SARDAR PATEL UNIVERSITY, VALLABH VIDYANAGAR, GUJARAT
FACULTY OF SCIENCE
COURSE OF STUDY
PROPOSED

RULES FOR DEGREE OF THE MASTER OF SCIENCE (M.Sc.) IN RENEWABLE ENERGY (RE)

RPG.RE.1: A candidate who has obtained the degree of Bachelor of Science (Any Sciences Graduation) and Engineering (Any B.E/ B. Tech Graduation) from any recognized University, after successful completion of the course work prescribed for the M. Sc. degree examination, for a period of two years subsequent to his passing the B. Sc. Degree/ B.E/B. Tech. Degree examination will be admitted to the examination for the degree of M. Sc. The degree of the Master of Science will be taken by papers, practical and project work only.

RPG.RE.2: The examination for the various theory courses and laboratory work will be conducted under semester system. For this purpose each academic year will be divided into two semesters.

RPG.RE.3: The ratio between the External and Internal assessment will be 70:30

RPG.RE.4: Candidate will be required to attend at least 80 % of the total theory, lectures, practical and project work organized under each of the course by them during the semester.

RPG.RE.5: Candidate will be offered specialization in three different disciplines in second year (from III semester) on the basis of merit list

RPG.RE.6: (i) The head of the department in consultation with other teachers of the department will prepare in the beginning of the semester a detailed scheme of the periodic test(s), seminars, quizzes etc., and the program for the test examinations and the same will be announced to the candidates. (ii) The record of the test examinations as well as seminars and quizzes will be maintained by the department. (iii) Every candidate shall maintain a regular record of this practical and project work which shall be duly certified by his teacher(s) from time to time.

RPG.RE.7: The weightage of the semester evaluation (internal evaluation) shall be 40 % (30%) and weightage of the semester evaluation (external evaluation) shall be 60% (70%)

In internal assessment, the student will have to score 25 % marks in each of the Course and in aggregate have to score 35 %. In external assessment, the student will have to score 40 % marks in each of the course. In overall, aggregate of internal and external for particular course student will also have to score 40% marks in each of the course. The candidate will NEVER be said to have failed in a course if he/she is unsuccessful in completing the course by the end of the semester. On the contrary he/she is said to have DROPPED the paper.

RPG.RE.8: A teacher offering a particular course will be one of the examiners at the university examination and the examiner may be either a teacher from within the university or from outside the university.

RPG.RE.9: The final results for the awards of the degree will be declared on the basis of the grand total of all the semesters examinations prescribed for the degree examination.

RPG.RE.10: No candidate will be allowed to reappear in course in which he / she has already passed.

RPG.RE.11: Standard of passing: The standard of passing of M. Sc. (Renewable Energy) degree examination will be as under:-

i. To pass any semester examination for the M. Sc. degree a candidate must obtain at least 40% marks in the university examination and 40% marks in the aggregate of university and internal examination in each course of Theory, Practical and project work.

ii. Those of the successful candidates who obtain 50% or more marks in the aggregate of all the semesters taken together will be placed in the Second class and those who obtain 60% or more marks in the aggregate will be placed in the first class.
The successful candidates who obtain 70% or more marks in the aggregate of all the semesters taken together will be declared to have passed the examination in the first class with distinction.

RPG.RE.12:

A candidate who has undergone a regular course of study in a particular Semester, fulfill the required criteria of attendance and has secured marks equal to passing standard both in internal and External Examination shall be eligible for continuing study in next semester, provided that-

"A candidate will be allowed to go to IV semester only if he/she has passed all the courses of I semester."

Syllabus (Effective from the academic year June, 2013)
Institute of Studies and Research in Renewable Energy
Sardar Patel University, Vallabh Vidyanagar – 388 120, Gujarat

M. Sc. (Renewable Energy)
Structure for Semester System & Choice Based Credit System (CBCS)

INSTITUTE OF STUDIES AND RESEARCH IN RENEWABLE ENERGY (ISRRE) NEW VALLABH VIDYANAGAR

M. Sc. in Renewable Energy (UNDER CBCS)

SEMESTER-I: RENEWABLE ENERGY								
No	**Course**	**Teaching Scheme**				**Marks**		
	Code & Title	**Theory (T)/ Practical (P)**	**Credit**	**Theory hr/week**	**Exam Duration, hrs**	**Internal**	**External**	**Total**
						Total/ Passing	**Total/ Passing**	**Total/ Passing**
CORE COURSES								
1	PS01CREN01 Fundamental of Renewable Energy Technology	T	4	4	3	30/12	70/28	100/40
2	PS01CREN02 Solar Energy	T	4	4	3	30/12	70/28	100/40
3	PS01CREN03 Geothermal Energy and Biomass Energy	T	4	4	3	30/12	70/28	100/40
ELECTIVE COURSE								
4	PS01EREN01 Wind Energy	T	4	4	3	30/12	70/28	100/40
CORE COURSES								
5	PS01CREN04 Practical	P	4	6	3	30/12	70/28	100/40
6	PS01CREN05 Practical	P	4	6	3	30/12	70/28	100/40
7	PS01CREN06 Viva	-	1	-	-	-	50/20	50/20
	TOTAL		**25**					

SEMESTER-II: RENEWABLE ENERGY								
No	**Course**	**Teaching Scheme**				**Marks**		
	Code & Title	**Theory (T)/ Practical (P)**	**Credit**	**Theory hr/week**	**Exam Duration, Hrs**	**Internal**	**External**	**Total**
						Total/ Passing	**Total/ Passing**	**Total/ Passing**
CORE COURSES								
1	PS02CREN01 Renewable Energy: Conversion, Storage and Environmental	T	4	4	3	30/12	70/28	100/40

	aspects							
2	PS02CREN02 Ocean Energy and Tidal Energy	T	4	4	3	30/12	70/28	100/40
3	PS02CREN03 Hydro Energy and Chemical Energy Sources	T	4	4	3	30/12	70/28	100/40
ELECTIVE COURSE								
4	PS02EREN01 Alternate Energy Sources	T	4	4	3	30/12	70/28	100/40
CORE COURSES								
5	PS02CREN04 Practical	P	4	6	3	30/12	70/28	100/40
6	PS02CREN05 Practical	P	4	6	3	30/12	70/28	100/40
7	PS02CREN06 Viva	-	1	-	-	-	50/20	50/20
	TOTAL		**25**					

SEMESTER-III: RENEWABLE ENERGY-SYSTEM TECHNOLOGY								
No	**Course**	**Teaching Scheme**				**Marks**		
	Code & Title	**Theory (T)/ Practical (P)**	**Credit**	**Theory hr/week**	**Exam Duration, Hrs**	**Internal**	**External**	**Total**
						Total/ Passing	**Total/ Passing**	**Total/ Passing**
CORE COURSES								
1	PS3CRESYT1 Energy Audit and Energy Conservation	T	4	4	3	30/12	70/28	100/40
2	PS3CRESYT2 Energy policy & Regulation Act-India	T	4	4	3	30/12	70/28	100/40
3	PS3CRESYT3 Solar Thermal Technology	T	4	4	3	30/12	70/28	100/40
ELECTIVE COURSE								
4	PS3ERESYT1 Solar Photovoltaic Technology	T	4	4	3	30/12	70/28	100/40
CORE COURSES								
5	PS3CRESYT4 Practical	P	4	6	3	30/12	70/28	100/40
6	PS3CRESYT5 Practical	P	4	6	3	30/12	70/28	100/40

7	PS3CRESYT6 Viva	-	1	-	-	-	50/20	50/20
	TOTAL		**25**					

SEMESTER-III: RENEWABLE ENERGY-ENVIRONMENTAL MODELING								
No	**Course**	**Teaching Scheme**				**Marks**		
	Code & Title	**Theory (T)/ Practical (P)**	**Credit**	**Theory hr/week**	**Exam Duration, Hrs**	**Internal**	**External**	**Total**
						Total/ Passing	**Total/ Passing**	**Total/ Passing**
CORE COURSES								
1	PS3CREEMO1 Energy Audit and Energy Conservation	T	4	4	3	30/12	70/28	100/40
2	PS3CREEMO2 Energy policy & Regulation Act-India	T	4	4	3	30/12	70/28	100/40
3	PS3CREEMO3 Environmental Modeling	T	4	4	3	30/12	70/28	100/40
ELECTIVE COURSE								
4	PS3EREEMO1 Environmental Control	T	4	4	3	30/12	70/28	100/40
CORE COURSES								
5	PS3CREEMO4 Practical	P	4	6	3	30/12	70/28	100/40
6	PS3CREEMO5 Practical	P	4	6	3	30/12	70/28	100/40
7	PS3CREEMO6 Viva	-	1	-	-	-	50/20	50/20
	TOTAL		**25**					

SEMESTER-III: RENEWABLE ENERGY-ENERGY MANAGEMENT								
No	**Course**	**Teaching Scheme**				**Marks**		
	Code & Title	**Theory (T)/ Practical (P)**	**Credit**	**Theory hr/week**	**Exam Duration, Hrs**	**Internal**	**External**	**Total**
						Total/ Passing	**Total/ Passing**	**Total/ Passing**
CORE COURSES								
1	PS3CREEMA1 Energy Audit and Energy Conservation	T	4	4	3	30/12	70/28	100/40
2	PS3CREEMA2 Energy policy & Regulation Act-India	T	4	4	3	30/12	70/28	100/40

3	PS3CREEMA3 Energy Management and Energy Planning	T	4	4	3	30/12	70/28	100/40
ELECTIVE COURSE								
4	PS3EREEMA1 Solar Thermal Technology	T	4	4	3	30/12	70/28	100/40
CORE COURSES								
5	PS3CREEMA4 Practical	P	4	6	3	30/12	70/28	100/40
6	PS3CREEMA5 Practical	P	4	6	3	30/12	70/28	100/40
7	PS3CREEMA6 Viva	-	1	-	-	-	50/20	50/20
	TOTAL		**25**					

SEMESTER-IV: RENEWABLE ENERGY-SYSTEM TECHNOLOGY								
No	**Course**	**Teaching Scheme**				**Marks**		
	Code & Title	**Theory (T)/ Practical (P)**	**Credit**	**Theory hr/week**	**Exam Duration, Hrs**	**Internal**	**External**	**Total**
						Total/ Passing	**Total/ Passing**	**Total/ Passing**
CORE COURSES								
1	PS4CRESYT1 Research Methodology	T	4	4	3	30/12	70/28	100/40
2	PS4CRESYT2 Modelling of Solar Thermal system	T	4	4	3	30/12	70/28	100/40
ELECTIVE COURSE								
3	PS4ERESYT1 Solar Heating and Cooling of Building	T	4	4	3	30/12	70/28	100/40
4	PS4ERESYT2 Energy Storage and Distribution	T	4	4	3	30/12	70/28	100/40
CORE COURSES								
5	PS4CRESYT3 Practical	P	4	6	3	30/12	70/28	100/40
6	PS4ERESYT4 Practical	P	4	6	3	30/12	70/28	100/40
7	PS4CRESYT5 Project/ Dissertation		12					300
8	PS4CRESYT6 Viva	-	1	-	-	-	50/20	50/20
	TOTAL							

