallaj, Kristofer Kiszynski

3. Energy Storage – Technologies and applications by Ahmed Faheem Zobaa

SEMESTER-I

ETC 1-4 Energy Scenario Lab

Practical: 2h/week **Credit: 1**

Expt. No.	Title
1	Study of various forms of energy and energy flow diagram to earth.
2	Study of role of energy in economic development and social transformation.
3	Study of global energy consumption in various sectors and various energy resources.
4	Study of Indian energy scenario.
5	Study of air and water pollution due to power plants.
6	Study of various pollution related issues.
7	Experiment on pyranometer to estimate solar radiation.
8	Experiment on sunshine recorder to estimate sunshine hours.

SEMESTER-I

ETC 1-5 Biomass and its Conversion Technologies Lab

Practical: 2h/week **Credit: 1**

Expt. No.	Title
1	Study of biomass classification and estimation.
2	Study of various thermochemical techniques of biomass conversion.
3	Study of biomethantion process and biogas digester.
4	Study of liqidbiofuels and biodiesel such as ethanol methanol.
5	Study of working of IC engine on biofuels.
6	Study of energy plantation and power programme.
7	Trial on Biogas digester
8	Trial on downdraft Gasifier

SEMESTER-I

ETC 1-6 Solar Photovoltaic Energy Conversion Lab

Practical: 2h/week **Credit: 1**

Expt. No.	Title
1	To demonstrate the I-V and P-V characteristics of PV module with varying radiation and temperature level
2	To demonstrate the I-V and P-V characteristics of series and parallel combination of PV modules.
3	To show the effect of variation in tilt angle on PV module power.
4	To demonstrate the effect of shading on module output power.
5	To demonstrate the working of diode as Bypass diode and blocking diode.
6	Workout power flow calculations of standalone PV system of DC load with battery.
7	Workout power flow calculations of standalone PV system of AC load with battery..
8	Workout power flow calculations of standalone PV system of DC and AC load with battery.
9	To draw the charging and discharging characteristics of battery.

SEMESTER-II

ETC 2-1: Solar Thermal Energy Conversion

Lectures: 4 h/ Week **Credits: 4**

Course Outcomes

1. Acquire the knowledge of STEC system.
2. Characterization of STEC System.
3. Design the STEC System.
4. Market Analysis & Techno-economical feasibility of STEC System.

Unit – 1 Radiative Properties and Characteristics of Materials. (4 h)
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.

Unit – 2 Flat-plate Collectors (7 h)
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.

Unit -3 Solar Thermal Energy Storage (4 h)
Types: Sensible storage; Latent heat storage; Thermo-chemical storage. Design of storage system.

Unit -4 Concentrating Collector Designs (7 h)
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

Unit -5 Performances of solar collectors (7 h)
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;

Unit-6 Solar Energy for Industrial Process Heat (7 h)
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.

Unit-7 Solar Thermal Energy Systems (7 h)
Solar still; Solar cooker: Solar pond; Greenhouse technology, Fundamentals, design, modeling and applications, Emerging technologies: Linear Fresnel reflector, Solar chimney, Application of softwares: TRNSYS, RETScreen, Solar advisor Design of solar thermal power plant layout and design Solar thermal power plants: Performance study, site selection and land requirement
Government regulations and policies, feed in tariff, economics of solar thermal energy generation

Text Books –

1. Principles of Solar Energy by D.Yogi Goswami
2. Solar Energy by S.P. Sukhatme
3. Solar Energy by H.P.Garg

References-

1. Solar energy handbook by Kreider,J.F, Kreith,F
2. Passive solar Energy Book by Mazria,E.
3. Thermodynamics of solar energy conversion by A. De Vos.
4. Thermoelectrics: Direct solar thermal energy conversion.
5. Fundamentals of solar energy conversion: by E.E. Anderson.
6. Solar hydrogen generation by K Rajeshwar.
7. Principles of Cylindrical concentrators for Solar energy by R Winston.

Semester II

ETC 2-2: Energy Management And Audit

Lectures: 4h/ Week **Credits: 4**

Course Outcomes

1. Apply Energy conservation techniques.
2. Demonstrate Energy efficiency improvements by energy audit.
3. Install Energy management systems.
4. Describe energy conservation & environmental concerns.

