M.Sc., ENERGY STUDIES (CBCS)

REGULATIONS, SCHEME & SYLLABUS

WITH EFFECTIVE FROM 2017-2018

DEPARTMENT OF ENERGY STUDIES

PERIYAR UNIVERSITY
PERIYAR PALKALAI NAGAR
SALEM – 636 011
TAMIL NADU

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Regulations & Scheme

Department of Energy Studies, Periyar University
PG Degree of Energy Studies
Choice Based Credit System (CBCS) Regulation, Scheme and Syllabus
(With effective from 2017-2018 onwards)

1. Eligibility for Admission

Candidate who has passed the B.Sc., degree in Physics/Chemistry /Geology/Electronics/Energy Studies or B.E/B.Tech degree in Mechanical/Mechatronics/Electrical & Electronics/Electronics & Communication/Automobile/Chemical Engineering of the University or an Examination of any other University accepted by the Syndicate as equivalent thereto shall be eligible for admission to M.Sc., Degree of this University or any other University recognized by the Syndicate as equivalent thereto shall be eligible to register for the Degree of Master in Energy Studies (M.Sc.,) and undergo the prescribed course of study in an approved department of this University.

2. Mode of Selection

Applicants have to be selected through entrance examination and also as per the norms of Tamil Nadu Government.

3. Duration of the Course

The duration of the M.Sc., Degree shall be two years consist of four semesters under Choice Based Credit System.

4. Distribution of Credit Points

The minimum credit requirement for M.Sc., Degree shall be 90 Credits. The break-up of credits for the programme is as follows;

- Core Courses : 72 credits
- Elective Courses : 12 credits
- Supportive Courses : 08 credits
- Human Rights : 02 credits

5. Course of Study

The course of study for the M.Sc., Degree shall be in Energy Studies (CBCS) with internal assessment according to syllabi prescribed from time to time.

5.1 Component of Internal Examination

Internal Tests (Best of two out of 3)	10 Marks
Seminar	05 Marks
Assignment	05 Marks
Attendance	05 Marks
Total	25 Marks

The allotment of marks and Scheme of examination as follows;

5.2 Theory Core Paper

External	75 Marks
Internal	25 Marks
Total	100 Marks
Duration of	3 Hours

5.3 Practical Internal & External

Model Practical	30 Marks
Record	05 Marks
Viva Voce	05 Marks
Internal Total	40 Marks
External	60 Marks
Total	100 Marks

5.4 Marks allotment for attendance as follows

% of attendance	Marks
91% - 100%	5
81%- 90%	4
71% - 80%	3
65% - 70%	2
Below 64%	No marks

6. Details of Mini & Main Project Marks

Mini Project

Submission of Dissertation	50 Marks
Viva Voce	25 Marks
Internal Marks ❖ The marks should be provide by Internal Examiner only (Supervisor of the student)	25 Marks
Total	100 Marks

Main Project

Submission of Dissertation	100 Marks
Viva-voce	50 Marks
Internal marks ❖ The marks should be provide by Internal Examiner only (Supervisor of the student)	50 Marks
Total	200 Marks

7. Question Paper Pattern

Time: 3 Hrs **Maximum Marks: 75**

PART – A (10X2=20 Marks)
Answer All Questions (No choice)

PART – B (5X5=25 Marks)
Answer All Questions with either or type (Two questions from each unit)

PART – C (3X10=30 Marks)
Answer any three from five Questions (One question from each unit)

8. Passing Minimum

1. There shall be no Passing Minimum Marks for Internal.
2. For External Examination, Passing Minimum shall be of 50% (Fifty Percentage) of the maximum marks prescribed for the paper.
3. In the aggregate (External + Internal) the passing minimum shall be of 50% for each Paper/Practical/Project and Viva-voce.
4. Grading shall be based on overall marks obtained (internal + external).

9. Classification of Successful Candidates

9.0 and above	First Class with Exemplary
7.5 and above but below 9.0	First Class with Distinction
6.0 and above but below 7.5	First Class
5.0 and above but below 6.0	Second Class
0.0 and above but below 5.0	Re-appear

10. Marks and Grades

Letter Grade & Description	**Grade points**	**Range of Marks**
`O' = Outstanding	9.0 – 10.0	**90 – 100**
`D+' = Excellent	8.0 – 8.9	**80-89**
`D' = Distinction	7.5 – 7.9	**75-79**
`A+' = Very Good	7.0 – 7.4	**70-74**
`A' = Good	6.0 – 6.9	**60-69**
`B' = Average	5.0 – 5.9	**50-59**
`U' = Re-Appear	0.0	**00-49**
'AAA'= Absent	**0.0**	**Absent**

11. Industrial Visit

As a Part of M.Sc., Energy Studies Degree, students shall under taken a field visit of different types of Energy Source Systems etc., under the guidance of faculty members.

12. Elective courses

The University Department of Energy Studies offers following Elective course subjects.

- ❖ Waste Management and Energy Generation
- ❖ Pollution Control in Power Plants
- ❖ Nuclear Energy and its Applications
- ❖ Hydrogen and Fuel Cell
- ❖ Solar Refrigeration and Air-Conditioning
- ❖ Advanced Instrumental Methods of Analysis

13. Supportive Courses

The University Department of Energy Studies offers following Supportive course to other Department students.

- Basic Concepts in Energy Sciences
- Climate Change And CO_2 Emission Assessment
- Energy and environmental impacts
- Erection And Maintenance Of Refrigeration And Air-Conditioning Equipment's

Course Structure

DEPARTMENT OF ENERGY STUDIES
PERIYAR UNIVERSITY
SALEM – 11

PG Programme M.Sc., Energy Studies – Course Structure

(Applicable to the candidates admitted from the academic year 2017-2018 onwards)

SEM	Core Course	Paper Code	Subject	Credits	CIA	EA	Total
I	I	17PGERSC01	Applied Mathematics	4	25	75	100
	II	17PGERSC02	Energy Scenario and Policy	4	25	75	100
	III	17PGERSC03	Renewable Energy	4	25	75	100
	IV	17PGERSC04	Thermal and Wind Energy System	4	25	75	100
	V	17PGERSP01	Energy Laboratory–I	4	40	60	100
	ELE-I	-	Elective –I	4	25	75	100
II	VI	17PGERSC05	Solar Thermal Energy	4	25	75	100
	VII	17PGERSC06	Wind Energy	4	25	75	100
	VIII	17PGERSC07	Thermodynamics & Heat and Mass Transfer	4	25	75	100
	IX	17PGERSP02	Energy Laboratory–II	4	40	60	100
	ELE-II	-	Elective –II	4	25	75	100
	SUP-I	-	Supportive-I	4	25	75	100
	COMM	06PHR01	Human Rights	2	25	75	100
III	X	17PGERSC08	Bio and Geo Thermal Energy	4	25	75	100
	XI	17PGERSC09	Basics of Solar Cell	4	25	75	100
	XII	17PGERSC10	Energy Audit and Management	4	25	75	100
	ELE-III	-	Elective –III	4	25	75	100
	SUP-II	-	Supportive-II	4	25	75	100
	PRO	17PGERPR01	Mini Project	6	25	75	100
IV	XIII	17PGERSC11	Industrial Instrumentation	4	25	75	100
	XIV	17PGERSC12	Solar PV, Fundamental, Technologies and applications	4	25	75	100
	PRO	17PGERPR02	Project Work	10	50	150	200
			Total	94			2300

Elective courses

- Waste Management and Energy Generation
- Pollution Control In Power Plants
- Nuclear Energy and its Applications
- Hydrogen and Fuel Cell
- Solar Refrigeration And Air-Conditioning
- Advanced Instrumental Methods Of Analysis

Supportive Courses

- Basic Concepts in Energy Sciences
- Climate Change And Co_2 Emission Assessment
- Energy and environmental impacts
- Erection And Maintenance Of Refrigeration And Air-Conditioning Equipment's

Detailed Syllabus

17PGERSC01- APPLIED MATHEMATICS

OBJECTIVE

- ✓ To expose the student to various numerical problems that are frequently used in Energy Application
- ✓ To make the student proficient in solving problems in heat transfer and fluid that require numerical analysis

OUTCOMES

Students will have

- ✓ Identify the specific numerical technique required to solve a problem
- ✓ Numerically solve problems related to heat transfer and fluid flow.