Note: Project will be offered in forth semester to student who will have to complete PS4CRESYT1, PS4CRESYT2, PS4CRESYT3 and PS4CRESYT6 courses only

SEMESTER-IV: RENEWABLE ENERGY-ENVIRONMENTAL MODELING								
No	**Course**	**Teaching Scheme**				**Marks**		
	Code & Title	**Theory (T)/ Practical (P)**	**Credit**	**Theory hr/week**	**Exam Duration, Hrs**	**Internal**	**External**	**Total**
						Total/ Passing	**Total/ Passing**	**Total/ Passing**
CORE COURSES								
1	PS4CREEMO1 Research Methodology	T	4	4	3	30/12	70/28	100/40
2	PS4CREEMO2 Environmental Planning and Management	T	4	4	3	30/12	70/28	100/40
ELECTIVE COURSE								
3	PS4EREEMO1 Statistical and Research Methods: Theory and Practical	T	4	4	3	30/12	70/28	100/40
4	PS4EREEMO2 Modeling of Solar Thermal system	T	4	4	3	30/12	70/28	100/40
CORE COURSES								
5	PS4CREEMO3 Practical	P	4	6	3	30/12	70/28	100/40
6	PS4EREEMO4 Practical	P	4	6	3	30/12	70/28	100/40
7	PS4CREEMO5 Project/ Dissertation		12			-	-	300
8	PS4CREEMO6 Viva	-	1	-	-	-	50/20	50/20
	TOTAL							

Note: Project will be offered in forth semester to student who will have to complete PS4CREEMO1 , PS4CREEMO2, PS4CREEMO3, and PS4CREEMO6 courses only

SEMESTER-IV: RENEWABLE ENERGY-ENERGY MANAGEMENT								
No	**Course**	**Teaching Scheme**				**Marks**		
	Code & Title	**Theory (T)/ Practical (P)**	**Credit**	**Theory hr/week**	**Exam Duration, Hrs**	**Internal**	**External**	**Total**
						Total/ Passing	**Total/ Passing**	**Total/ Passing**
CORE COURSES								

1	PS4CREEMA1 Research Methodology	T	4	4	3	30/12	70/28	100/40
2	PS4EREEMA2 Energy Efficiency and Analysis in Electrical Systems I	T	4	4	3	30/12	70/28	100/40
ELECTIVE COURSE								
3	PS4EREEMA1 Energy Efficiency and Analysis in Electrical Systems II	T	4	4	3	30/12	70/28	100/40
4	PS4EREEMA2 Energy Efficiency and Analysis in Thermal Utilities	T	4	4	3	30/12	70/28	100/40
CORE COURSES								
5	PS4CREEMA3 Practical	P	4	6	3	30/12	70/28	100/40
6	PS4EREEMA4 Practical	P	4	6	3	30/12	70/28	100/40
7	PS4CREEMA5 Project/ Dissertation		12					300
8	PS4CREEMA6 PS01CREN06 Viva	-	1	-	-	-	50/20	50/20
	TOTAL							

Note: Project will be offered in forth semester to student who will have to complete PS4CREEMA1 , PS4CREEMA2, PS4CREEMA3, and PS4CREEMA6 courses only

ALL THE COURSES ARE COMPULSORY

Scope: The scope of the course is very wide. The students passing with the M. Sc. degree in Renewable Energy are expected to have opportunity at:

a. Renewable energy industries like solar, wind, biofuels.
b. Colleges and Universities in academics
c. Nonprofit organizations working in Renewable Energy Field
d. As research scientists, associate or fellow at various research organizations, college universities
e. The students may start their own entrepreneurship as research administrator, programmer, and data analyst, product manufacture

Duration: Two years Master Degree Course in Science with Four Semesters.

Eligibility: Bachelor of Science (Any Sciences Graduation) and Engineering (Any B.E or B. Tech Graduation

Number of Seats: 75 (Seventy Five)

COURSE STRUCTURE, M. Sc. in Renewable Energy (UNDER CBCS)

SEMESTER-I

CORE COURSES

PS01CREN01: Fundamental of Renewable Energy Technology
PS01CREN02:Solar Energy
PS01CREN03: Geothermal Energy and Biomass Energy

ELECTIVE COURSES

PS01EREN01: Wind Energy
PS01CREN04: Practical
PS01CREN05: Practical
PS01CREN06: Viva Voce

SEMESTER-II

CORE COURSES

PS02CREN01: Renewable Energy: Conversion, Storage and Environmental aspects
PS02CREN02: Ocean Energy and Tidal Energy
PS02CREN03: Hydro Energy and Chemical Energy Sources

ELECTIVE COURSES

PS02EREN01:Alternate Energy Sources
PS02CREN04: Practical
PS02CREN05: Practical
PS02CREN06: Viva Voce

SEMESTER-III-RENEWABLE ENERGY-SYSTEM TECHNOLOGY

CORE COURSES

PS3CRESYT1: Energy Audit and Energy Conservation
PS3CRESYT2: Energy Policy & Regulation Act- India
PS3CRESYT3: Solar Thermal Technology

ELECTIVE COURSES

PS3ERESYT1: Solar Photovoltaic Technology
PS3CRESYT4: Practical
PS3CRESYT5: Practical
PS3CRESYT6: Viva Voce

SEMESTER-III-RENEWABLE ENERGY-ENVIRONMENTAL MODELING

CORE COURSES

PS3CREEMO1: Energy Audit and Energy Conservation
PS3CREEMO2: Energy Policy & Regulation Act- India
PS3CREEMO3: Environmental Modeling

ELECTIVE COURSES

PS3EREEMO1: Environmental Control
PS3CREEMO4: Practical
PS3CREEMO5: Practical
PS3CREEMO6: Viva Voce

SEMESTER-III-RENEWABLE ENERGY-ENERGY MANAGEMENT

CORE COURSES

PS3CREEMA1: Energy Audit and Energy Conservation

PS3CREEMA2: Energy Policy & Regulation Act- India

PS3CREEMA3: Energy Management and Energy Planning

ELECTIVE COURSES

PS3EREEMA1: Solar Thermal Technology

PS3CREEMA4: Practical

PS3CREEMA5: Practical

PS3CREEMA5: Viva Voce

SEMESTER-IV-RENEWABLE ENERGY-SYSTEM TECHNOLOGY

CORE COURSES

PS4CRESYT1: Research Methodology

PS4CRESYT2: Modeling of Solar Thermal system

ELECTIVE COURSES

PS4ERESYT1: Solar Heating and Cooling of Building

PS4ERESYT2: Energy Storage and Distribution

PS4CRESYT3: Practical

PS4ERESYT4: Practical

PS4CRESYT5: Project/ Dissertation

PS4CRESYT6: Viva Voce

SEMESTER-IV-RENEWABLE ENERGY-ENIRONMENTAL MODELING

CORE COURSES

PS4CREEMO1: Research Methodology

PS4CREEMO2: Environmental Planning and Management

ELECTIVE COURSES

PS4EREEMO2: Statistical and Research Methods: Theory and Practical

PS4EREEMO3: Modeling of Solar Thermal system

PS4CREEMO3: Practical

PS4EREEMO4: Practical

PS4CREEMO5: Project/ Dissertation

PS4CREEMO6: Viva Voce

SEMESTER-IV-RENEWABLE ENERGY-ENRGY MANAGEMENT

CORE COURSES

PS4CREEMA1: Research Methodology

PS4CREEMA2: Energy Efficiency and Analysis in Electrical Systems I

ELECTIVE COURSES

PS4EREEMA2: Energy Efficiency and Analysis in Electrical Systems II

PS4EREEMA3: Energy Efficiency and Analysis in Thermal Utilities

PS4CREEMA3: Practical

PS4EREEMA4: Practical

PS4CREEMA5: Project/ Dissertation

PS4CREEMA6: Viva Voce

SEMESTER-I

PS01CREN01: Fundamental of Renewable Energy Technology

Unit 1: Fundamentals of Energy Science & Energy Technology

Introduction to Energy Science, Energy Science and other Sciences, Energy, Man and Environment, Review of various forms of Energy, Energy Chains or Energy Routes. Introduction to Energy Technology, Energy Science and Energy Technology. Commercial Energy Source-Coal, Oil, Petrol, Diesel, Natural gas and other sources, Trends in Energy Consumption of primary Energy sources. World future energy demand, Alternate Energy Resources-Non Commercial Energy resources-Solar Energy, Wind Energy Energy from biomass and biogas OTEC, Tidal, Geothermal Energy, Hydrogen Energy, Fuel cell, Thermoelctric Power, Prospects of Renewable Energy sources& Advantages.

Unit 2: Energy Measurements, Conversion & Calculations

Introduction to Measurements and Units, Various Systems of Units, Energy Conversion Equations, Mechanical Energy, Work and Power, Kinetic Energy, Potential Energy, Energy, Power and Work, Energy in Matter at Rest, Conservation of Energy, Electrical Energy, Electrical Quantities-Current, Voltage, Power, Single Phase and Three Phase AC Quantities, Energy in Inductance and Capacitance, Mechanical– Electrical-Thermal Energy Conversion, Active Power, Reactive Power and Power.

Unit 3: Fundamental of Heat, Heat and Mass Transfer

Introduction, Conduction-Fourier Law-Thermal conductivity, Radiation- Kirchoff Law- Law of thermal radiation, Reflectivity, Transmissivity, Transmittace-Absorptance product, Convection-Forced convection and Wind loss, Heat Exchanger, Heat transfer through an insulated wall and pipe. Introduction to Heat and Mass Transfer

Unit 4: Fundamentals of Thermodynamic cycles

Introduction, Definition of thermodynamics, Closed system, Open system, Isolated system, System surroundings/Environment and Boundary. First law of thermodynamics, Second law of thermodynamics, Reversible and Irreversible process, Thermodynamic cycle, Entropy, Enthalpy, Isothermal, Adiabatic, Isentropic, Sensible heat, latent heat, Specific heat capacity, Thermal efficiency. Heat engine, Coefficient of Performance, Available Energy and Unavailable Energy.

Reference Book:

1. Energy Technology, Non conventional, Renewable & Conventional, Third Edition, Khanna Publishers, p.1144. ISBN NO. 81-7409-040-1
   S. Rao and B.B. Parulekar. (2012)
2. Solar Energy- Fundamentals, Design, Modelling and Applications, Revised edition 2013, Narosa Publishing house Pvt.Ltd, p.525
   G.N.Tiwari. (2013)

Text Book:

3. Non-Conventional Energy Sources, Fourth Edition, Khanna Publishers, p.912
   G.D.Rai. (2011)
4. Solar Energy Utilization, Fifth Edition, Khanna Publishers, p.644
   G.D.Rai. (2011)

SEMESTER-I

PS01CREN02: Solar Energy

Unit 1: Solar Radiation Analysis

Introduction, Structure of the sun-fusion energy-characteristics of the sun, Solar constant, Electromagnetic energy spectrum, Extra Terrestrial radiation, Terrestrial radiation-beam radiation- diffuse radiation-sun at zenith-Air mass, Attenuation of Beam Radiation-absorption, Scattering, Solar radiation Geometry, Basic of Earth and Sun angles-Latitude-Hour angle-Sun declination, Solar Time, Solar angles derivation, Sunrise, Sunset, and Day length.