Unit -1 Energy Conservation: (3 h)

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

Unit -2 Energy Management (6 h)

Definition & Objectives of Energy Management; Importance; Indian need of Energy Management; Duties and responsibilities of energy managers. Introduction to ISO 50001- 2011 Energy Management System (EnMS)

Unit -3 Energy Audit: (6 h)

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.

Unit -4 Material and Energy Balance: (8 h)

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

Energy Action Planning

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

Unit -5 Energy Monitoring and Targeting: (6 h)

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.

Unit -6 Electrical and Thermal Energy Management (11 h)

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. Building energy management, energy management commissioning,

energy conservation with respect to IAQ and IEQ.
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, building thermal performance.

Text Books –

1. Energy Audit Professional by Dheungel
2. Energy Management and Audit- Bureau of Energy Efficiency

References-

1. Energy Management, Audit and Conservation (Kindle Edition) Barun Kumar De
2. Energy Management Handbook - BSR
3. Energy management handbook / by Wayne C. Turner & Steve Doty
4. NPC energy audit manual and reports
5. Cleaner Production – Energy Efficiency Manual for GERIAP, UNEP, Bangkok prepared by National Productivity Council
6. Handbook of Energy Audits, Ninth Edition Hardcover – by Albert Thumann , Terry Niehus, William J. Younger
7. Guide to energy management by BL Capehart, WC Turner, WJ Kennedy

SEMESTER-II

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

Lectures: 4 h/ Week **Credits: 4**

Course Outcomes

1. Demonstrate performance evaluation of various components of energy system.
2. Demonstrate energy conservation techniques.
3. Apply performance evaluation techniques for Energy conservation
4. Determine potential of energy conservations for various utilities

Unit -1 Boilers (6 h)

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

Steam System

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

Unit -2 Furnaces (7 h)

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

Insulation and Refractories

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

Unit -3 FBC Boilers (6 h)

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.

Unit -4 Waste Heat Recovery (7 h)

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

Unit -5 Electric Motors (6 h)

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

Compressed Air System

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

HVAC And Refrigeration System

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

FANS AND BLOWERS

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

Pumps And Pumping System

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

Cooling Towers

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

Unit -6 DG Set System (6 h)

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

Energy Efficient Technologies In Electrical Systems

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

Text Books –

1. Energy Conservation Guidebook by Patrick, Fordo

2. Energy Efficiency in Thermal Utilities by Bureau of Energy Efficiency

3. Energy Efficiency in Electricall Utilities by Bureau of Energy Efficiency

References-

1.Handbook Of Energy Engineering by Thumann & Mehta

2.Introduction To Heat Transfer by Incropera, Dewitt

3.Energy Systems Engineering by Pistikopoulos

4.Energy Efficiency in Electrical Motors by Modi

5.Energy Audit Professionals by Dheungel

6.Handbook of Energy Efficiency By Krith & West

SEMESTER-II

Elective Course

ETE 3-1: Hydrogen Technology and Fuel Cell Technology

Lectures : 3 h/ Week **Credits : 3**

Course Outcomes

1. To understand basic of hydrogen energy and its production processes.
2. Describe Hydrogen storage methods and applications.
3. Describe Fuel cells and its developments in India.

Unit -1 Hydrogen Energy (6 h)
Hydrogen: Its merit as a fuel; Applications

Unit -2 Hydrogen Production Methods (7 h)
Production: from fossil fuels, electrolysis, thermal decomposition, photochemical, photocatalytic, hybrid;

Unit -3 Hydrogen Storage Methods (6 h)
Storage: Metal hydrides, Metallic alloy hydrides, Carbon nano-tubes; Sea as the source of Deuterium.

Unit -4 Fuel Cell: Basics (7 h)
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 (6 h)
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 Researches and development related to fuel cell development in India. (7 h)

References –

1. Hydrogen and Fuel Cells, Second Edition: Emerging Technologies and Applications by Bent Sørensen

2. Hydrogen and Fuel Cells: A Comprehensive Guide by Rebecca L. Busby

3. Solid Oxide Fuel Cell Technology: Principles, Performance and Operations By K Huang, J B Goodenough

4. Hydrogen and Fuel Cell Technologies and Market Perspectives by Töpler**,** Johannes**,** Lehmann**,** Jochen.

SEMESTER-II

ETE 3-2: Alternative Fuels for transportation

Lectures: 3 h/ Week **Credits: 3**

Course Outcomes

1. Describe petroleum based fuels & its influence on environment.
2. Describe alternative fuels & its characterization.
3. Demonstrate of alternative fuels for engineering applications.