UNIT-I EMPIRICAL LAWS AND CURVE FITTING

Introduction - Linear law –method of group averages – law containing three constants –Principle of Least Squares – Fitting a Straight line – Fitting a parabola – Fitting an exponential curve – Methods of moments

UNIT-II FINITE DIFFERENCES

Finite Differences – Interpolation – Newton forward Interpolation formula – Methods: Forward difference, backward difference, central difference- Gaussion forward and backword formula – Bessel Formula – Laplace- Evert Formula- Operators – Forward (Δ) , backward (∇)and central (δ) , shifting (E) Average (μ) and their interrelations

UNIT-III NUMERICAL SOLUTION OF DIFFERENTIAL EQUATION:

Methods: Taylor's series method – First and Second order differential equations-, Euler- Modified Euler- Runge-Kutta method- Milne's predictor corrector method – Adams- Bash forth predictor corrector method- Picard methods of successive approximation. Solution of Laplace's equation, Poisson's equation;

UNIT- IV CONFORMAL MAPPING AND APPLICATIONS

The Schwarz- Christoffel transformation – Transformation of boundaries in parametric form – Physical applications: Fluid flow and heat flow problems.

UNIT-V OPTIMIZATION TECHNIQUES

Introduction; Linear programming methods: Simplex method, artificial variables and dual phase method. Computational Techniques: Introduction to MATLAB and MATHAMATICA.

TEXT AND REFERENCE BOOKS

1. Singaravelan, E (1999) NumericalMethods, Tata Mc Graw Hill , New D elhi
2. Jain M K., Iyengar S R K., Jain R K (1993) ; Numerical Methods for Scientific and Engineering Computation, New Age International (P) Ltd. New Delhi

3. Gupta, A.S., Calculus of Variations with Applications, Prentice Hall of India Pvt. Ltd., New Delhi (1997)
4. Spiegel, M.R., Theory and Problems of Complex Variables and its Application (Schaum's Outline Series), McGraw Hill Book Co., Singapore (1981).
5. Andrews, L.C. and Shivamoggi, B.K., Integral Transforms for Engineers, Prentice Hall of India Pvt. Ltd., New Delhi (2003)

17PGERSC02- ENERGY SCENARIO AND POLICY

OBJECTIVE

- ✓ To get an awareness of present energy pattern and to understand the energy policy

OUTCOMES

Students will have

- ✓ An exposure to Evaluation / utilization of energy usage and finding alternate energy resources and policy implications.

UNIT- I ENERGY CONSERVATION

Energy Conservation Act-2001 and its features - Electricity Act – 2003 and its features - Framework of Central Electricity Authority (CEA), Central & States Electricity Regulatory Commissions (CERC & ERCs)-Role of MoP(Ministry of Power)-BEE (Bureau of Energy Efficiency).

UNIT-II INDIAN ENERGY SCENARIO

Energy resources & Consumption-Commercial and noncommercial forms of energy- Fossil fuels- Renewable sources in India- Sector wise energy Consumption - Impact of energy on economy – Need for use of new and renewable energy sources-present status and future of nuclear and renewable energy-Energy Policy Issues related Fossil Fuels-Renewable Energy-Power sector reforms-restructuring of energy supply sector-energy strategy for future

UNIT-III GLOBAL ENERGY SCENARIO

Role of energy in economic development and social transformation - Energy and GDP - GNP and its dynamics - Energy sources, overall Energy demand and availability - Energy consumption in various sectors and its changing pattern - Depletion of energy sources and impact economics on international relations.

UNIT-IV INDIAN ENERGY POLICY

Global Energy Issues-National & State Level Energy Issues-National & State Energy Policy-Industrial Energy Policy- Energy Security-Energy Vision-Energy Pricing and Impact of Global Variations-Energy Productivity (National & Sector wise productivity).

UNIT-V GLOBAL ENERGY POLICY

International Energy Polices of G-8 Countries - G-20 Countries - OPEC Countries - EU Countries - International Energy Treaties (Rio, Montreal and Kyoto) - INDO-US Nuclear Deal- Future Energy Options-Sustainable Development-Energy Crisis-Role of International Energy Agency.

TEXT AND REFERENCE BOOKS

1. Mohan Munasinghe, Peter Meier. Energy Policy analysis and Modelling: Cambridge University Press1993
2. J. Goldemberg, T.B. Johansson, A.K.N. Reddy and R.H. Williams: Energy for a Sustainable World, Wiley Eastern, 1990.
3. P. Meier and M. Munasinghe: Energy Policy Analysis & Modeling, Cambridge University Press, 1993
4. World Energy Resources: Charles E. Brown, Springer 2002.
5. Resources, Charles E. Brown, 'International Energy Outlook' - EIA annual Publication
6. Principles of Energy Conversion: A.W. Culp (McGraw Hill International edition) BEE Reference book: no. 1/2/3/4
7. S Rao, Energy Technology, Khanna Publishers

17PGERSC03- RENEWABLE ENERGY

OBJECTIVES

- ✓ To explain the concepts of renewable energy systems
- ✓ To outline utilization of renewable energy sources for both domestic and industrial applications
- ✓

OUTCOMES

Students will have

- ✓ An understanding of renewable energy sources
- ✓ Knowledge of working principle of various energy systems
- ✓ Capability to carry out basic design of renewable energy systems

UNIT-I SOLAR ENERGY

Basic concepts, solar radiation, potential of solar energy- environmental aspects of solar energy, technologies overview - Photon-to-electric energy conversion, photon-to-thermal-to-electric energy conversion, photon-to-chemical energy conversion, semiconductors, solar cells, batteries, satellite solar power systems.

UNIT-II BIOMASS ENERGY

Concepts and systems, biomass production, energy plantations, short rotation species, forestry system, biomass resource agro forestry wastes, municipal solid wastes and agro processing industrial residues, environmental factors and biomass energy development, combustion, pyrolysis, gasification and liquefaction, modeling, appliances and latest development.

UNIT-III BIOGAS CONVERSION ENERGY

Bioconversion: biogas, fermentation and wet processes, chemicals from biomass and biotechnology. Biodiesel, ethanol, methanol, manufacture properties and uses.

UNIT-IV GEOTHERMAL AND WAVE ENERGY

Geothermal energy, types, systems and applications, ocean thermal energy, systems and applications. Wave energy systems and applications. Tidal energy - systems and applications.

UNIT-V HYDRO ENERGY

Magneto Hydrodynamic system (MHD), thermionic and thermo electric generator– types and applications, hydrogen technologies, micro-hydel systems. Hybrid systems and applications.

TEXT AND REFERENCE BOOKS

1. Frank Kreith and Yogi Goswami D, “Handbook of Energy Efficiency and Renewable Energy”, CRC Press, 2007.
2. Kothari P, Singal K C and RakeshRanjan, “Renewable Energy Sources and Emerging Technologies”, PHI Pvt. Ltd., New Delhi, 2008.
3. Sukhatme S P and Nayak J K, “Solar Energy - Principles of Thermal Collection and Storage”, Tata McGraw Hill, 2008.
4. Rai G D, "Non Conventional Sources of Energy", Khanna Publishers, 2006.
5. Bent Sorensen, “Renewable Energy”, Academic Press, 2004.
6. Abbasi S A and Naseema Abbasi, “Renewable Energy Sources and their Environmental Impact”, PHI Private Limited, 2001.
7. Wakil M M H, “Power Plant Technology”, McGraw Hill, 1984.

17PGERSC04- THERMAL AND WIND ENERGY SYSTEM

OBJECTIVES

- ✓ To explain the concepts of Thermal and Wind energy systems
- ✓ To outline Basics of Renewable -non-renewable energy sources for both domestic and industrial applications

OUTCOMES

Students will have

- ✓ An understanding of Steam and Hydro Power energy sources
- ✓ Knowledge of working principle of Wind energy systems
- ✓ Capability to carry out basic parameters of wind energy systems

UNIT- I STEAM POWER PLANT

Layout of steam power plants- fuels and ash handling systems-fuel and ash handling systems-Combustion equipment for burning coal- Mechanical stokers, Pulverizers-Electostatic precipitator-draught-different types, surface condenser types, cooling tower, pollution controls.