Unit 2: **Solar Radiation Measurement and Data Estimation**

Solar energy measuring equipments-classification, Pyrheliometers, Pyranometers, 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, Ratio of total radiation on tilted surface to a horizontal surface.

Unit 3: Radiation Characteristics of Opaque Materials

Absorptance and Emisttance, Kirchoff's Law, Reflectance of Surfaces, Relationships Among Absorptance, Emittance and Reflectance, Reflection of radiation, Absorptoin by Glazing, Optical properties of cover system, Measurement of surface radiation properties, selective surfaces, Mechanisms of selectivity, Optimum Properties, Angular Dependence of solar absorptance, Absorptance of cavity receivers specularly reflecting surfaces.

Unit 4: Principle of Solar Energy Collecting Devices

Principle of Active system, Passive system, Operating principle of Collectors - Flat Plate Collectors-Non Tracking collectors, Tracking Collectors-Focusing (Concentrating)-Tilted Collectors- Solar Pond Collectors-Photo-Optical Collectors-Photovoltaic (PV) Cells-Fuel Cells-Energy Storages-Hydrogen Storage and Transport-Solar Energy Home- Solar Energy and Desalination Plants –Solar cooling, Future Expectations.

Text Book:

1. Solar Engineering of Thermal Process, Fourth edition, Wiley Publications, p.910
   Duffie and Beckman. (2013)
2. Solar Energy- Fundamentals, Design, Modelling and Applications, Revised edition 2013, Narosa Publishing house Pvt.Ltd, p.525
   G.N.Tiwari. (2013)

Reference Book:

1. Solar Energy Utilization, Fifth Edition, Khanna Publishers, p.644
   G.D.Rai. (2011).

PS01CREN03: Geothermal Energy and Biomass Energy

Unit 1: Geothermal Energy

Introduction and 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, Geo-Pressure Geothermal Resources Petro-Geothermal Resources, Geothermal Electrical Power Plants and its Fluids

Unit 2: 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, Binary cycle Liquid dominated GTEP Plant, and Liquid dominated Total Flow GTEP Plant, Geothermal (Hot Dry Rock) GTEP Plant, and Scope for Geothermal Energy systems in India

Unit 3 Biomass Energy Resources and Conversion Processes

Introduction, Origin of Biomass, Hydrocarbon Family, Biomass Energy Resources, Biomass Conversion Process, Direct Combustion of Biomass (Incineration), Thermo chemical Conversion of Biomass, Biochemical Conversion, Fermentation, Gaseous Fuels from Biomass, Applications of Biomass Energy Conversion Processes

Unit 4 Biogas Plants for Urban Waste and Rural Waste to Energy

Introduction, Raw Biomass materials for Conversion to Biogas, Agriculture waste and Agriculture Crops, Fruit Farms, Aquatic Biomass, Raw materials for Biogas Production, Significance of Biogas Plants, Average Composition of Biogas, Anaerobic Fermentation and Digestion Process used in Biogas Plants, Biogas Plants and its Types, Technical data Calculation for Biogas Plant, Large Biogas Plants, Uhde-Schwarting Process of Two Stage Wet Fermentation, Dry Anaerobic Digestion Process of MSW, Ocean Biomass energy Conversion, Principal Marine Bio energy Resources, Kelp Bio energy Conversion Process

Text Book:

2. Energy Technology-Nonconventional, Renewable & Conventional
   S. Rao and Dr. B. B. Parulekar, Khanna Publishers, ISBN No. 81-7409-040-1
3. Solar Energy Utilization
   G. D. Rai, Khanna Publishers, ISBN-81-7409-073-8
4. Non-Conventional Energy Sources
   G. D. Rai, Khanna Publishers, ISBN No. 81-7409-073-8

References Books:

1. Nonconventional energy sources
   Domkundwar,Dhanpat rai & Co.
2. Biomass- Application, technology & production
   N.C. Cheremenisoff, P.N. Cheremenisoff & F. Ellurbrush, Marcel Dekker, New York, 1980.
3. The Alcohol Fuel Handbook, ISBN No. 07-4140-64-62
   Lynn Ellen Doxon
4. Biomass for Renewable Energy, Fuels, and Chemicals, ISBN-10: 0124109500
   Donald L. Klass, Reed Elsevier India Private Limited
5. Geothermal Energy: An Alternative Resource for the 21st Century
   K. Gupta and Roy Sukanta.
6. Geothermal Energy: Renewable Energy and the Environment
   William E. Glassley.
7. Geothermal Energy Systems: Exploration, Development, and Utilization
   Ernst Huenges (Editor), Patrick Ledru (Editor).
8. Geothermal Heat Pumps: A Guide for Planning and Installing
   Karl Oschner.
9. Geothermal Power Plants, Second Edition: Principles, Applications, Case Studies and Environmental Impact
   Ronald DiPippo.
10. Geothermal Energy: Utilization and Technology by
    Mary H. Dickson.

PS01EREN01: Wind Energy

Unit 1 Wind Energy – Fundamentals and Applications

Introduction, Application and Historical background, Merits and Limitations, Nature and Origin of Wind, Wind Energy Quantum, Variables in Wind Energy Conversion Systems, Wind Power Density, Power in a Wind Stream, Wind Turbine Efficiency, Power of a Wind Turbine, Forces on the Blade of a Propeller, Wind Velocities and Height from Ground, Mean Wind Velocity, Wind Velocity duration curve, Energy Pattern Factor, Wind Power duration Characteristics

Unit 2 Wind Turbine- Generator Units

Introduction, Various terms and definitions, Types of Wind Turbine Generator(WTG) Units, Planning of a Wind Farm, Horizontal Axis Propeller type Wind Turbine Generator, Three Blade Horizontal Axis Wind Turbine(HAWT), Dimensioning of Horizontal Axis Wind Turbine, Vertical Axis Wind Turbine, Vertical Axis Darrieus Rotor Wind Turbine, Vertical Axis Wind Turbine with H-Rotor, Wind Turbine Rotor Speed, Practical PV Characteristics, Power Coefficients Versus Tip Speed Ratio, Operation and Control of a HAWT, Economic Consideration

Unit 3 Wind Energy Farm and Energy Conversion System

Wind to Electric Energy Conversion System, Power Versus Velocity of WTG, Power Duration Curves

Types of Wind Energy System, Wind to Electrical Energy Conversion Alternatives, Grid Connection, Energy Storage Requirements with Wind Energy System, Wind Turbine Generator Unit with Battery Storage Facility, Wind Turbine Generator Unit with Diesel Generator, Solar-Wind Hybrid (Futuristic), Electrical Main Circuit of a Wind Farm, Control and Monitoring System of a Wind Farm, Wind Farm Siting, Wind Map of India, Wind-Electric Energy Stations in India, Indigenously Developed Wind Turbine Generators by BHEL, India

Unit 4 Wave Energy

Introduction, Wave Energy Generation-Potential Energy, Kinetic Energy, Wave Energy Conversion Devices-Wave Energy Conversion by Floats, High Level Reservoir Wave Machine, Dolphin type Wave, Power Machine, Other Wave Machine, Advantages and Disadvantages of Wave Energy, Wave Energy in India

References:

1. Energy Technology-Nonconventional, Renewable & Conventional
   S. Rao and Dr. B. B. Parulekar, Khanna Publishers, ISBN No. 81-7409-040-1
2. Solar Energy Utilization
   G. D. Rai, Khanna Publishers, ISBN-81-7409-073-8
3. Non-Conventional Energy Sources
   G. D. Rai, Khanna Publishers, ISBN No. 81-7409-073-8

PS01CREN04: Practical

1. Measurement of Solar Radiation
2. Measurement of Solar Angles
3. Measurement of total and Diffused solar radiation on a horizontal surface and comparison of computed values of total solar radiation on an inclined plane with experimentally measured values
4. Determination of thermal efficiency of Solar Water Heater
5. Performance of Solar Air Heater (Forced Dryer)
6. Performance Evaluation of Solar Still
7. Thermal testing of a Box-type Solar Cooker and determination of first and second figure of merit.
8. To study the transmissivity of given solar flat plate collector glass
9. Measurement of power of wind mill
10. Energy Content in Wind. (Prototype Wind Mill of 100W)

PS01CREN05: Practical

1. Study and determination of proximate analysis of biomass

2. Study of ultimate analysis of biomass
3. Measurement of calorific value of different biomass (at least two types)
4. Measurement of load and power factor for the electrical utilities
5. Study of various types of bio-gas plants
6. Determination of thermal efficiency of biogas burner
7. Study of diesel generator set
8. Performance evaluation of blower
9. Performance evaluation of air compressors

INSTITUTE OF STUDIES AND RESEARCH IN RENEWABLE ENERGY (ISRRE)
NEW VALLABH VIDYANAGAR

M. Sc. Renewable Energy (UNDER CBCS)

SEMESTER-II

PS02CREN01: Renewable Energy: Conversion, Storage and Environmental aspects

Unit 1 Energy Conversion Technologies and Electrical Power Plants

Introduction, Energy Conversion process an d devices, Summary of energy and Conversion devises, Electrical energy route, Unit of energy and power in electrical form, Electrical energy supply system (power system), Basic objectives of electrical energy supply undertaking, Difficulties in electrical energy route, Electrical load curves and peak load, Energy conversion plant for base load intermediate load peak load and energy displacement, Suitable type of energy conversion plant for various primary energy sources, Coal fired steam thermal power plant, Gas turbine power plant, Combined coal gasification combined cycle power plant (ICGCC), Diesel electric power plant, Plant factors and reserves, Magneto hydro dynamics(MHD), Nuclear fusion energy Conversion, Fuel cells and chemical to electrical energy Conversion, Thermionic Converters, Heat pumps, Energy densities in primary resources, Net energy analysis of electrical route /plant

Unit 2 Energy Storage and Distribution-I

Introduction, Energy storage systems, Mechanical Energy storage, pumped hydroelectric storage, compressed air storage, Energy storage via flywheels Electric storage :The lead acid battery, Chemical storage- Introduction, Energy storage via hydrogen, ammonia, reversible chemical reactions

Unit 3 Energy Storage and Distribution-II

Electromagnetic Electric storage, Thermal Energy storage, Sensible heat storage, latent heat storage, Biological storage, Distribution of energy- Introduction, gas pipelines, electricity transmission, batch transport, Heat, chemical heat pipe

Unit 4 Environmental Aspects of Energy and Pollution Control

Introduction, Terms and definitions, Pollution from use of energy, Combustion products of fossil fuels, Particulate matter, Fabric filter and bag house, Electro-statics precipitator, Carbon dioxide, Greenhouse effect and global warming, Emission of carbon monoxide, Pollution by sulphur dioxide and hydrogen sulphide, Emission of nitrogen oxides, Acid rains ,acid snow ,acidic fog and dry acidic deposits, Acid fog, Dry acidic deposition, FGD and SCR systems for cleaning flue gases