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

Unit -2 Alternative fuels (7 h)
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.

Unit -3 Biodiesel formulation techniques (6 h)
transesterification, application in diesel engines. CME (Dimethyl ether), properties Fuel injection consideration

Unit -4 General introduction to LPG and LNG. (7 h)
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.

Unit -5 Biogas, Producer gas and their characteristics. (6 h)

Unit -6 System development for engine application. (7 h)

References-

1. Alternative Fuels for Transportation by A S Ramadhas

2. Alternative Transportation Fuels: Utilisation in Combustion Engines M.K. Gajendra Babu, K.A. Subramanian

3. Towards Sustainable Road Transport by Ronald M. Dell, Patrick T. Moseley, David A J Ran

SEMESTER-II

ETE 3-3: Power Plant Engineering

Lectures: 3 h/ Week **Credits: 3**

Course Outcomes

1. Describe various types of power plants
2. To analyze & characterize types of load & load curves.
3. Demonstrate performance evaluation of various power plants

Unit - 1 Introduction (3 h)

Choice of power generation; load & load duration curves; load factor; diversity factor; load deviation curve; load management; number and size of generating units, combustion of fuels.

Unit - 2 Coal Fired Power Plant **(**10 h)

Steam power plant, Rankin cycle, Carnot cycle, mean temperature of heat addition, effect of variation of steam condition on thermal efficiency of steam power plant, reheating of steam, regeneration, regenerative feed water heating, feed water heaters, canonization of Rankin cycle, optimum degree of regeneration, optimum degree of regeneration, supercritical pressure cycle, steam power plant appraisal, deaerator, typical layout of steam power plant, efficiencies in a steam power plant, cogeneration of power and process heat,

Basic types of steam generators, fire-tube boilers, water-tube boilers, economizers, super heaters, reheaters, steam generator control, air preheater, fluidized bed boilers, electrostatic precipitator, fabric filters and bug houses ash handling system, feed water treatment, deaeration, evaporation, internal treatment, boiler blow down, steam purity,

Flow through nozzles, turbine blading, electrical energy generations, need of a condenser, direct contact condensers, surface condensers, feed water heaters, circulating water system, cooling towers, and cooling tower calculations.

Unit - 3 Diesel Engine Power Plant (5 h)

Basics of a diesel engine and its parts' combustion in a CI engine, pressure- volume curves, applications of diesel engines in power field, advantages and disadvantages of diesel engine power plant, types of diesel plants, general layout, , performance characteristics, supercharging, layout of a diesel engine power plant.

Unit - 4 Gas turbine Power Plant (5 h)

Gas turbine power plant, components of gas turbine plant, gas turbine fuels, gas turbine materials, binary vapor cycle, and combined cycle plants, gas turbine-steam turbine power plant,

Unit - 5 Nuclear Power Plants (8 h)

Structure of the atom, chemical and nuclear reactions, nuclear stability and binding energy, radioactive decay and half life, nuclear fission, chain reaction, neutron energies, nuclear cross-sections, neutron flux and reaction rates, moderating power and moderating ratio, variation of neutron cross-sections

with neutron energy, neutron life cycle, reflectors, heat transfer and fluid flow in nuclear reactors, types of reactors, pressurized water reactor, boiling water reactor, Gas-cooled reactors, liquid metal fast breeder reactor, heavy water reactors. status of nuclear energy generation in the world.

Unit - 6 Hydroelectric Power Plant (6 h)

Advantages and disadvantages of water power, optimization of hydro-thermal mix, selection of site for a hydroelectric plant, hydrological cycle, hydrographs, storages and pondage, essential elements of a hydroelectric power plants, classification of hydroelectric power plants, hydraulic turbines, turbine size, Pelton wheel, degree of reaction, Francis turbines, propeller and Kaplan turbines, Deriaz turbine, bulb turbine, specific speed, comparison of turbines, cavitations, governing of hydraulic turbines, governing of reaction turbines, surge tanks, performance of turbines

Unit - 7 Energy Storage (2 h)

Need for storage of electricity, pumped hydro, compressed air storage. flywheel energy storage, electrochemical storages, magnetic energy storage, chemical energy storage, hydrogen energy storage.