UNIT-II HYDEL POWER PLANTS

Layout of hydroelectric power plant- classification of hydroelectric power plants-selection of a site for hydroelectric power plants-water turbines, pelton wheel turbine, francis turbine-kaplan turbine, selection of turbines, governing of turbines, components of micro-hydro power plant.

UNIT- III NUCLEAR POWER PLANT

Layout of Nuclear plant, Nuclear energy, fission, fussion reactions, types of reactors, pressurized water reactor, boiling water reactor, gas cooled reactor-fast breeder reactor, waste disposal and safety.

UNIT- IV OVERVIEW OF WIND ENERGY

Introduction, Commercial wind development, challenges and opportunities, Types of axis, stand alone and grid connected WPPs, upwind and downwind WPPs, blade count (one, two, three and Multi), Power ratings of WPPs, Aerodynamic power regulations methods, Types of Electrical generators in WPPs, Constant speed and variable speed WPPs, Geared direct drive and semi geared, WPP with single gearbox and multigenerators, Conversion of wind energy.

UNIT-V WIND CHARACTERISTICS

Introduction, wind climate, power density and energy content, frequency distribution of wind speeds, wind measurements, wind resource maps, conversion of wind energy, wind turbine rotor, rotor blade design, energy production, adaption of wind turbine to a site, power control.

TEXT AND REFERENCE BOOKS

1. Joshua Earnest and Tore Wizelius Wind Power Plants and Prjects Development PHI Private Limited 2015
2. D. Lindsay, Boiler Control Systems, Mcgraw Hill International, London, 1992.
3. H.G. Stoll, Least Cost Electrical Utility / Planning, John Wiley & Sons, 1989.
4. A.B.Gill, Power Plant Performance, Butterworths, 1984. 6. Wood, A.J., Wollenberg, B.F., Power Generation, operation & control, John Wiley, New York, 1984.
5. Mukund R. Patel, Wind and Solar Power Systems , CRC Press; (1999)
6. Erich Hau, Wind Turbines: Fundamentals, Technologies, Application and Economics, Springer Verlag; (2000)
7. John F. Walker and Nicholas Jenkins, Wind Energy Technology, John Wiley, 1997

17PGERSP01 - Energy Laboratory–I

S. No.	List of Experiments
1	I-V and P-V characteristics of PV module with various radiation and temperature
2	I-V and P-V characteristics of series and parallel combination of PV module
3	Effect of variation in tilt angle on PV module power
4	Effect of shading on solar module
5	Demonstration the working of diode as bypass and blocking diode
6	Charging period analysis of system containing PCM-1 (Organic fatty acid)
7	Discharging period analysis of system containing PCM-1 (Organic fatty acid)
8	Charging period analysis of system containing PCM-2 (paraffin wax)
9	Discharging period analysis of system containing PCM-2 (Paraffin wax)
10	Charging period analysis of the system containing PCM-1 and PCM-2 in cascading

17PGERSC05 – SOLAR THERMAL ENERGY

OBJECTIVE

- ✓ To achieve extensive knowledge about solar thermal energy collector systems used for various applications with economical aspects

OUTCOMES

Students will have

- ✓ To clarify impression of various solar thermal energy collectors
- ✓ To delineate the other applications and the devices used to collect solar energy
- ✓ To summarize the basic economics of solar energy collection system

UNIT-I INTRODUCTION TO THERMAL ASPECTS IN SOLAR ENERGY

Sun as a Source of Energy – Solar Radiation– Extra-terrestrial at earth's surface – Horizontal, tilted surface – Estimation of Radiation –hourly, daily and monthly average – Alternation of Solar radiation by atmosphere – Effect of orientation of receiving surface.

UNIT-II MEASUREMENT OF SOLAR RADIATION

Measurement of solar radiation – Radiation characteristics of opaque materials –Sun-shine recorder, Solar radiation data, Estimation of average solar radiation, Estimation of Direct and Diffused radiation-during no cloudy days-during cloudy days- Ratio of Beam radiation on tilted surface to horizontal surface

UNIT- III SOLAR COLLECTORS

Flat plate - Evacuated tube – Concentrated - Pool and Air collectors Construction – Function Suitability – Comparison - Storage Tank - Solar Fluids.

UNIT- IV SOLAR WATER HEATING SYSTEMS

Integral Collector Storage System - Thermosyphon System - Open Loop, Drain Down, Drain Back,Antifreeze Systems - Refrigerant Solar Water Heaters - Solar Heated Pools - Solar Heated Hot Tubs and Spas.

UNIT- V SOLAR LIQUID CONDITIONING SYSTEMS

Liquid Type Solar Heating System With / Without Storage - Heat Storage Configurations – Heat Delivery Methods - Air-Type Solar Heating Systems - Solar Refrigeration and Air Conditioning.Solar Cooking – Distillation - Desalination - Solar Ponds – Solar Passive Architecture – Solar Drying –Solar Chimney.

TEXT AND REFERENCE BOOKS

1. H P Garg, M Dayal, G Furlan, Physics and Technology of Solar Energy-Volume I: Solar Thermal Applications, Springer, 2007.
2. Sukhatme and Nayak, Solar Energy: Principles Of Thermal Collection And Storage, Tata McGraw.Hill, 2008.

3. Bob Ramlow & Benjamin Nusz, Solar Water Heating, New Society Publishing, 2006.
4. John Canivan, Solar Thermal Energy, Sunny Future Press - 2003.
5. Charles Christopher Newton - Concentrated Solar Thermal Energy-Published by VDM Verlag, 2008.
6. H.P.Garg, S.C.Mullick, A.K.Bhargava, D.Reidal, Solar Thermal Energy Storage Springer, 2005.

17PGERSC06 – WIND ENERGY

OBJECTIVES

- ✓ Understand the processes of generation of wind, its potential and energy extraction
- ✓ Identify and estimate wind resource potential of an area
- ✓ Understand the aerodynamic principles of turbine blade design
- ✓ Understand the functioning of wind electric generators and the operation wind farms.

OUTCOMES

Students will have

- ✓ Prepare and evaluate detailed project reports for establishing a wind farm
- ✓ Understand the operation of a wind farm and economics of power generation

UNIT- I INTRODUCTION TO WIND TURBINE

Introduction-operating principles of modern wind turbine- wind turbine rotor blade characteristics hub and main shaft functions- geared WPP working-direct drive WPP working semi geared /Hybrid WPP working, electric substation and grid, specifications of WPPs.

UNIT- II GRID CONNECTION WPP

Introduction, power quality issues, Impact of WPPs on electrical grid network, Node voltage and voltage control, fault current contribution during faults and protection schemes, Electromagnetic compatibility, overview of local impacts, reaction power and WPPs, dynamic and stability, system wide impact and electrical safety, direct and indirect grid connection of variable speed WPP, short term and long term balancing.

UNIT- III PROJECT DEVELOPMENT

Estimation of power production- evaluation of sites- Historical meteorological data-onsite measurement data- long term correlation-roughness of terrain-hills and obstacles-micro siting of WPPS and optimization-pitfalls-extreme temperature and wind speeds.

UNIT-IV ECONOMICS OF PLANT

Introduction-Investment of wind turbine- Economic result-risk assessment-financing-wind turbine options-types of wind turbines-nominal power vs rotor climate-grid compatibility-supervision and quality control-commissioning and transfer.

UNIT-V WIND POWER POLICY AND ENVIRONMENT

Introduction- permission inquiry-conflicting interest-permission process-wind power policies-wind power on the power market-support schemes for renewable energy-Evaluation-Independent power producers-energy

subsidies-policy recommendation-scheduled and unscheduled maintenance-preventive maintenance.