References:

1. Energy Technology-Nonconventional, Renewable & Conventional
   S. Rao and Dr. B. B. Parulekar, Khanna Publishers, ISBN No. 81-7409-040-1
2. Solar Energy Utilization
   G. D. Rai, Khanna Publishers
3. Non-Conventional Energy Sources
   G. D. Rai, Khanna Publishers, ISBN No. 81-7409-073-8
4. Renewable Energy Sources and Emerging Technologies (Second Edition)
   D. P. Kothari, K. C. Singal, Rakesh Ranjan, PHI Learning Private Limited, New Delhi, ISBN No.-978-81-203-4470-9
5. Thermal Energy Storage: Systems and Applications,
   Ibrahim Dincer, Marc A. Rosen
6. Energy Storage
   Huggins, Robert, 1st Edition., XXVIII, ISBN 978-1-4419-1024-0

7. Alternative Energy Resources: The Quest for Sustainable Energy
   Paul Kruger.
8. Nonconventional energy sources
   Domkundwar,Dhanpat rai & Co.
9. Non conventional Energy Sources
   S.Hasan Saeed, Sharma, D K,

PS02CREN02: Ocean Energy and Tidal Energy

Unit 1 Ocean Energy Technologies

Introduction to Energy form oceans, Oceans energy Resources, Off shore and on-shore oceans energy conversion technology, Advantage and limitation of oceans energy conversion technology, The guide lines for oceans energy conversion plant, Ocean energy routes, High voltage direct current power transmission from Off shore oceans energy conversion plant to land based load centers

Unit 2 Ocean Thermal Energy Conversion

Introduction, Principle of OTEC, Ocean surface temperature, Deep water temperature, Efficiencies of OTEC plants and their influence on plants size, Open cycle, Limitation of Open cycle OTEC system, Historical review of Open cycle OTEC plants, India's first oceans thermal energy conversion, Modified Open cycle OTEC plants, Cogeneration of electricity and fresh water from open cycle OTEC, Closed cycle OTEC

Unit 3 Ocean Wave Energy Conversion

Introduction, Ocean waves, Parameters of a progressive wave, Equation of a progressive wave, Energy and power in ocean waves, Summary of Equation Motion of water particles in the waves, Wave data collection, Routes of energy conversion of wave energy, Wave machines, Dolphin-buoy type of ocean wave energy converter, Oscillating float-air pump type wave machine Three- raft energy converter, Nodding duck Oscillating cam wave machine

Unit 4 Tidal Energy Conversion

Introduction tidal Current, High and Low Tides, Tidal Energy conversion, Tidal power, Average theoretical Power per tide (rise and fall), Summary of Expressions Tidal Work or Energy Conversion, Ocean tidal energy conversion schemes, Terms and definitions, Single basin tidal schemes, Double basin scheme and multi basin scheme, Details about plant and equipment, Economic aspects about tidal energy conversion plant, Tidal power plant in the world, Tidal energy resources in India, The rance tidal power plants in france, Kislaya guna plants Russia, Interaction between tidal power plant and electrical grid

Text Book:

1. Energy Technology-Nonconventional, Renewable & Conventional
   S. Rao and Dr. B. B. Parulekar, Khanna Publishers, ISBN No. 81-7409-040-1
2. Solar Energy Utilization
   G. D. Rai, Khanna Publishers, ISBN-81-7409-073-8
3. Non-Conventional Energy Sources
   G. D. Rai, Khanna Publishers, ISBN No. 81-7409-073-8
4. Nonconventional energy sources
   Domkundwar,Dhanpat rai & Co.

References Books:

1. Renewable Energy Sources and Emerging Technologies (Second Edition)
   D. P. Kothari, K. C. Singal, Rakesh Ranjan, PHI Learning Private Limited, New Delhi, ISBN No.-978-81-203-4470-9
2. Alternative Energy Resources: The Quest for Sustainable Energy

Paul Kruger.

3. Non conventional Energy Sources

   S.Hasan Saeed, Sharma, D K,

PS02CREN03: Hydro Energy and Chemical Energy Sources

Unit 1 Hydropower

Introduction, Power Equation, Classification of Small Hydropower (SHP) Stations, Classification of Water Turbines, Impulse Turbines, Specific Speed Range of Application of Various Types of Turbines for a small Hydro Project Civil Works for Small Hydropower Facilities, Major Components of Small Hydropower Projects, Low-Head Small Hydro Projects, Electric Generators Examples of Small Hydro-electric Project Installation with Unique Features Global Scenario of Small Hydro

Unit 2 Fuel Cells

Introduction, Principal of operation of an acidic fuel cell, Technical of parameter of a fuel cell, Fuel processor, Hydrogen for fuel cells from renewable source, Methanol fuel cell, Fuel cell types, -alkaline fuel cells (AFCs), -polymer electrolyte membrane fuel cells (PEMFC), -Phosphoric acid fuel cell (PAFC), -molten carbonate fuel cell (MCFC), - solid oxide fuel cell (SOFC), Advantages of fuel cell power plants, Fuel cell battery –powered bus system, Comparison between acidic and alkaline hydrogen –oxygen fuel cells, State of the art fuel cells, Microbial fuel cell, World's first fuel cell gas turbine, Energy output of a fuel cell, Efficiency and EMF of a fuel cell, Gibbs-Helmholts equation, free energy change in chemical reaction, - Helmholts free energy, -Gibbs free energy, Hydrogen fuel cell analysis with thermodynamic potential, Comparison of electrolysis and fuel cell process, Operating characteristics of fuel cell, Thermal efficiency of fuel cell, Future potential of fuel cell

Unit 3 Hydrogen Energy Systems

Introduction, Hydrogen production, - Introduction, -Electrolysis, -Thermo-chemical method, -Some Thermo-chemical cyclic processes, -Fossil fuel methods, -Solar energy methods, Hydrogen storage, Hydrogen transportation

Utilization of Hydrogen gas, Hydrogen as an alternative fuel for motor vehicles, Safety and management, Hydrogen technology development in India

Unit 4 Hybrid Energy Systems

Introduction, Need for hybrid systems, Types of hybrid systems, -PV hybrid with diesel generator, -Wind-diesel hybrid systems, -Biomass- diesel hybrid systems, -Wind-PV hybrid systems, - Micro hydel-PV hybrid systems, - Biogas-solar thermal hybrid systems, - Solar-cum-biomass dryer hybrid systems, Electric and hybrid electric vehicles, -E-vehicle need, -emission, -limitations, Hydrogen-powered electric vehicle, -clean mobility options

PS02EREN01: Alternate Energy Sources

Unit 1 Magneto Hydro Dynamic (MHD) Power Generation

Introduction, Principle of MHD Power Generation, MHD systems-Introduction - open-cycle systems – closed-cycle systems, MHD design problems and developments, Advantage of MHD systems, Electrical condition-Voltage and power output of MHD generator, Gas conductivity, Materials for MHD generator, Magnetic field, Super-conductivity, International status of MHD power generation and its future prospects

Unit 2 Thermo Electric Power

Introduction, Basic principles of thermoelectric power generation, Thermoelectric power generator, Performance analysis of Thermoelectric power generator, Thermoelectric materials, Selection of materials

Unit 3 Thermionic Generation

Introduction, Thermionic emission and work function, Basic thermionic generator, Analysis of thermionic generator

Unit 4 Thermo Nuclear Fusion Energy

Introduction, The basic :nuclear fusion and reactions, Requirements for nuclear fusion, Plasma confinement, Magnetic confinement fusion, Inertial confinement fusion, Muon catalyzed fusion, Characteristics of D-T reaction Advantages of Nuclear Fusion, Fusion hydrid, Cold fusion

Text Books:

1. Non-Conventional Energy Sources
   G. D. Rai, Khanna Publishers, ISBN No. 81-7409-073-8
2. Energy Technology-Nonconventional, Renewable & Conventional
   S. Rao and Dr. B. B. Parulekar, Khanna Publishers, ISBN No. 81-7409-040-1
3. Solar Energy Utilization
   G. D. Rai, Khanna Publishers, ISBN-81-7409-073-8

References Books:

1. Renewable Energy Sources and Emerging Technologies (Second Edition)
   D. P. Kothari, K. C. Singal, Rakesh Ranjan, PHI Learning Private Limited, New Delhi, ISBN No.-978-81-203-4470-9
2. Thermal Energy Storage: Systems and Applications,
   Ibrahim Dincer, Marc A. Rosen
3. Energy Storage
   Huggins, Robert, 1st Edition. XXVIII, ISBN 978-1-4419-1024-0
4. Alternative Energy Resources: The Quest for Sustainable Energy
   Paul Kruger.
5. Nonconventional energy sources
   Domkundwar,Dhanpat rai & Co.
6. Non conventional Energy Sources
   S.Hasan Saeed, Sharma, D K,

PS02CREN04: Practical

1. Study of Electrical load curves & peak load & plant efficiency
2. Study of Modern Thermal Power Plant
3. To study different energy storage devices
4. To study the thermal performance of parabolic solar cooker
5. To study different OTEC system
6. To study different ocean wave energy conversion system
7. To study different Tidal Energy conversion system
8. To prepare a seminar report on prospectus of above energy conservation system in India

PS02CREN05: Practical

1. Performance evaluation of biomass cook stove
2. Performance evaluation of downdraft biomass gasifier
3. Study of different small Hydro-electric project installation with unique features
4. To study principle & operation of different types of fuel cells
5. To study Hydrogen as an alternative fuel for different application
6. To study different Hybrid System

7. To study different MHD Power generation systems
8. To study Thermo-Electric and Thermionic Power generation
9. To study Nuclear Fusion Energy System
10. To study biomass briquetting technologies

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Note:

1. **Student can choose any one discipline from three specializations i.e. System Technology, Environmental Modeling and Energy Management for 2nd year (3rd and 4th semester)**

M. SC. RENEWABLE ENERGY AND SYSTEM TECHNOLOGY (UNDER CBCS)

SEMESTER-III

PS3CRESYT1**: Energy Audit and Energy Conservation**

Unit 1 Definition, Need for Energy Audit, Types of Energy Audit and Approach, Preliminary Energy Audit, Targeted Energy Audit, Detailed Energy Audit, Ten Step Methodology for Conducting Detailed Energy Audit, Pre Audit Phase, Detailed Energy Audit Phase, Preparing Process Flow Diagram, Identification of ENCON Opportunities, Technical and Economical feasibility, classification of ENCON Measures, Energy Audit report, Post Audit Phase,

Unit 2 Understanding Energy Cost, Fuel Cost, Power Cost, Benchmarking, Industrial Benchmarking Programme, Energy Performance, Plant Energy Performance, Matching Energy usage to requirement, Maximize System Efficiencies, Optimize Input Energy Requirement, Fuel and Energy Substitution,

Unit 3 Instrument and Metering for Energy Audit, Key Performance parameters for Energy Audit, Bureau of Energy Efficiency, Interval of Time for Conduct Energy Audit, Manner of Energy Audit-Verification of data-Scope of Energy Audit-Monitoring and Analysis of the use of energy data for energy audit, Preparation of Energy saving measures and its benefits, Prioritization and preparation of action plan, Structure of the energy Audit Report

Unit 4 Energy Conservation opportunity (ECOs), Energy Conservation Measures (ECMs), Listing of Energy Conservation Measures, Categories, Integrated Energy Conservation Measures, Electrical ECOs, Simple, Intermediate and Comprehensive ECOs, ECO through Renewable Energy, Thermodynamic ECOs-Simple-Intermediate and High Tech, ECOs in Residential Buildings, Shopping Complexes and University campus.