Unit - 8 Economics of Electricity Generation (3 h)

Electricity generation from renewable energy resources, comparison of various electricity producing energy resources including capital cost, running cost, plant life, capacity factor, construction time, taxes etc.

Text books-

1. A Text Book of Power Plant Engineering, R.K. Rajput, Laxmi Publications
2. A Course in Power Plant Engineering, Arora, Domkundwar, DhanpatRai & Co.
3. Power Plant Engineering, 2nd ed, P.K. Nag , Tata McGraw-Hill Pub. Com., New Delhi.

References-

1. Power Plant Engineering, A K Raja, Amit Praksh Shrivastava, Manish Dwivedi, New Age International Publishers

2. Power Plant Familiarization, Manual of Central Training Resources Unit of NTPC India, 1991

3. Hydro-Electric and Pumped Storage Plants, M G Jog, New Age International Publishers

4. Power Plant Engineering, P.C. Sharma, S.K. Kataria& Sons.

5. Power Plant Engineering, G.R. Nagpal, Khanna Publishers

6. Power station Engineering and Economy by Bernhardt G.A. Skrotzki and William A. Vopat, Tata Mc Graw Hill Publishing Campany Ltd., New Delhi

7. Nuclear Energy An Introduction to the Concepts, Systems and Applications of Nuclear Processes, 6th Edition, Raymond L Murray, , ELSEVIER

8. Power Plant Engineering, Manoj Kumar Gupta, PHI Learning

9. Nuclear Power Plant Engineering, James Rust, Haralson Publishing Company

10. Nuclear Power Plants, Edited by Soon Heung Chang, InTech Publishers, 2012

11. Nuclear Power Plants, Geotge Petridis and Dimitrios Nicolau, NOVA Publishers

SEMESTER-II

ETE 4-1: Power Cogeneration

Lectures: 3 h/ Week **Credits: 3**

Course Outcomes

1. Describe the basics of cogeneration.
2. Demonstrate performance evaluation of cogeneration power plants.
3. Determine techno-economical feasibility of cogeneration energy system

Unit -1 Need for Cogeneration, Principle of Cogeneration (6 h)

Unit -2 Technical Options for Cogeneration, (7 h)
Classification of Cogeneration Systems.

Unit -3 Factors Influencing Cogeneration Choice, (6 h)
Important Technical Parameters for Cogeneration.

Unit -4 Prime Movers for Cogeneration, Typical (7 h)
Cogeneration Performance Parameters, Relative Merits of Cogeneration Systems.

Unit -5 Cogeneration alternatives, Gas turbine (6 h)
Steam turbine, Diesel engine, Bottoming cycles. Industry/ utility cogeneration.

Unit -6 Thermodynamic evaluation, (7 h)
Technoeconomic evaluation, Environmental evaluation. Cogeneration in sugar and steel industry, Case Studies. (6 Hrs.)

References:-

1. Handbook for Cogeneration and Combined Cycle Power Plants by Meherwan P. Boyce

2. Energy Audit: Thermal Power, Combined Cycle, and Cogeneration Plants by Y P Abbi

3. Combined Production of Heat and Power (Cogeneration) Hardcover – Import, 9 Aug 1990 by J. Sirchis (Editor)

SEMESTER-II

ETE 4-2: Energy Modeling & Project Management

Lectures: 3 h/ Week **Credits: 3**

Course Outcomes

1. Describe econometrics & model useful for energy sector & analyze & simulate types of energy models.
2. Describe energy conservation, project & finance management.
3. Analyze the project evaluation techniques & performance indices

Unit -1 Introduction (6 h)

Basic concept of econometrics and statistical analysis; 2-variable regression model; 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

Unit -2 Input – Output Analysis (7 h)

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

Unit -3 Energy Modeling (6 h)

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

Unit -4 Simulation and forecasting (7 h)

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

Unit -5 Project Evaluation & Management (6 h)

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.

Unit -6 Network analysis for project management; (7 h)

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.