TEXT AND REFERENCE BOOKS

1. Thomas Ackermann, (2005), Wind Power in Power Systems, John Wiles & Son Ltd.
2. Ray Hunter, (1997), Wind Energy Conversion: From Theory to Practice, John Wiley and Son Ltd.
3. Gary L.Johnson, (1985), Wind Energy Systems, Prentice-Hall Inc., New Jersey.
4. Desire Le Gouriers, (1982), Wind Power Plants: Theory and Design, Pergamon Press.
5. Tony Burton, David Sharpe, Nick Jenkins and Ervin Bossanyi (2001), Wind Energy Handbook, 1 st Edition, John Wiley & Sons.
6. Paul Gipe (1999), Wind Energy Basics: A Guide to Small and Micro Wind Systems, Chelsea Green Publishing Company.

17PGERSC07 – THERMODYNAMICS & HEAT AND MASS TRANSFER

OBJECTIVES

- ✓ To understand and apply the concept of availability and to calculate the behavior of real gases
- ✓ To predict the condition of systems and analyze them by the criteria of equilibrium
- ✓ To apply the concepts of advanced thermodynamics to combustion systems and refrigeration systems

OUTCOMES

Students will have

- ✓ To calculate the availability of the systems and cycles
- ✓ Analyze the engineering systems to improve and optimize its performance
- ✓ Understand the working and the design principles of combustion systems and refrigeration systems

UNIT- I BASIC CONCEPT AND LAW OF THERMODYNAMICS

Basic concepts - concept of continuum, macroscopic approach, thermodynamic systems. Property, state, path and process. Kelvin's and Clausius statements of second law. Reversibility and irreversibility. Carnot cycle, reversed carnot cycle, efficiency, COP.

UNIT-II PROPERTIES OF PURE SUBSTANCE AND THERMO DYNAMIC RELATIONS

Properties of pure substances — Thermodynamic properties of pure substances in solid, liquid and vapour phases, phase rule.Gas mixtures — Properties of ideal and real gases, equation of state, Avagadro's law. Dalton's law of partial pressure, Joule Thomson Coefficient.

UNIT-III CONDUCTION, CONVECTION AND RADIATION

Basic Concepts — Mechanism of Heat Transfer — Conduction, Convection and Radiation — General Differential equation of Heat Conduction — Fourier Law of Conduction - Free Convection. Basic Concept - Laws of Radiation — Stefan Boltzman Law, Kirchoff Law - Black Body Radiation

UNIT-IV PSYCHROMETRY AND HEAT EXCHANGERS

Psychrometry and property calculations of air vapour mixtures. Psychrometric process — Sensible heat exchange processes. Latent heat exchange processes. Types of Heat Exchangers — LMTD Method of heat Exchanger Analysis — Effectiveness —Fouling Factors.

UNIT- V MASS TRANSFER

Basic Concepts — Diffusion Mass Transfer — Fick's Law of Diffusion — Steady state Molecular Diffusion.

TEXT AND REFERENCE BOOKS

1. Nag.P.K., "Engineering Thermodynamics", Tata McGraw-Hill, New Delhi,1998.
2. Sachdeva R C, "Fundamentals of Engineering Heat and Mass Transfer" New Age International, 1995.
3. Holman.J.P., "Thermodynamics", 3d Ed. McGraw-Hill, 1995.
4. Arora C.P, "Thermodynamics", Tata McGraw-Hill, New Delhi, 2003.
5. Kothandaraman C.P "Fundamentals of Heat and Mass Transfer" New Age International, New Delhi, 1998.

17PGERSP02 - Energy Laboratory–II

S.No.	List of Experiments
1	Power flow calculation of PV system of DC load with battery
2	Power flow calculation of PV system of AC load with battery
3	Power flow calculations of PV system of AC&DC load with battery
4	Power flow calculations of PV system of DC load in series connection
5	Power flow calculations of PV system with AC load in series connection
6	Charging analysis of fatty acid as PCM by varying mass flow rate
7	Discharging analysis of fatty acid as PCM by varying mass flow rate
8	Charging analysis of paraffin wax as PCM by different mass flow rate
9	Discharging analysis of paraffin wax as PCM for different mass flow rate
10	Charging analysis of both fatty acid and paraffin wax cascading method by varying mass flow rate

17PGERSC08 –BIO AND GEOTHERMAL ENERGY

OBJECTIVES

- ✓ To have an exposure on the types of Bio and Geothermal energy, its surplus availability and characteristics.
- ✓ Analyze the technologies available for conversion of biomass to energy in terms of its technical competence and economic implications.

OUTCOME

Students will have

- ✓ A practical understanding on the various Bio and Geo thermal energy conversion technologies and its relevance towards solving the present energy crisis.

UNIT-I BIOMETHANATION

Microbial Systems – Phases in Biogas production – Parameters affecting gas production – Effect of additives on Biogas yield – Possible feed stocks. Biogas plants – Types – Design – Constructional details & comparison – Biogas appliances – Burner, Illumination & Power Generation – Effect on Engine Performance.

UNIT-II COMBUSTION

Perfect, Complete & Incomplete – Equivalence ratio – Fixed Bed, Fluid Bed – Fuel & Ash handling – Steam Cost comparison with conventional fuels. Briquetting: Types of Briquetting – Merits & Demerits – Feed requirements & Preprocessing – Advantages - Drawbacks

UNIT-III GASIFICATION

Types – Comparison – Application – Performance Evaluation – Economics – Dual fuel engines –100 % Gas Engines – Engine characteristics on gas mode – Gas Cooling & cleaning train.

UNIT-IV IMPORTANT ASPECTS OF GEOTHERMAL ENERGY

Important aspects of Geothermal Energy (GTE), Applications, Geothermal Energy Resources, Origin of Geothermal Thermal Resources, Geothermal Thermal Gradients, Non-uniform Geothermal Thermal Gradients, Hydro-Geothermal Resources

UNIT- V GEOTHERMAL ELECTRIC POWER (GTEP) PLANTS

Introduction, Classification and Types, Historical Background, Vapor dominated GTEP Plant (Steam), Liquid dominated GTEP Plant (Hot Water), Liquid dominated Flashed Steam GTEP Plant, Scope for Geothermal Energy systems in India.

TEXT AND REFERENCE BOOKS

1. G D Rai, Non Conventional Energy Sources, Khanna Publishers, New Delhi

2. David Boyles, Bio Energy Technology Thermodynamics and costs, Ellis Hoknood, Chichester, 1984
3. Khandelwal KC, Mahdi SS, Biogas Technology – A Practical Handbook, Tata McGraw Hill, 1986
4. R.C. Mahaeswari, Bio Energy for Rural Energisation, Concepts Publication, 1997
5. Tom B Reed, Biomass Gasification – Principles & Technology, Noyce Data Corporation, 1981
6. Best Practises Manual for Biomass Briquetting, I R E D A, 1997
7. S. Eriksson & M. Prior, The briquetting of Agricultural wastes for fuel, FAO Energy & Environment paper, 1990
8. PVR Iyer et al, Thermochemical Characterisation of Biomass, M N E S.

17PGERSC09- BASICS OF SOLAR CELL

OBJECTIVES

- ✓ To explain concept of various materials using for photovoltaic cells
- ✓ To expose latest developments in PV technology.

OUTCOME

Students will have

- ✓ An understanding of materials for solar energy.

UNIT- I SOLAR ENERGY FUNDAMENTALS

Nature of solar energy, conversion of solar energy, photochemical conversion of solar energy, photovoltaic conversion, photo-physics of semiconductors and semiconductor particles, photo-catalysis.

UNIT- II FUNDAMENTALS OF SOLAR CELLS

Basic of Semiconductor Physics- the p-n junction, charge carriers in semiconductors, optical properties of semiconductors, Hetero- junctions,

UNIT- III SOLAR CELL:

Different types of materials – Availability – Advantages – Disadvantages - applications. Spectral response of solar cells - Dark conductivity - I-V characterization - Introduction to physics of semiconductor devices.

UNIT- IV TYPES OF SOLAR CELLS

High efficiency solar cells - PERL Si solar cell - LGBC solar cell - III-V, II-VI high efficiency solar cells - thin film technology - GaAs solar cells - tandem and multi junction solar cells - solar PV concentrator cells and systems.

UNIT- V DIFFERENT MATERIALS USED FOR SOLAR CELLS

Nano - micro and poly crystalline Si for solar cells - Mono micro silicon composite structure - Silicon and non silicon thin film deposition techniques - Advanced solar cell concepts and technologies – Amorphous silicon thin film technologies - Multi junction solar cells – CDTE – CIGS - Quantum dots - Peroskvite.