Text Book:

1. http://www.energymanagertraining.com
2. NPC Energy Audit Manual and reports, NCP
3. Energy Management Handbook, John and Sons –Wayne C Turner
4. Energy Technology-Nonconventional, Renewable & Conventional
   S. Rao and Dr. B. B. Parulekar, Khanna Publishers, ISBN No. 81-7409-040-1
5. Guide to Energy Management, Cape Hart, Turner and Kennedy
6. Cleaner production –Energy Efficiency Manual for GERIAP, UNEP, bankok prepared by national Productivity Council
7. www.eeae.gov.nz
8. www.energyyusernews.com

PS3CRESYT2 **Energy Policy and Regulation Act- India**

Unit 1

Central Agency and State Agencies for Energy, Sate Nodal Agencies and their function,
Energy policy in India, Need for renewable energy policy in India

Energy Act,
Energy sector reformation,
Energy conservation code for Building,
Greenhouse Effect
Clean Development mechanism (CDM)

Unit 2

Solar Power policy- Objectives, Tariff for solar PV and Solar thermal, Transmission/wheeling charges, Subsidy charges, CDM benefits,
Wind Power Policy-Operative Period, Eligible Unit:, Eligible Sites:, Wheeling of Electricity:, exemptions, sale of energy, third part sale, land, plant and machinery, metering electricity, reactive power charges

Unit 3

National Policy on biofuel- Vision and goal, definition and scope, strategy and approach, intervention and enabling mechanism, Distribution and marketing biofuel, Quality standard, Import and export of biofuel, Roles of state
Biomass Power Policy-Capital cost, Evacuation Cost, Tenure of Loan, Interest on loan,Return on Equity, Life of plant and machinery and agreement period, Depreciation, Debt-Equity Ratio, Operations and Maintenance expenses, Interest on Working Capital, Plant Load Factor (PLF), Auxiliary Energy Consumption, Station Heat Rate (SHR)

Unit 4

Jawaharlal Nehru National Solar mission- objectives,
Strategic plan for, New and renewable energy sector for the period 2011-17
National National Biomass Cookstoves Programme-National Biomass Cookstoves Initiatives (NBCI)-Technology & Models of Biomass Cookstoves, Biomass Cookstove Test Centers, Modified Standards and Test Protocols, Approved Models of Cook-stoves

Text Book:

1. Shyam Divan & Armin Rosencranz, Environmental Law and Policy in India: Cases, Materials and Statutes, Second edition
2. M.Munasinghe and P. Meier (1993): Energy Policy Analysis and Modeling, Cambridge University Press.
3. W.A.Donnelly (1987): The Econometrics of Energy Demand: A Survey of Application, Newyork.
4. State Government and central Governments and regulations regarding non-conventional sources and utilization implemented by Gujarat Govt. and Govt. of India time to time.
5. National Policy on Biofuels, Government of India Ministry of New & Renewable Energy, Block No. 14, C.G.O. Complex Lodhi Road New Delhi- 110003
6. www.mnre.gov.in
7. Strategic plan for, new and renewable energy sector for the period 2011-17
8. Solar Power Policy-2009, Gujarat Energy Development Agency, GEDA
9. Wind Power Policy – 2013, Gujarat Energy Development Agency, GEDA
10. Biomass Power Policy-2013, Gujarat Energy Development Agency, GEDA
11. www.gedagujarat.gov.in
12. http://www.energymanagertraining.com
13. www.mnre.gov.in/schemes/decentralized-systems/national-biomass-cookstoves-initiative/

PS3CRESYT3 **Solar Thermal Technology**

Unit 1: Solar Thermal Systems

Introduction, Solar Collectors-Flat-Plate Collectors, Flat-Plate Collector -Thermal Testing Collector - Efficiency Curve, Evacuated-Tube Solar Collectors, Solar Concentrating Collectors-Optic, Fundamentals - Parabolic Concentrators, Compound Parabolic Concentrators (CPCs), Fresnel Lens Concentrators, Heliostats, Tracking Systems, Solar Thermal Systems-Passive and Active Solar Thermal Systems.

Unit: 2 Solar Thermal Systems Applications

Solar Thermal Application: Water Heating for-Domestic Use-Solar Thermal Application: Water Heating for Industrial Use, Case of Active Solar Drying: Sludge Drying, Solar Thermal Application: Solar Distillation, Case of Passive Direct and Indirect Solar Distillation: Water Desalination, Case of Passive Solar Indirect Drying: Food Drying Case of an Active Solar Chemical Process: Water Detoxification, Solar cooling-combined solar heating and cooling.

Unit: 3 Solar Power Plants

Solar Thermal Power Plants - Principles, Solar tower power stations, Parabolic trough power plants, Dish/Stirling systems, Solar updraft tower power plant, Solar pond power plants, Solar Chimney Power plant, Some Case Studies.

Unit: 4 Solar Process Economics

Introduction, Costs of Solar Process systems-Investment-Operating costs-Solar savings, Design Variables, Economic Figures of Merit-LC solar energy-LCC-LCS-ALCC-Payback time-ROI, Discounting inflation, Present-Worth factor, Life cycle Saving Method, Evaluation of other Economic Indicators, The P1, P2 Method, Uncertainties in Economic Analyses, Economic Analysis using solar saving fraction.

Text Books:

1. D.Y. Goswami, F.Kreith and J.F. Kreider. (2003) Principles of Solar Engineering, 2nd Edition, Taylor & Francis, p.694.
2. J.Twidell & T. Weir. (2010). Renewable Energy Resources, Second edition, Taylor & Francis, p.601.
3. Duffie and Beckman. ((2013). Solar Engineering of Thermal Process, Fourth edition, Wiley Publications, p.910.
4. G.N.Tiwari. (2013) Solar Energy- Fundamentals, Design, Modelling and Applications, Revised edition 2013, Narosa Publishing house Pvt.Ltd, p.525.\

PS3ERESYT1 **Solar Photovoltaic Technology**

Unit 1 Electricity from the sun

Introduction, why need photovoltaic's, Basics principles, operating principles, Types of solar cells, Features and Limitations of Solar Photovoltaic system

Unit 2 Solar Cell and Applications

Introduction, what are solar cells, How solar cells work- introduction, Electronic structure of semiconductors-the solar cell-power losses solar cells-Temperature and irradiation effects.

Application of solar PV system -Introduction, Rural electrification-domestic supply, Health care system, Lighting, Battery charging. Water pumping- water pumping technology – sizing and cost, Professional applications- telecommunications and remote monitoring. Electric power generation in SPACE- Satellite PV system- PV generator. Grid connected system- PV power station- PV in buildings.

Unit 3 Silicon & Thin-film Solar cell

Introduction, From sand to pure silicon, Growth of silicon crystals, typical solar cell fabrication process, Module fabrication. Energy storage-introduction, Battery operation in PV systems, Lead-acid batteries. Introduction, Amorphous silicon cells, Thin polycrystalline silicon on low-cost substrates, Copper indium telluride's cells, cadmium telluride cells, Integrally interconnected Modules.

Unit 4 Photovoltaic Technology

Introduction, Crystal Structure, Cell Physics, Energy Bands, More about Electrons and Their Energy, Electrons and Holes, Direct and Indirect Band-Gap Materials, Doping, Transport, Generation and

Recombination, The p–n Junction, Solar Cell Equations, Characterization, Efficiency- Temperature-Light, Type and Purity of Material, Parasitic Resistances, Current Research, Concentrating Solar Cells, Tandem Cells, Thin Film Technologies, Quantum Dots, Cell Applications, Utility Power Generation, Space Systems, Solar-Powered Products. Photovoltaic Power Generation**:** Principles, Technical description, Economic and environmental analysis, Some Case Studies.

Text Books:

1. Solar Electricity, Second edition, John Wiley & Sons Ltd, p.280.
   Tomas Markvart (2009)

Reference Book:

1. Non-conventional Energy Resources, S.K. Kataria & Sons, p.314
   S.Hasan Saeed and D.K.Sharma. (2013)
2. Solar Energy Utilization, Fifth Edition, Khanna Publishers, p.644
   G.D.Rai. (2011)

PS3CRESYT4 **Practical**

1. To study the effect of number of glazing on the optical efficiency factor of a flat plate solar collector
2. Determination of time constant of a flat plate solar collector
3. Stagnation temperature measurement of Flat plate solar collector
4. To determine the heat loss factor $F_R U_L$ of FPC by zero testing
5. Determination of optical efficiency of a seasonally adjusted linear solar concentrator
6. Heating and cooling tests on a paraboloid concentrator solar cooker to determine its F'η and F' U_L
7. To determine the top heat loss factor of a box type solar cooker
8. Study of wind induced heat losses from outer cover of a flat plate solar collector
9. To determine the top heat loss factor of a box type solar cooker
10. To measure the reflectance and absorptance of surfaces

PS3CRESYT5 **Practical**

1. To study the voltage and current of the solar cell in series and parallel combination
2. To calculate the efficiency of the solar cell
3. To study the I-V Characteristics of a Si solar cell with varying temperature at constant irradiation
4. Performance study of a solar cell with different irradiation
5. Performance evaluation of Photovoltaic thermal Tile.
6. To study the P_{mx} characterization of solar cell with different insolation.
7. To study of the application of solar cell of providing electrical energy to the domestic appliance such as lamp etc.
8. Energy audit of any one residential building
9. Energy audit of any one institutional or commercial building,

PS3CRESYT6 **Viva**

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M. SC. RENEWABLE ENERGY AND ENVIRONMENTAL MODELING (UNDER CBCS)

SEMESTER III

PS3CREEMO1**: Energy Audit and Energy Conservation**

Unit 1 Definition, Need for Energy Audit, Types of Energy Audit and Approach, Preliminary Energy Audit, Targeted Energy Audit, Detailed Energy Audit, Ten Step Methodology for Conducting Detailed Energy Audit, Pre Audit Phase, Detailed Energy Audit Phase, Preparing Process Flow Diagram, Identification of ENCON Opportunities, Technical and Economical feasibility, classification of ENCON Measures, Energy Audit report, Post Audit Phase,

Unit 2 Understanding Energy Cost, Fuel Cost, Power Cost, Benchmarking, Industrial Benchmarking Programme, Energy Performance, Plant Energy Performance, Matching Energy usage to requirement, Maximize System Efficiencies, Optimize Input Energy Requirement, Fuel and Energy Substitution,

Unit 3 Instrument and Metering for Energy Audit, Key Performance parameters for Energy Audit, Bureau of Energy Efficiency, Interval of Time for Conduct Energy Audit, Manner of Energy Audit-Verification of data-Scope of Energy Audit-Monitoring and Analysis of the use of energy data for energy audit, Preparation of Energy saving measures and its benefits, Prioritization and preparation of action plan, Structure of the energy Audit Report

Unit 4 Energy Conservation opportunity (ECOs), Energy Conservation Measures (ECMs), Listing of Energy Conservation Measures, Categories, Integrated Energy Conservation Measures, Electrical ECOs, Simple, Intermediate and Comprehensive ECOs, ECO through Renewable Energy, Thermodynamic ECOs-Simple-Intermediate and High Tech, ECOs in Residential Buildings, Shopping Complexes and University campus.