Text books –

1. Energy Management Book by Turner & Doty

2. Guide to energy Management by Capehart,Turner,Kennedy

3. Energy Modelling: Advances in Management of Uncertainty by Vincent Kaminski

References –

1.Project Planning And Financial Decision Analysis by S.S.Mahajan,K.V. Marukar,A.G. Suryawanshi,S.S.Kulkarni,V.B.Kakade.

2.Entrepreneurship and Project Management by S.S.Mahajan,A.G. Suryawanshi,Sarang Bhola,B.S. Kundachimath,K.Shivshankar

3.Energy Policy Analysis And Modelling by Mohan Munasinghe,Peter Meter

4.Energy Modeling And Computations in the Building Envelope by Alexander V. Dimitrov

SEMESTER-II

ETE 4-3: New Energy Technologies

Lectures: 3 h/ Week **Credits: 3**

Course Outcomes

1. Describe superconductors.
2. Synthesize High-Tc superconductors.
3. Apply knowledge of superconductors in electricity.
4. Describe the testing of superconductors

Unit -1 Introduction: (6 h)

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

Unit -2 High Tc Superconductors (7 h)

Cuprate Superconductors; La, Y, Bi, Tl and Hg based superconductors, Intermetallic MgB2 superconductor crystal structure and superconducting properties, conduction mechanism.

Unit -3 Synthesis of High Tc superconductors (6 h)

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

Unit -4 Applications of Superconductors in Energy (7 h.)

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.

Unit -5 Large scale applications of superconductors (6 h)

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

Unit -6 Experimental Techniques (7 h)

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

References –

1.Energy Autonomy: The Economic, Social and Technological Case for Renewable Energy by Kapoor, Rakesh

2. Renewable Energy Sources and Climate Change Mitigation by Ottmar Edenhofer

3. Alternative Energy: Political, Economic, and Social Feasibility by Christopher A. Simon

4. Consuming Power by David Nye

SEMESTER-II

ETC 2-4 Solar Thermal Energy Conversion Lab

Practical: 2h/week **Credit: 1**

Expt. No.	Title
1	Performance trial on Solar Flat Plate Collector
2	Performance trial on Solar Evacuated Tube Collector
3	Performance trial on Solar Air Heater
4	Performance trial on Solar Concentrating Collector
5	Performance trial on Solar Distillation Plant
6	Trial on hydraulic pressure testing of Solar Flat Plate Collector

SEMESTER-II

ETC 2-5 Energy Management and Audit Lab

Practical: 2h/week **Credit: 1**

Expt. No.	Title
1	Trial on Energy Audit Instruments
2	Study and formation of Energy Policy
3	Energy Audit of Institute/Industry/SSI/Corporate Building etc.
4	Three Assignments based on above topic

SEMESTER-II

ETC 2-6 Energy Efficiency in Thermal and Electrical Utility Lab

Practical: 2h/week **Credit: 1**

Expt. No.	Title
1	Assignment on performance evaluation of boiler.
2	Assignment on steam piping sizing stem traps and performance assessment methods of stream traps.
3	Assignment on performance evolution of furnace.
4	Assignment on economic thickness of insulation (ETI).
5	Assignment on retrofitting of FBC
6	Assignment on electrical motors characterization, efficiency calculation, loss calculation, speed control of IMS and load surveys.
7	Assignment on performance of compressor and capacity assessment.
8	Assignment on performance of of refrigeration and AC plants and EC opportunities.
9	Assignment on performance a pump, pump characteristics, flow control strategies.
10	Assignment on performance of cooling tower and energy conservation opportunities.
11	Assignment on performance and heat balance sheet of DG sets.
12	Experiment on performance of Induction Motor.
13	Experiment on performance of heat exchanger.

Semester-III

T 31 Industrial Training:

Teaching Scheme Examination Scheme
Contact hours: 2 h/Week/student
Credit: 4

Course Outcomes

1. Acquire the field knowledge in engineering & management.
2. Analyze the energy system of industry.
3. Demonstrate the skills of energy conservations & renewable energies.
4. Solve complex energy system problems.

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

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.

Course Outcomes

1. Describe the research methodology.
2. Write technical reports & presentations.
3. Design & demonstrate innovative energy systems