TEXT AND REFERENCE BOOKS

1. Solar cells: Operating principles, technology and system applications by Martin A Green, Prentice Hall Inc, Englewood Cliffs, NJ, USA, 1981.
2. Semiconductors for solar cells, HJ Moller, Artech House Inc, MA, USA, 1993.
3. Solid State electronic devices, Ben G Streetman, Prentice Hall of India Pvt Ltd., New Delhi 1995.
4. Carbon nanotubes and related structures: New material for twenty first century, PJF Harris, Cambridge University Press, 1999.
5. Think Film crystalline silicon solar cells: Physics and technology, R. Brendel, Wiley VCH, Weinheim, 2003.

6. Clean Electricity from photovoltaics, M. D. Archer, R. Hill, Imperial college press, 2001.
7. Organic photovoltaics: Concepts and realization, V Barbec, V.Dyakonov, J. Parisi, N.S. Saricifttci, Springer Verlag 2003.
8. Fuel cell and their applications, K. Kordesch, G. Simader, VCH, Weinheim, Germany, 1996.
9. Battery technology handbook, H. A. Kiehne, Marcel Dekker, New York, 1989.

17PGERSC10- ENERGY AUDIT AND MANAGEMENT

OBJECTIVES

- ✓ To understand the energy utilization pattern including wastage and its management.

OUTCOME

Students will have

- ✓ Student will be able to Carry out the energy audit in any type of building and suggest the relevant and appropriate conservation measures.

UNIT- I INTRODUCTION TO ROLE OF ENERGY AUDITING IN IDUSTRY

Basic elements and measurements - Mass and energy balances - Scope of energy auditing industries - Evaluation of energy conserving opportunities.

UNIT- II ENERGY AUDIT

Need of Energy audit - Types of energy audit - Energy management (audit) approach - understanding energy costs - Bench marking - Energy performance - Matching energy use to requirements - Maximizing system efficiencies - Optimizing the input energy requirements - Duties and responsibilities of energy auditors - Energy audit instruments - Procedures and Techniques.

UNIT- III ENERGY MANAGEMENT

Design of Energy Management Programmes - Development of energy management systems – Importance - Indian need of Energy Management - Duties of Energy Manager - Preparation and presentation of energy audit reports - Some case study and potential energy savings.

UNIT- IV 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.

UNIT- V ELECTRICAL ENERGY MANAGEMENT

Supply side Methods to minimize supply-demand gap - Renovation and modernization of power plants - Reactive power management - HVDC - FACTS - Demand side - Conservation in motors - Pumps and fan systems - Energy efficient motors.

TEXT AND REFERENCE BOOKS

1. Energy Management: W.R.Murphy, G.Mckay 109
2. Energy Management Principles: C.B.Smith

3. Efficient Use of Energy : I.G.C.Dryden
4. Energy Economics A.V.Desai
5. Hamies, Energy Auditing and Conservation; Methods Measurements, Management and Case study, Hemisphere, Washington, 1980.

17PGERSC11–INDUSTRIAL INSTRUMENTATION

OBJECTIVES

- ✓ To understand the principles and use of transducers for measurement of different pressure, thermal and electrical parameters.
- ✓ To understand the concepts of control systems, modes and design.

OUTCOME

Students will have

- ✓ To obtain knowledge on measurement and control techniques applicable to energy systems

UNIT-I GENERALIZED INSTRUMENTATION SYSTEM

Error theory – Calibration of instruments – Range – resolution – Span – Linearity, Sensitivity- Signal conditioning systems.

UNIT-II PRESSURE AND TEMPERATURE MEASUREMENT

Bimaterials, Pressure thermometers, Thermocouples, RTD, Thermisters, and Pyrometry, pyrometers- Calibration of Pressure measuring equipment, principles and operation of various vacuum pumps and gauges.

UNIT-III FLOW MEASUREMENT

Variable head flow meters- Rota meters, Electromagnetic flow meters, Hot wire anemometers, Hot film transducers, Ultrasonic flow meters, impellers turbine system, corollas meters, vortex-shed meters

UNIT-IV AIR POLLUTION AND ENERGY MEASUREMENTS

Particulate sampling techniques, SO_2, Combustion Products, Opacity , odour measurements - Measurement of liquid level, Humidity, O_2, CO_2 in flue gases- pH measurement, moisture analyzer.

UNIT-V ELECTRICAL ENERGY MEASUREMENT and ADVANCE MEASURMENT TECHNIQUES

Power factor, load factor, harmonic analyzer, lighting: Shadowgraph, Schlieren, Interferometer, Laser Doppler Anemometer, Hot wire, Anemometer, heat flux sensors, Telemetry in measurement.

TEXT AND REFERENCE BOOKS

1. Sawhney A K and PuneetSawney, “A course in Mechanical Measurements and instrumentation” DhanpatRai & Co 2002.
2. Doebelin E O, “Measurement Systems - Application and Design”, McGraw-Hill, 2004.
3. Bechwith, Marangoni and Lienhard, “Mechanical Measurements” Addison-Wesley, 2000.
4. Holman J P, “Experimental methods for engineer’s”, McGraw-Hill, 1994.
5. Rangan C S, Sharma G R and Mani V S V, “Instrumentation Devices and Systems”, Tata McGraw-Hill, 1983.

17PGERSC012 –SOLAR PV, FUNDAMENTAL, TECHNOLOGIES AND APPLICATIONS

OBJECTIVES

- ✓ To know Basics knowledge of Solar Radiation
- ✓ To have a knowledge of solar power generation from PV panels and thermal systems.
- ✓ To get an exposure to different cell technologies.

OUTCOME

Students will have

- ✓ An exposure to advanced cell technology and usage of different materials.

UNIT- I DEPOSITION TECHNIQUE

Deposition Technique: Thermal Evaporation: Resistive heating, Flash evaporation, Arc evaporation, Laser evaporation, rf heating, Electron bombardment heating, Sputtering: Glow discharge sputtering, Low pressure sputtering, Reactive sputtering, rf sputtering, Chemical Methods: Electro-deposition, Electrolytic deposition, Chemical Vapour deposition

UNIT- II SILICON BASED TECHNOLOGIES

Silicon based technologies -mono-crystalline- poly-crystalline – ribbon - silicon film - Flow of silicon material - Manufacturing processes –wafer-cell and module - Mono and poly Si technologies - Efficiency of Si cells - Thin film technologies -Silicon - Amorphous Si cells/modules - micro-morph cell - Silicon film

UNIT- III NON-SILICON BASED TECHNOLOGIES

Non-silicon technologies -Cadmium telluride - Cu Indium Gallium di-selenide - tandem cells - PV-Tracking requirements-High concentrator solar cells - Emerging solar cell technologies -Organic PV-Heterojunction with intrinsic thin film – HIT - Quantum dots - Dye Sensitized Solar cell - Peroskvite solar cells.

UNIT -IV PV MODULE DESIGN

Solar PV modules-Mismatch in series and parallel connection-design & structure of PV modules - PV module power output- Batteries for PV systems -DC to DC and DC to AC converters-charge controllers-MPPT- Standalone PV systems -

UNIT- V GRID CONNECTED PV SYSTEM

Design methodology of PV off grid and grid connected systems - Load estimation and System Sizing - Wire sizing in PV systems – Grid connected and hybrid PV systems - Design of roof top solar PV power plants (typically 100 kWp) - Use of PV Syst and PV Sol software for design of solar PV power plants.

TEXT AND REFERENCE BOOKS

1. Thin Film Phenomena, K. L. Chopra
2. Generating Electricity from the Sun/Edited by Fred C. Treble/Pergamon Press.
3. Solar photovoltaics-Fundamentals, technologies and Applications/Chetan Singh Solanki/PHI Learning private Ltd. New Delhi.
4. Terrestrial Solar photovoltaics, Tapan Bhattacharya, Narosa Publishing House
5. Solar Electricity, Tomas Markvart, John Wiley and Sons.
6. Solar Cells – Operating Principles, Technology and System Applications, Martin A. Green, Prentice Hall Inc.
7. Modelling Photovoltaic Systems using P Spice, Luis Castaner and Santiago Silvestre, John Wiley and Sons
8. Solar Energy – Fundamentals and Applications, H.P. Garg and J. Prakash, Tata McGraw-Hill.
9. Amorphous Silicon Solar Cells, K.Takahashi and M.Konagai, North Oxford Academic Photovoltaic Systems Engineering, Roger Messenger, CRC Press.