References:

1. NPC Energy Audit Manual and reports
2. Energy Management Handbook, John and Sons –Wayne C Turner
3. Guide to Energy Management, Cape Hart, Turner and Kennedy
4. Cleaner production –Energy Efficiency Manual for GERIAP, UNEP, bankok prepared by national Productivity Council
5. www.eeae.gov.nz
6. www.energyyusernews.com
7. http://www.energymanagertraining.com
8. Energy Technology-Nonconventional, Renewable & Conventional
   S. Rao and Dr. B. B. Parulekar, Khanna Publishers, ISBN No. 81-7409-040-1

PS3CREEMO2 **Energy Policy and Regulation Act- India**

Unit 1

Central Agency and State Agencies for Energy, Sate Nodal Agencies and their function,
Energy policy in India, Need for renewable energy policy in India
Energy Act,
Energy sector reformation,

Energy conservation code for Building,
Greenhouse Effect
Clean Development Mechanism (CDM)

Unit 2

Solar Power policy- Objectives, Tariff for solar PV and Solar thermal, Transmission/wheeling charges, Subsidy charges, CDM benefits,

Wind Power Policy-Operative Period, Eligible Unit:, Eligible Sites:, Wheeling of Electricity:, exemptions, sale of energy, third part sale, land, plant and machinery, metering electricity, reactive power charges

Unit 3

National Policy on biofuel- Vision and goal, definition and scope, strategy and approach, intervention and enabling mechanism, Distribution and marketing biofuel, Quality standard, Import and export of biofuel, Roles of state

Biomass Power Policy-Capital cost, Evacuation Cost, Tenure of Loan, Interest on loan,Return on Equity, Life of plant and machinery and agreement period, Depreciation, Debt-Equity Ratio, Operations and Maintenance expenses, Interest on Working Capital, Plant Load Factor (PLF), Auxiliary Energy Consumption, Station Heat Rate (SHR)

Unit 4

Jawaharlal Nehru National Solar mission- objectives,

Strategic plan for, New and renewable energy sector for the period 2011-17

National National Biomass Cookstoves Programme-National Biomass Cookstoves Initiatives (NBCI)-Technology & Models of Biomass Cookstoves, Biomass Cookstove Test Centers, Modified Standards and Test Protocols, Approved Models of Cook-stoves

References

1. Shyam Divan & Armin Rosencranz, Environmental Law and Policy in India: Cases, Materials and Statutes, Second edition
2. M.Munasinghe and P. Meier (1993): Energy Policy Analysis and Modeling, Cambridge University Press.
3. W.A.Donnelly (1987): The Econometrics of Energy Demand: A Survey of Application, Newyork.
4. State Government and central Governments and regulations regarding non-conventional sources and utilization implemented by Gujarat Govt. and Govt. of India time to time.
5. National Policy on Biofuels, Government of India Ministry of New & Renewable Energy, Block No. 14, C.G.O. Complex Lodhi Road New Delhi- 110003
6. www.mnre.gov.in
7. Strategic plan for, new and renewable energy sector for the period 2011-17
8. Solar Power Policy-2009, Gujarat Energy Development Agency, GEDA
9. Wind Power Policy – 2013, Gujarat Energy Development Agency, GEDA
10. Biomass Power Policy-2013, Gujarat Energy Development Agency, GEDA
11. www.gedagujarat.gov.in
12. www.mnre.gov.in/schemes/decentralized-systems/national-biomass-cookstoves-initiative/
13. http://www.energymanagertraining.com

PS3CREEMO3 **Environmental modeling**

Unit 1 Measurement of central tendency - mean (Geometric and Harmonic), median, mode, Measurement of dispersion moments, standard deviation, skewness and kurtosis, Correlation and linear regression of one independent variable, Basic laws and concepts of probability

Unit 2 Role of modelling in environmental sciences, Model classification deterministic models, stochastic models, steady state models, dynamic models, different stages involved in model building. Simple microbial growth kinetics monod equation, methods for formulation of dynamic balance equations mass balance procedures

Unit 3 Introduction to environmental modeling, Pollutant properties, behavior, and reactivity, Interphase transfer, Transport fundamentals, Numerical Methods for solution of ordinary and partial differential equations, Probabilistic Methods for modeling, Model Evaluation, Analysis and Optimization, Atmospheric chemical transport modeling, Atmospheric chemical transport and transformation modeling, Overview of modeling of other media, Exposure and risk assessment modeling

Unit 4 Models of population growth and interactions Lotka Volterra model, Leslies matrix model, Point source stream pollution, Box model, Gaussian plume model, Linear, simple and multiple regression models, validation and forecasting.

Text Books:

1. Integrated Environmental Modeling
   A. Ramaswami et al, John Wiley & Sons, 2005
2. Environmental Modeling,
   J. Schnoor, John Wiley & Sons, New York, 1996
3. Fundamentals of Atmospheric Modeling
   M.Z. Jacobson, Cambridge University Press, 2005
4. Handbook of Environmental Economics in India
   Vikram Dayal & Kanchan Chopra
5. Environmental Economics, In Theory & Practice, Second Edition
   Nick Hanley, Jason Shogren and Ben White ,Palgrave Macmillan
6. Dynamics of Environmental Bioprocesses-Modelling and simulation-
   Snape and Dunn.
7. Environmental Modeling
   Jorgensen

PS3EREEMO1 **Environmental Control**

Unit 1 Elementary Concept of Physical Environment

Definition, Principles and scope of Environmental Science, Earth, Man and Environment, Ecosystem, Pathways in Ecosystems, Physico- chemical and biological factors in the Environment, Geographical classification and zones, Structure and composition of Biosphere, General, relationship between landscapes, biomes and climates, Primary differentiation and formation of core, mantle and crust. Igneous, sedimentary and, metamorphic rocks, weathering, erosion, transportation and deposition of earth's material by running water, wind and glaciers, Mass and energy transfer across the various interphases, Material Balance, Heat Transfer processes, Scales of Meteorology, various kinds of lapse rates, vertical stability of atmosphere, cloud classification & formation.

Unit 2 Air pollution- natural and anthropogenic sources of pollution, primary and secondary pollutants, transport and diffiusion of pollutants, gas laws governing the behavior of pollutants in the atmosphere, Methods of monitoring and control of air pollution, SO2, NOx, CO, SPM, Water pollution - types sources and consequences of water pollution, physico-chemical and bacteriological sampling, Analysis of water quality, standards, sewage and wastewater treatment and recycling, water quality and standards.

Unit 3 Soil pollution chemical and bacteriological sampling as analysis of soil quality, soil pollution control, industrial waste effluents and heavy metals and their intreactions with soil components, Noise pollution -

sources of noise pollution, measurement and indices, Marine pollution, sources of marine pollution and its control, Effects of pollutants on human beings, plants, animals and climate, air quality standards and air pollution.

Unit 4 Environmental Laws

Scheme of labeling of environmentally friendly products (ecomark). Public liability Insurance Act. 1991. Provision of constitution of India regarding environment (article 48 A & 58A). Environmental policy resolution, legislation, public policy strategies in pollution control. Wild life protection act, 1972 amended 2002. Forest conservation act, 1980. Indian forest act 1927. Air (prevention & control of pollution) Act 1981 as amended by amendment 1987 & rule 1982. Motor vehicle act, 1988, The environment (protection) Act, 1986, rules 1986. The water (prevention & control of pollution) Act, 1974 as amended by amendment 1978 & rules 1975. Environment protection issues & problems, international & national efforts for environment protection.

References

1. Ecology
   P.D. Sharma
2. Concepts of physical environment-
   Savinder Singh
3. The Atmosphere- an Introduction-
   F.K. Lutagens
4. Atmospheric weather and climate
   Navarra
5. Introduction to Environmental Modeling,
   Jo Smith & Pete Smith,
6. Basics of Environmental Studies
   R. Rajagopalan, (GTU),
7. Environmental administration & law
   Paras Diwaa.
8. Environmental planning, policies & programs in India
   K.D. Saxena
9. Air pollution and control
   K.V.S.G. Murlikrishan
10. Industrial noise control
    Bell & Bell
11. Environmental engineering
    Peary
12. Introduction to environmental engineering and science
    Gilbert Masters

PS3CREEMO4 **Practical**

1. Experiments related to water Sampling and Data Analysis
2. Study water pollution control methods
3. Experiments related to Air Sampling and Data Analysis
4. Study air pollution control methods
5. Experiments related to soil Sampling and Data Analysis
6. Use of computer for analysis of environmental data
7. Study Principle component analysis of environmental variable.

8. Determination of turbidity of water of different sources
9. Experiments based on the use of Noise Level meter and weather equipments
10. Experiments based on microbiological analysis of waste water

PS3CREEMO5 **Practical**

1. To study instruments and metering for energy audit
2. Methodology for detailed energy audit
3. Study on preparation of Energy Audit report
4. Practical based on environmental modeling
5. Determination of time constants of flat plate collector
6. Stagnation Temperature measurement of flat plate collector
7. To measure the voltage and current of solar cell in series and parallel combination
8. To calculate efficiency of solar cell
9. Energy Audit of residential/institutional building
10. Field work - Fieldwork related to any local ecosystem

PS3CREEMO6 **Viva**

INSTITUTE OF STUDIES AND RESEARCH IN RENEWABLE ENERGY (ISRRE)
NEW VALLABH VIDYANAGAR

M. SC. RENEWABLE ENERGY AND ENERGY MANAGEMENT (UNDER CBCS)

SEMESTER-III

PS3CREEMA1 **Energy Audit and Energy Conservation**

Unit 1 Definition, Need for Energy Audit, Types of Energy Audit and Approach, Preliminary Energy Audit, Targeted Energy Audit, Detailed Energy Audit, Ten Step Methodology for Conducting Detailed Energy Audit, Pre Audit Phase, Detailed Energy Audit Phase, Preparing Process Flow Diagram, Identification of ENCON Opportunities, Technical and Economical feasibility, classification of ENCON Measures, Energy Audit report, Post Audit Phase,

Unit 2 Understanding Energy Cost, Fuel Cost, Power Cost, Benchmarking, Industrial Benchmarking Programme, Energy Performance, Plant Energy Performance, Matching Energy usage to requirement, Maximize System Efficiencies, Optimize Input Energy Requirement, Fuel and Energy Substitution,

Unit 3 Instrument and Metering for Energy Audit, Key Performance parameters for Energy Audit, Bureau of Energy Efficiency, Interval of Time for Conduct Energy Audit, Manner of Energy Audit-Verification of data-Scope of Energy Audit-Monitoring and Analysis of the use of energy data for energy audit, Preparation of Energy saving measures and its benefits, Prioritization and preparation of action plan, Structure of the energy Audit Report

Unit 4 Energy Conservation opportunity (ECOs), Energy Conservation Measures (ECMs), Listing of Energy Conservation Measures, Categories, Integrated Energy Conservation Measures, Electrical ECOs, Simple, Intermediate and Comprehensive ECOs, ECO through Renewable Energy, Thermodynamic ECOs-Simple-Intermediate and High Tech, ECOs in Residential Buildings, Shopping Complexes and University campus.