17PGERSE01 - WASTE MANGEMENT AND ENERGY CONVERSION TECHNOLOGIES

OBJECTIVES

- ✓ To make the students realize the importance of treatment Disposal and energy recovery of waste from various industries including agriculture through the knowledge of processes, Equipment and Materials used in industrial waste
- ✓ Characteristics & Composition of industrial waste and the pollution control techniques.

OUTCOMES

Students will have

- ✓ To categorize the waste from various industries & recycle for energy extraction.

UNIT-I SOLID WASTE

Definitions: Sources, types, compositions; Properties of Solid Waste; Municipal Solid Waste: Physical, chemical and biological property; Collection, transfer stations; Waste minimization and recycling of municipal waste Landfill method of solid waste disposal; Landfill classification; Types, methods & siting consideration

UNIT- II WASTE TREATMENT & DISPOSAL SIZE REDUCTION

Incineration; Furnace type & design; Types of Incinerators – Fuel Economy – Medical- Pharmaceutical waste -Hazardous waste- Nuclear Waste incineration Environmental impacts; Measures of mitigate environmental effects due to incineration;

UNIT- III ENERGY GENERATION FROM WASTE TYPE BIOCHEMICAL CONVERSION

Sources of energy generation, Industrial waste, agro residues; Anaerobic Digestion: Biogas production; Determination of BOD, DO, COD, TOC, & Organic loading, Aerobic & Anaerobic treatments – types of digester – factors affecting biodigestion - Activated sludge process.

UNIT-IV INDUSTRIAL WASTE

Methods of treatment and recovery from the in industrial waste water – Case Studies in sugar, distillery, dairy, pulp and paper mill, fertilizer, tanning, steel industry, textile, petroleum refining, chemical and power plant.

UNIT- V SAFETY AND IMPACT ANALYSIS IN ENERGY INDUSTRIES

Evolution of modern safety concept- Safety policy - Safety Organization - line and staff functions for safety- Safety Committee- budgeting for safety. Techniques: Incident Recall Technique (IRT), disaster control, Job Safety Analysis (JSA), safety survey, safety inspection, safety sampling, Safety Audit.

TEXT AND REFERENCE BOOKS

1. Parker, Colin, & Roberts, Energy from Waste - An Evaluation of Conversion Technologies, Elsevier Applied Science, London, 1985
2. Shah, Kanti L., Basics of Solid & Hazardous Waste Management Technology, Prentice Hall, 2000
3. Manoj Datta, Waste Disposal in Engineered Landfills, Narosa Publishing House, 1997
4. Rich, Gerald et.al., Hazardous Waste Management Technology, Podvan Publishers, 1987
5. Bhide AD., Sundaresan BB, Solid Waste Management in Developing Countries, INSDOC, New Delhi,1983.

17PGERSE02- POLLUTION CONTROL IN POWER PLANTS

OBJECTIVE

- ✓ To make aware and understand of the subject and its impact on power plants.

OUTCOME

Students will have

- ✓ An exposed to minimization / elimination/ introduction of new technologies, identify optimum energy utilization techniques.

UNIT-I COAL POWER PLANTS

CO2 mitigation - Carbon foot-print reduction - Carbon credits - Fly Ash generation and environment impact - Fly ash utilization and disposal.

UNIT-II FLUIDIZED BED BOILERS

Post Combustion Controls, Particulate controls, Cyclone, Wet scrubbers, ESP and fabric filters.

UNIT-III NUCLEAR POWER PLANTS

Nuclear fuel cycle, radioactive wastes – treatment and disposal.

UNIT-IV POLLUTION CONTROL METHODS: Pre-combustion controls - Combustion controls Low NOx burners, Clean Development Mechanism (CDM).

UNIT-V GASEOUS POLLUTANTS CONTROLS

Flue gas desulfurization (FGD) systems, CSR reduction applications of electron beam and non-thermal plasmas for SOx and NOx treatments, Thermal pollution and its impact on aquatic life.

TEXT AND REFERENCE BOOKS

1. Introduction to Environmental Engineering and Science, M. Giblbert Masters. Prentice Hall, 1991
2. Environmental Pollution Control Engineering. C. S. Rao. Wiley Eastern Ltd. Delhi 1991
3. Estimation of resource savings due to fly ash utilization in road construction. Resource conservation and Recycling, Subodh Kumar and C. B. Patil. 48, 125-140 (2006)
4. Potential of fly ash utilization in India. U. Bhattcharjee and T. C. Kandpal. Energy 27, 151-66, 2002.
5. TIFAC (Technology Information Forecasting and assessment Council) Home page http://www.tifac.org.in/news/flyindia.htm.2005
6. Nuclear engineering handbook. H. Etherington. McGraw Hill (New York) 1958
7. Power Plant Engineering, P. K. Nag, Tata McGraw Hill (2001)
8. Fuel and Combustion . Samir Sarkar., Orient Longman Limited. (Hydrabad), 2001.

Power Plant Technology, El Wakil, Mc Graw Hil

17PGERSE03- NUCLEAR ENERGY AND ITS APPLICATIONS

OBJECTIVE

- ✓ To understand the concept and different technologies in energy generation, their advantages.

OUTCOME

Students will have

- ✓ Support to convention energy sources in energy crisis and its utilization extent and particularly nuclear energy risk management

UNIT-I -NUCLEAR FUEL AND REACTOR THEORY

Nuclear fuels - Occurrence and extraction – Fissile characteristics – Enrichment - Fission process - Thermal and fast fission – Energy released from fission - Chain reaction - Reaction control.

UNIT-II NUCLEAR REACTORS

General components of nuclear reactor - Fuel cladding – fuel assembly – moderators – coolants - control rods -Different types of reactors - Pressurized Water Reactor - Boiling Water Reactor - Heavy Water cooled Reactor – Fast Breeder Reactors - Reactor safety - Neutron Population growth - Assurance of safety - Emergency core cooling and containment.

UNIT-III RADIOACTIVE WASTE MANAGEMENT

The nuclear fuel cycle - Waste classification – Spent fuel storage – Transportation – Reprocessing - High-Level waste disposal - Low-level waste generation and treatment - Low-level waste disposal - Nuclear power plant decommissioning.

UNIT-IV BIOLOGICAL AND ENVIRONMENTAL EFFECTS

Biological effects of radiation - Radiation dose - Basic for limits and exposure - Sources of radiation dosage - Gas counters – Neutron detectors - Scintillation counters - Solid state detectors - Statistics of counting – Pulse height analysis - Protective measures - Calculation of dose - Effects of distance and shielding - Internal exposure - The Radon problem - Environmental radiological impact - Radiation standards.

UNIT-V NUCLEAR POWER FOR PROPULSION AND ENERGY ECONOMICS: Reactors for naval propulsion - Space reactors - Space isotopic power generator - Energy economics - Components of electrical power – cost forecast versus Reality - Challenges and opportunities – Technical and institutional improvements – Developments in nuclear reactor.

TEXT AND REFERENCE BOOKS

1. Nuclear Power Technology, W.Marshall, Vol. I &II, Clarendon press, Oxford, 1985.
2. Principle of Nuclear Reactor Engineering, Samual Glasstone, Van Nostrand Reinhold

3. Co. Inc., New York, 1963.
4. Nuclear Power Station, Margulova, Mir Publishers, Moscow, 1978.
5. Principle of Energy Conversion, Archie W.Culp, McGraw Hill Kogakusha Ltd., 1984.
6. A Course in Power Plant Technology, Domkundwar, Dhanpat Rai Sons

17PGERSE04- HYDROGEN AND FUEL CELLS

OBJECTIVE

- ✓ To introduce to emerging technologies like production and storage of Hydrogen

OUTCOME

Students will have

- ✓ An Exposure to different fuel cells in particularly Hydrogen fuel cells

UNIT-I HYDROGEN AS ENERGY

Hydrogen Energy Economy – Conception, Present status and a vision – Applications of Hydrogen - Transport application-cars, light trucks, buses - Stationary and Portable-Electronic gadgets.

UNIT-II HYDROGEN AND PRODUCTION TECHNIQUES

Hydrogen – Physical and chemical properties, salient characteristics - Production of hydrogen – Steam reforming – Water electrolysis – Gasification and woody biomass conversion – Biological hydrogen production – Photo dissociation – Direct thermal or catalytic splitting of water.

UNIT-III HYDROGEN STORAGE & TRANSPORT

Hydrogen storage options – Compressed gas – Liquid hydrogen – Hydride – Chemical Storage – Comparisons - Transport of Hydrogen -
Pipelines, gaseous, liquid and compound materials.

UNIT-IV 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 – Relative merits and demerits.

UNIT-V APPLICATION OF FUEL CELL

Fuel cell usage for domestic power systems - Large scale power generation – Automobile - Space - Environmental analysis of usage of Hydrogen in Fuel cell - Future trends in fuel cells.

TEXT AND REFERENCE BOOKS

1. Hydrogen and Fuel Cells: A Comprehensive Guide, Rebecca L. and Busby, Penn Well Corporation, Oklahoma (2005)
2. Hydrogen and Fuel Cells: Emerging Technologies and Applications, Bent Sorensen (Sørensen), Elsevier, UK (2005)
3. Fuel Cell and Their Applications, Kordesch, K and G.Simader, Wiley-Vch, Germany (1996).
4. Fuel Cells: Theory and Application, Hart, A.B and G.J.Womack, Prentice Hall, NewYork Ltd., London (1989)
5. The Hydrogen Economy, Jeremy Rifkin, Penguin Group, USA (2002).

6. Fuel Cells – Principles and Applications, Viswanathan, B and M Aulice Scibioh, Universities Press (2006)

17PGERSE05 - SOLAR REFRIGERATION AND AIR-CONDITIONING

OBJECTIVE

- ✓ To have awareness of solar applications to solar refrigeration and air-conditioning.

OUTCOMES

Students will have

- ✓ To make, design modifications and cost reduction methods.
- ✓ An exposure on solar refrigeration or A/C.

UNIT-I CONCEPT OF SOLAR ENERGY:

Review of Solar Collectors - Solar concentrators – Potential and scope of solar cooling - Types of solar cooling systems - Solar collectors and storage systems for solar refrigeration and air-conditioning.

UNIT-II REFRIGERATION CYCLES

Evolving Vapor Compression Cycle from Basic Carnot Cycle — Analysis Multipressure Systems, Cascade Systems. Air Refrigeration Cycles. -Types of Evaporators, Compressors, Condensors, Expansion Devices, Functional Aspects of the above components Driers / Filters, Receiver, Accumulator. Functional Aspects of the above accessories.

UNIT-III REFRIGERANTS AND ELECTRICAL COMPONENTS & CONTROLS

Classification of Refrigerants, Refrigerant Properties, Oil Compatibility, Blends, Eco Friendly Refrigerants-Starting and Running Circuits, Relay Types and Controls.

UNIT- IV PSYCHROMETRY AND SYSTEM DESIGN

Moist Air Properties, use of Psychrometric Chart, Various Psychrometric Processes, Air Washer, Adiabatic Saturation-Air conditioning Processes — RSHF, Summer Air conditioning, Winter Air conditioning, Bypass Factor. Applications with specified ventilation air quantity — use of ERSHF.

UNIT- V AIR DISTRIBUTION, FANS AND CHILLED WATER CIRCUITS

Flow through Ducts, Static & Dynamic Losses, Air Outlets, Duct Design — Equal Friction Methods-Indoor Air Quality, Thermal Insulation, Fans & Duct System Characteristics, Fan Arrangement-Water Piping in Chilled Water Systems, Condensers and Cooling Towers.

TEXT AND REFERENCE BOOKS

1. Arora and Domkundwar., A Course in Refrigeration and Air conditioning, Dhanpat rai & co, 2002
2. C P Arora., Refrigeration and Air conditioning. Tata McGraw-Hill Pub. Company, New Delhi, 2004.
3. Carrier Air conditioning Co., Handbook of Air conditioning systems design, McGraw-Hill, 1985.

17PGERSE06- ADVANCED INSTRUMENTAL METHODS OF ANALYSIS

OBJECTIVES

- ✓ To understand the principles and use of characterization of solar cell, thermal and electrical parameters.
- ✓ To understand the measurement of energy materials and thermal analysis

OUTCOME

Students will have

- ✓ To obtain knowledge on measurement and control techniques applicable to energy systems

UNIT- I ATOMIC SPECTROSCOPY

Optical atomic spectroscopy: Designs of Optical Instruments - Types of Optical Instruments - Principles of Fourier Transform Optical Measurements - Atomic absorption spectrometry - atomic fluorescence spectrometry - Atomic Absorption Instrumentation - Atomic Fluorescence Spectroscopy - X-ray Fluorescence Methods - X-ray Absorption Methods.

UNIT- II MOLECULAR SPECTROSCOPY

Ultraviolet – Visible molecular absorption spectroscopy - principle and instrumentation - Infra-red Absorption Spectrometry - IR Instrumentation - IR Sources and Transducers - FTIR - Advances in Raman Spectroscopy - Applications of Raman Spectroscopy - SERS.

UNIT- III ELECTROANALYTICAL CHEMISTRY

Electrochemical Cells Potentials - Currents in Electrochemical Cells - Types of Electroanalytical methods – Potentiometry – Principles - Metallic Indicator Electrodes -Membrane Indicator Electrodes.Potentiometric Titrations - Coulometry – Current - Voltage Relationships during Electrolysis – Controlled - Potential Coulometry - Coulometric Titrations - Voltammetric Instrumentation - Cyclic Voltammetry - Pulse Voltammetry - Applications of Voltammetry Stripping Methods - Electrochemical impedance spectroscopy.

UNIT- IV ADVANCED CHARACTERIZATION TECHNIQUES FOR ENERGY MATERIALS

Principles and applications of X-ray Photoelectron Spectroscopy (XPS) - Scanning Electron Microscopy (SEM) - Scanning Tunneling Microscopy (STM) - Atomic Force Microscopy (AFM) - Transmission Electron Microscopy (TEM) - X-ray diffraction (XRD) and Energy dispersive X-ray spectroscopy (EDAX).

UNIT- V THERMAL ANALYSIS

Thermal methods - Thermo gravimetric Analysis - Differential Thermal Analysis -Differential Scanning Calorimetric - Micro thermal Analysis.

TEXT AND REFERENCE BOOKS

1. R.M Silverstein, C.G. Bassler and Morril, Spectrometric identification of organic compounds, VI Edn., John Wiley & Sons, New York, 2002.
2. Willard, Merit Dean and Settle, Instrumental Methods of Analysis, CBS Publishers, IV Edn., 1986.
3. Schoog, Holler, Nieman, Thomson, Principles of Instrumental Analysis, Asia Pvt. Ltd., Singapore, 2004.
4. D.A.Skoog and D.M.West, Fundamentals of Analytical Chemistry, Winston Publications, IV Edn, 2004.
5. J.M.Mermet, M.Otto, R.Kellner, Analytical chemistry: a modern approach to analytical science, Wiley-VCH, 2004.
6. F.Rouessac, A.Rouessac, Chemical Analysis: Modern Instrumentation Methods and Techniques, 2nd Edition, Wiley & sons, USA, 2011.
7. W. Kemp, NMR in Chemistry, MacMillan Ltd,1986.

SUPPORTIVE COURSES (For other Departments)

17PGERSS01- BASIC CONCEPTS IN ENERGY SCIENCES

OBJECTIVES

- ✓ To analyze the working principle, pros and cons of Conventional energy conversion techniques
- ✓ Direct energy conversion systems Need and necessity of energy storage systems and their desirable characteristics & Fuel cells

OUTCOME

Students will have

- ➢ Awareness on the existence of various mechanisms for conversion and storage of energy, their merits, constraints and drawbacks

UNIT –I ENERGY SOURCES

Environment and sustainable development - Energy sources - sun as the source of energy – photosynthesis - classification of energy sources - fossil fuel reserves and resources - overview of global/ India's energy scenario.