References:

1. NPC Energy Audit Manual and reports
2. Energy Management Handbook, John and Sons –Wayne C Turner
3. Guide to Energy Management, Cape Hart, Turner and Kennedy
4. Cleaner production –Energy Efficiency Manual for GERIAP, UNEP, bankok prepared by national Productivity Council
5. www.eeae.gov.nz
6. www.energyyusernews.com
7. http://www.energymanagertraining.com
8. Energy Technology-Nonconventional, Renewable & Conventional
   S. Rao and Dr. B. B. Parulekar, Khanna Publishers, ISBN No. 81-7409-040-1

PS3CREEMA2 **Energy Policy and Regulation Act- India**

Unit 1

Central Agency and State Agencies for Energy, Sate Nodal Agencies and their function,
Energy policy in India, Need for renewable energy policy in India
Energy Act,
Energy sector reformation,

Energy conservation code for Building,
Greenhouse Effect
Clean Development mechanism (CDM)

Unit 2

Solar Power policy- Objectives, Tariff for solar PV and Solar thermal, Transmission/wheeling charges, Subsidy charges, CDM benefits,

Wind Power Policy-Operative Period, Eligible Unit:, Eligible Sites:, Wheeling of Electricity:, exemptions, sale of energy, third part sale, land, plant and machinery, metering electricity, reactive power charges

Unit 3

National Policy on biofuel- Vision and goal, definition and scope, strategy and approach, intervention and enabling mechanism, Distribution and marketing biofuel, Quality standard, Import and export of biofuel, Roles of state

Biomass Power Policy-Capital cost, Evacuation Cost, Tenure of Loan, Interest on loan,Return on Equity, Life of plant and machinery and agreement period, Depreciation, Debt-Equity Ratio, Operations and Maintenance expenses, Interest on Working Capital, Plant Load Factor (PLF), Auxiliary Energy Consumption, Station Heat Rate (SHR)

Unit 4

Jawaharlal Nehru National Solar mission- objectives,

Strategic plan for, New and renewable energy sector for the period 2011-17

National National Biomass Cookstoves Programme-National Biomass Cookstoves Initiatives (NBCI)-Technology & Models of Biomass Cookstoves, Biomass Cookstove Test Centers, Modified Standards and Test Protocols, Approved Models of Cook-stoves

References

1. Shyam Divan & Armin Rosencranz, Environmental Law and Policy in India: Cases, Materials and Statutes, Second edition
2. M.Munasinghe and P. Meier (1993): Energy Policy Analysis and Modeling, Cambridge University Press.
3. W.A.Donnelly (1987): The Econometrics of Energy Demand: A Survey of Application, Newyork.
4. State Government and central Governments and regulations regarding non-conventional sources and utilization implemented by Gujarat Govt. and Govt. of India time to time.
5. National Policy on Biofuels, Government of India Ministry of New & Renewable Energy, Block No. 14, C.G.O. Complex Lodhi Road New Delhi- 110003
6. www.mnre.gov.in
7. Strategic plan for, new and renewable energy sector for the period 2011-17
8. Solar Power Policy-2009, Gujarat Energy Development Agency, GEDA
9. Wind Power Policy – 2013, Gujarat Energy Development Agency, GEDA
10. Biomass Power Policy-2013, Gujarat Energy Development Agency, GEDA
11. www.gedagujarat.gov.in
12. www.mnre.gov.in/schemes/decentralized-systems/national-biomass-cookstoves-initiative/

PS3CREEMA3 **Energy Management and Energy Planning**

Unit 1 Definition and Significance, Energy Strategy, Energy Policy and Energy Planning, Two sides of Energy Management, Sector of Supply Side Energy Management, Objectives of Energy Management, Hierarchical level of Supply of Supply Side Energy Management, Energy Strategies and Energy Planning, Energy and Economy, Energy Planning Flow for Supply Side, Essential Data for Supply-side Energy Planning, Infrastructure Planning, Transportation of Energy, Per Capita Energy Consumption

Unit 2 Essential Imperative and Steps in User Side Energy Planning, Energy Management and Control System for Demand Side, Energy Management in End User Plant, Energy Policy of a Supply Organization and Demand Side Organization, Energy Policy of demand Side Organization, organization for Energy Management, Training and Human Resource Development, Motivation

Unit 3 Financial management, Introduction, Investment need, Appraisal and Criteria, Financial Analysis Techniques, Payback Period, Net Present Value, Return on Investment, Rate of Return, Time Value Money, Net Present Value Method, Internal Rate of Return Method (IRR), Advantages and Limitations of IRR , Comparison between Net present Value and Internal rate of Return, Cash Flow-Capital investment-Consideration- Initial Capital Cost-Net Operating Cash Inflow- Economic Life- Salvage Value- Cash Flow Diagram, Sensitivity and Risk Analysis

Unit 4 Project Management, What is Project, Project Development Cycle (PDC)-Project Identification and Screening-Technical Design-Financing-Contracting-Implementation-Performance Monitoring, Project Review, Project Planning Techniques-Work Break Down Structure (WBS)-WBS role in Project Planning, Gantt Chart-Limitaions-Enhancements-Project Networking Techniques-Network Definitions-Critical Path Method, Steps in CPM Project Planning, Update CPM Diagram, Programme Evaluation and Review Techniques (PERT)

References:

1. Energy Technology-Nonconventional, Renewable & Conventional
   S. Rao and Dr. B. B. Parulekar, Khanna Publishers, ISBN No. 81-7409-040-1
2. Financial Management. Tata McGraw hill,
   Prasanna Chandra
3. Manual for the Development of Energy Efficiency Project, International Finance Corporation
4. Principles of project Management, NPC Publication
5. Project Management, Chodhury S., Tata McGraw Hill
6. Project Mangement-Step by Step (Amacom)
   Richman Larry
7. Energy Management,
   WR Murphy, C McKay, Elsevier, ISBN-978-0-408-00508-1
8. Handbook on Energy Audit and Environment Management,
   Y P Abbi, Shashank Jain, TERI, ISBN-978-81-7993-092-2

PS3EREEMA1 **Solar Thermal Technology**

Unit 1 Solar Thermal Systems

Introduction, Solar Collectors-Flat-Plate Collectors-Flat-Plate Collector -Thermal Testing
Collector -Efficiency Curve-Evacuated-Tube Solar Collectors, Concentrating Collectors-Optic Fundamentals for Solar Concentration-Parabolic Concentrators-Compound Parabolic Concentrators (CPCs)-Fresnel Lens Concentrators-Heliostats-Tracking Systems, Solar Thermal Systems-Passive and Active Solar Thermal Systems.

Unit 2 Solar Thermal Systems Applications

Solar Thermal Application: Water Heating for-Domestic Use-Solar Thermal Application: Water Heating for Industrial Use, Case of Active Solar Drying: Sludge Drying, Solar Thermal Application: Solar Distillation, Case of Passive Direct and Indirect Solar Distillation: Water Desalination, Case of Passive Solar Indirect

Drying: Food Drying Case of an Active Solar Chemical Process: Water Detoxification, Solar cooling-combined solar heating and cooling.

Unit 3 Solar Power Plants
Solar Thermal Power Plants - Principles, Solar tower power stations, Parabolic trough power plants, Dish/Stirling systems, Solar updraft tower power plant, Solar pond power plants, Solar Chimney Power plant, Some Case Studies

Unit 4 Solar Process Economics
Introduction, Costs of Solar Process systems-Investment-Operating costs-Solar savings, Design Variables, Economic Figures of Merit-LC solar energy-LCC-LCS-ALCC-Payback time-ROI, Discounting inflation, Present-Worth factor, Life cycle Saving Method, Evaluation of other Economic Indicators, The P1, P2 Method, Uncertainties in Economic Analyses, Economic Analysis using solar saving fraction.

Text Book:

1. Principles of Solar Engineering, 2nd Edition, Taylor & Francis, p.694
   D.Y. Goswami, F.Kreith and J.F. Kreider. (2003).
2. Renewable Energy Resources, Second edition, Taylor & Francis, p.601
   J.Twidell & T. Weir. (2010)
3. Solar Engineering of Thermal Process, Fourth edition, Wiley Publications, p.910
   Duffie and Beckman. ((2013)
4. Solar Energy- Fundamentals, Design, Modelling and Applications, Revised edition 2013, Narosa Publishing house Pvt.Ltd, p.525
   G.N.Tiwari. (2013)

PS3CREEMA4 **Practical**

1. Methodology for detailed energy audit
2. Example on energy auditing
3. Energy audit of any one residential, institutional or commercial building
4. Prepare energy audit report for institutional
5. Prepare energy conservation measures for institutional building
6. Study on simple payback period, return on investments
7. Study on net present value, internal rate of return, sensitive analysis
8. Examples on Energy Managements
9. Preparing energy audit for institutional/ Residential/industrial building
10. Study on chart representation of energy consumption

PS3CREEMA5 **Practical**

1. Study different instrument for energy audit
2. To study measure to maximize system efficiency
3. To study instruments and metering for energy audit
4. Study of Gantt chart and
5. Study of CPM project
6. Determination of time constants of flat plate collector
7. Stagnation Temperature measurement of flat plate collector
8. To measure the voltage and current of solar cell in series and parallel combination
9. To calculate efficiency of solar cell
10. To determine top heat loss factor for solar cooker

PS3CREEMA6 **Viva**

INSTITUTE OF STUDIES AND RESEARCH IN RENEWABLE ENERGY (ISRRE)
NEW VALLABH VIDYANAGAR

M. Sc. Renewable Energy: SYSTEM TECHNOLOGY (UNDER CBCS)
SEMESTER-IV

PS4CRESYT1 **Research Methodology**

Unit 1 General introduction and Research problem Formulation

History of Science & Technology: Importance of research, role of research, aims& objectives, research process, phases of research. Review of Research Literature: Purpose and use of literature review, locating relevant information, use of library & electronic databases, preparation & presentation of literature review, research article reviews, theoretical models and frame work. Identification of gaps in research, formulation of research problem, definition of research objectives.

Unit 2 Research Design

Qualitative Methods: Types of hypothesis and characterization. Quantitative Methods: Statistical methods for testing and evaluation. Characterization of experiments: Accuracy, reliability, reproducibility, sensitivity, Documentation of ongoing research.

Unit 3 Research Publication & Presentation

Thesis, Research paper, Review Article & Technical Reports: Organization of thesis and reports, formatting issues, citation methods, references, effective oral presentation of research. Quality indices of research publication: impact factor, immediacy factor, H- index and other citation indices.