UNIT- II SOLAR ENERGY

Solar radiation: measurements and prediction - Solar thermal energy conversions systems: flat plate collectors - solar concentrators and other applications - Solar Photovoltaic: Principle of photovoltaic conversion of solar energy.

UNIT – III WIND ENERGY

Wind Resource: Meteorology of wind, India's wind energy potential and challenges -distribution across the world - Eolian features - Biological indicators - Wind measurement systems - Wind Energy Conversion Systems.

UNIT- IV BIOENERGY

Biomass as energy resources - Classification and estimation of biomass - Source and characteristics of biofuels – Biodiesel – Bioethanol – Biogas - Waste to energy conversions.

UNIT- V GEOTHERMAL ENERGY

Introduction - Geothermal sources - advantages and disadvantages of geothermal energy over other energy forms - Geothermal energy in India: Prospects - Applications of Geothermal energy - Material selection for geothermal power plants

TEXT AND REFERENCE BOOKS

1. D. A. Spera, Wind Turbine Technology: Fundamental concepts of Wind Turbine Engineering, ASME Press.
2. S.P. Sukhatme, Solar Energy: principles of Thermal Collection and Storage, Tata McGraw-Hill (1984).

3. Energy and EnvironmentSet: Mathematics of Decision Making, Loulou, Richard; Waaub, Jean-Philippe; Zaccour, Georges (Eds.), 2005, XVIII, 282 p. ISBN: 978-0-387-25351-0
4. Energy and the Environment, 2nd Edition, John Wiley, 2006, ISBN:9780471172482; Authors: Ristinen, Robert A. Kraushaar, Jack J. AKraushaar, Jack P. Ristinen, Robert A., Publisher: Wiley, Location: New York, 2006.
5. Energy and the Challenge of Sustainability, World Energy assessment, UNDP, N York, 2000.
6. E H Thorndike, Energy & Environment: A Primer for Scientists and Engineers, Addison-Wesley Publishing Company
7. R Wilson & W J Jones, Energy, Ecology and the Environment, Academic Press Inc.
8. D W Davis, Energy: Its Physical Impact on the Environment, John Wiley & Sons

17PGERSS02- CLIMATE CHANGE AND CO_2 EMISSION ASSESSMENT

OBJECTIVES

- ✓ To study the global climate change
- ✓ To analysis emission assessment

OUTCOME

Students will have

- ✓ Awareness on the existence of various mechanisms for conversion and storage of energy, their merits, constraints and drawbacks

UNIT-I INTRODUCTION TO ENERGY

Introduction to Energy: Overview of energy sources and technologies - energy consumption Pattern - social and economic implications of energy uses - equity and disparity.

UNIT-II INTRODUCTION TO GLOBAL CLIMATE CHANGE

Introduction to global climate change: theory of global climate change - mechanism of Greenhouse Gases Emission - theory and proof of climate change impacts - global overview - International concern on Climate change and mitigation efforts.

UNIT-III CARBON DIOXIDE (CO_2) EMISSIONS AND CONVERSION/CONSUMPTION

Carbon dioxide (CO_2) emissions in relation to energy conversion/consumption: theory of CO_2 emission in relation to energy conversion processes.

UNIT- IV METHODOLOGY FOR CO_2 ASSESSMENT/CARBON FOOT PRINT

Methodology for CO_2 assessment/carbon foot print: estimation of emission from fossil fuel combustion (Fuels and their composition - fuel to energy conversion - concept of emission factor) - emission from major sectors (industry – transport – agriculture – domestic - service)

UNIT-V CARBON CREDIT

Carbon credit: Definition - concept and examples - Carbon credit - national policies *vis-à-vis* international market scenario - Current efforts and future prospect/limitation of carbon trading mechanism.

TEXT AND REFERENCE BOOKS

1. Mathez E. A. (2009); Climate Change: The Science of Global Warming and Our Energy Future, First edition, Columbia University Press.
2. Dessler A. (2011); Introduction to Modern Climate Change, Cambridge University Press.
3. Yamin F. (ed.) (2005); Climate Change and Carbon Markets: A Handbook of Emissions Reduction Mechanisms, Earthscan.

4. Franchetti M. J. and Apul D. S. (2013); Carbon Footprint Analysis: concepts, methods, implementation and case studies, CRC Press.
5. Clean Development Mechanism, UNFCC Website; http://cdm.unfccc.int/
6. Stern N. (2007); The Economics of Climate Change. The Stern Review. Cambridge University Press.
7. Barrett S. (2007). Why Cooperate? The Incentive to Supply Global Public Goods. Oxford University Press.

17PGERSS03- ENERGY AND ENVIRONMENTAL IMPACTS

OBJECTIVES

- ✓ To teach the principal of energy and environmental issues
- ✓ To explore the environmental impact of various energy sources and also the effects of different types of pollutants.

OUTCOME

Students will have

- ✓ Learn about challenges and opportunities related to energy use and conversion. Learn how to evaluate the sustainability of energy systems.

UNIT-I ENERGY SOURCES

Present Energy resources in India and its sustainability - Different type of conventional Power Plant--Energy Demand Scenario in India-Advantage and Disadvantage of conventional Power Plants – Conventional vs Non-conventional power generation

UNIT-II SOLAR ENERGY

Basics of Solar Energy- Solar Thermal Energy- Solar Photovoltaic-Advantages and Disadvantages-Environmental impacts and safety.

UNIT-III BIOMASS AND GEO THERMAL ENERGY

Biomass resources-Biomass conversion Technologies- Feedstock preprocessing and treatment methods- Bioenergy program in India-Environmental benefits and impacts. Geothermal Energy resources –Ocean Thermal Energy Conversion – Tidal.

UNIT-IV POLLUTION CONTROL

Air pollution- Sources, effects, control, air quality standards, air pollution act, air pollution measurement. Water pollution-Sources and impacts, Soil pollution-Sources and impacts, disposal of solid waste.

UNIT-V ENVIRONMENTAL AFFECT FACTORS

Greenhouse gases – effect, acid rain. Noise pollution. Pollution aspects of various power plants. Fossil fuels and impacts, Industrial and transport emissions- impacts.

TEXT AND REFERENCE BOOKS

1. Boyle, G. 2004.' Renewable energy: Power for a sustainable future'. Oxford University press.
2. B H Khan, 'Non Conventional Energy Resources'-The McGraw –Hill Second edition.
3. G. D. Rai, 'Non conventional energy sources', Khanna Publishers, New Delhi, 2006.
4. Gilbert M. Masters, 'Introduction to Environmental Engineering and Science', 2nd Edition, Prentice Hall, 2003.

5. 'Unleashing the Potential of Renewable Energy in India' –World bank report.
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17PGERSS04- ERECTION AND MAINTENANCE OF REFRIGERATION AND AIR-CONDITIONING EQUIPMENTS

OBJECTIVES

- ✓ To analyze the working principle, pros and cons of Conventional energy conversion techniques
- ✓ To know about energy based testing measurement
- ✓ To know about energy based measurement & maintenance system

OUTCOME

Students will have

- ✓ Awareness on the existence of various instrument objective and their merits, constraints and drawbacks

UNIT-I INTRODUCTION

Refrigeration and air-conditioning plant layout, parameters affecting the location.

UNIT-II ERECTION OF R&AC SYSTEMS

Erection methodology, foundation, padding, network analysis, critical path, interconnections; safety precautions, air handling equipment's. Maintenance procedures.

UNIT-III TESTING OF EQUIPMENTS

Testing of compressors, condensers, evaporators, cooling towers, motors, controls, test rings, ISI standards. Testing of control systems, circuitry and trouble shooting, condition monitoring.

UNIT-IV TOTAL PREVENTIVE MAINTENANCE

TPM Principles, Corrective and preventive measures and Reliability analysis.

UNIT-V MAINTENANCE SCHEDULES

Studies on different maintenance schedules followed by various industries

TEXT AND REFERENCE BOOKS

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