Unit 4 Research Ethics and Morals

Issues related to plagiarism, collaborative models and ethics, acknowledgements. Intellectual Property Rights: copy rights, copy left: patents, Industrial designs, Trademarks.

Reference Books

1. Research Methodology, Methods & Techniques, Viswa Prakashan, 2nd Edition, 2009
   C.R. Kothari
2. Research Methods- A Process of Inquiry, Pearson Publications, 7th Edition, 2009
   Graziano, A.M., Raulin, M.L
3. How to Write a Thesis, R. Tata McGraw Hill, 2nd Edition, 2010
   Murray
4. Writing For Academic Journals, McGraw Hill International, 2009
   Murray, R
5. Writing for Publication, Henson, 2005
   K.T., Allyn &Bacon
6. What is this thing called Science, Queensland University Press, 1999
   Chalmers, A.F
7. Methods &Techniques of Social Research, Himalaya publications, 2009
   Bhandarkar & Wilkinson
8. Doing your Research project, Open University Press, Berkshire, 4thEdition, 2005
   Bell J
9. A Handbook of Academic Writing, Tata McGraw Hill International,
   Murray, R. and Moore, S

PS4CRESYT2 **Modelling of Solar Thermal system**

Unit 1: Solar Collector System Thermal Calculations

Introduction, Component Models, Collector heat exchanger factor, Duct and Pipe loss factors, Control system, Collector arrays: Series Connection, Performance of Partially Shaded collectors, Series arrays with sections having different orientations, Use of Modified Collectors Equations, System Models, Solar fraction and solar saving fraction. Performance and Thermal analysis for Air heater. Solar concentrator, characteristic parameters, Aperture area, Acceptance angle, Geometric concentration ratio, Intercept factor, Optical efficiency, Thermal efficiency, concentration ratio, Thermal analysis of Concentrating collector.

Unit 2: Simulation in Solar Process Design

Introduction, Simulation program, Utility simulations, Information from Simulations, Thermal process simulation program, Simulation and Experiments, Meteorological Data, Limitations of Simulations. Thermal modelling of Open sun drying, Computational procedure for convective heat transfer, Prediction of crop temperature and moisture evaporation, Analysis for steady state condition, Experimental setup for open sun drying, Methodology and input parameters for computation, Equivalent solar air temperature, Thermal Analysis of Cabinet Dryer, Energy balance for indirect solar drying system

Unit 3: Design of Active systems

Introduction to active and passive solar system, Review of Design Methods, The f-chart method, the f-chart for liquid systems, the f-chart for Air system, Service water heating system, the f-chart results, Parallel solar energy- heat pump systems.

Unit4: Design of Active, Passive and Hybrid Heating Systems

Design of active systems by utilizability methods- hourly utilizability, daily utilizability, the φ-Chart, f-chart method. Approaches to Passive Design, Solar – Load ratio method, Solar-Load Ratio method, Unutilizability Design method: direct gain, Unutilizability Design method: Collector-Storage walls. Hybrid systems: Active Collection with Passive storage, other hybrid systems

Text Book:

1. Principles of Solar Engineering, 2nd Edition, Taylor & Francis, p.694. (2003)
   D.Y. Goswami, F.Kreith and J.F. Kreider
2. Renewable Energy Resources, Second edition, Taylor & Francis, p.601.(2010)
   J.Twidell & T. Weir.
3. Solar Engineering of Thermal Process, Fourth edition, Wiley Publications, p.910, (2013)
   Duffie and Beckman.
4. Solar Energy- Fundamentals, Design, Modelling and Applications, Revised edition 2013, Narosa Publishing house Pvt.Ltd, p.525(2013)
   G.N.Tiwari.

PS4ERESYT1: **Solar Heating and Cooling of Building**

Unit 1 Solar Architecture

Thermal comfort, sun motion, Building orientation and design, passive heating and cooling concepts, Thumb rules, heat transfer in buildings; thermal modelling of passive concepts, evaporative cooling, energy efficient window and day lighting, Earth air tunnel and heat exchanger, zero energy building concept and rating systems, Energy conservation building codes, software for building simulation, Automation and energy management of buildings.

Unit 2 Active Building Heating Systems

Introduction, Solar heating system, Heating system parametric study, solar energy- heat pump systems, phase change storage systems, seasonal energy storage system, solar and off-peak electric systems, solar systems overheating, solar heating economics.

Unit 3 Passive and Hybrid heating of building

Introduction, Concepts of Passive heating, Comfort criteria and heating loads, movable insulation and controls, shading: overhangs and Wing walls, Direct-Gain system, Collector storage and Roofs, Sunspaces, Active collection-Passive storage hybrid systems, Other hybrid system, Passive applications, Heat distribution in passive buildings, cost and economics of passive heating.

Unit 4 Solar Refrigeration and Air-conditioning

Potential and scope of solar cooling, Types of solar cooling systems, Solar collectors and storage systems for solar refrigeration and air-conditioning, solar operation of vapour absorption and vapour absorption and vapour compression refrigeration cycles and their thermodynamic assessment, Rankin cycle, sterling cycle based solar cooling systems, solar desiccant cooling system, Open cycle absorption/desorption solar cooling alternatives, advanced solar cooling systems-solar thermoelectric refrigeration and air-conditioning, solar thermo acoustic cooling and hybrid air-conditioning, solar economics of cooling systems.

Text Book:

1. Principles of Solar Engineering, 2nd Edition, Taylor & Francis, p.694, 2003
   D.Y. Goswami, F.Kreith and J.F. Kreider
2. Renewable Energy Resources, Second edition, Taylor & Francis, p.601. (2010),
   J.Twidell & T. Weir
3. Solar Engineering of Thermal Process, Fourth edition, Wiley Publications, p.910. (2013)
   Duffie and Beckman
4. Solar Energy- Fundamentals, Design, Modelling and Applications, Revised edition 2013, Narosa Publishing house Pvt.Ltd, p.525, (2013)
   G.N.Tiwari.

PS4ERESYT2 **: Energy Storage and Distribution**

Unit: 1 Introduction to Energy Storages and Distribution

Introduction and overview of Energy storages, Types of storages -Mechanical, Electrical, Chemical, Electromagnetic, Thermal, Biological. Introduction to distribution system. Comparison of ES Technologies

Unit: 2 Mechanical and Electrical Energy storage

Introduction, Pumped hydroelectric storage, compressed air storage, energy storage via flywheels. Introduction electrical Energy storages- Types of batteries, lead acid battery storages, Merit and demerits of mechanical and electrical energy storages.

Unit: 3 Hydrogen Energy Storages

Introduction to Hydrogen energy systems, Hydrogen storage- Physical and chemical properties- general storage methods, compressed storage- composite cylinders-Glass micro sphere storage-Zeolites, Metal hydride storage, chemical hydride storage and cryogenic storage. Overview of hydrogen utilization.

Unit: 4 Thermal, Biological Energy Storages & Distribution of Energy

Introduction to thermal energy storages- latent heat storages-sensible heat storages. Biological storages.

Distribution of Energy- Introduction, Gas pipelines, Electricity transmission, batch transport, heat, chemical heat pipe.

Reference Book:

1. Principles of Solar Engineering, 2nd Edition, Taylor & Francis, p.694. (2003)
   D.Y. Goswami, F.Kreith and J.F. Kreider
2. Renewable Energy Resources, Second edition, Taylor & Francis, p.601(2010)
   J.Twidell & T. Weir.

3. Solar Engineering of Thermal Process, Fourth edition, Wiley Publications, p.910. (2013)
   Duffie and Beckman
4. Solar Energy- Fundamentals, Design, Modelling and Applications, Revised edition 2013, Narosa Publishing house Pvt.Ltd, p.525, (2013)
   G.N.Tiwari

PS4CRESYT3 **Practical**

1. To measure the remittance of given sample
2. Heat loss test on a built in storage solar water heater
3. Performance monitoring of a simple solar greenhouse
4. Determination of bond conductance of a flat plate solar collector
5. To study the effect of wind on thermal performance of a praboloid concentrator solar cooker
6. To measure the solar reflectance and absorptance of surfaces
7. Performance evaluation of single basin solar still
8. To study the performance of single basin solar still with different input temperature

PS4ERESYT4 **Practical**

1. To study the effect of number of glazing on the optical efficiency factor of a flat plate solar collector
2. Determination of incidence angle modifier constant of a flat plate solar collector
3. Performance study of heat pump system
4. To study a heat pipe heat exchanger and to find its effectiveness
5. To study the time variation of water temperature in a built-in –storage solar water heater
6. Testing of solar cabinet dryer
7. Determination of heat loss factor for linear solar absorber using an indoor test set-up

PS4CRESYT5 : **Project/Dissertation**

PS4CRESYT6 **: Viva**

INSTITUTE OF STUDIES AND RESEARCH IN RENEWABLE ENERGY (ISRRE)
NEW VALLABH VIDYANAGAR

M.Sc. in Renewable Energy and Environmental Modeling

SEMESTER IV

PS4CREEMO1**Research Methodology**

Unit-1 General introduction and Research problem Formulation

History of Science & Technology: Importance of research, role of research, aims& objectives, research process, phases of research. Review of Research Literature: Purpose and use of literature review, locating relevant information, use of library & electronic databases, preparation & presentation of literature review, research article reviews, theoretical models and frame work. Identification of gaps in research, formulation of research problem, definition of research objectives.

Unit 2 Research Design

Qualitative Methods: Types of hypothesis and characterization. Quantitative Methods: Statistical methods for testing and evaluation. Characterization of experiments: Accuracy, reliability, reproducibility, sensitivity, Documentation of ongoing research.

Unit 3Research Publication & Presentation

Thesis, Research paper, Review Article & Technical Reports: Organization of thesis and reports, formatting issues, citation methods, references, effective oral presentation of research. Quality indices of research publication: impact factor, immediacy factor, H- index and other citation indices.

Unit4 Research Ethics and Morals

Issues related to plagiarism, collaborative models and ethics, acknowledgements. Intellectual Property Rights: copy rights, copy left: patents, Industrial designs, Trademarks.

Reference Books

1. Research Methodology, Methods & Techniques, Viswa Prakashan, 2nd Edition, 2009
   C.R. Kothari
2. Research Methods- A Process of Inquiry, Pearson Publications, 7th Edition, 2009
   Graziano, A.M., Raulin, M.L
3. How to Write a Thesis, Tata McGraw Hill, 2nd Edition, 2010
   Murray, R.
4. Writing For Academic Journals, McGraw Hill International, 2009
   Murray, R.
5. Writing for Publication, Henson, 2005.\
   K.T., Allyn &Bacon
6. What is this thing called Science, Queensland University Press, 1999
   Chalmers, A.F
7. Methods &Techniques of Social Research, Himalaya publications, 2009
   Bhandarkar & Wilkinson,
8. Doing your Research project, Open University Press, Berkshire, 4thEdition, 2005
   Bell J
9. A Handbook of Academic Writing, Tata McGraw Hill International,
   Murray, R. and Moore, S

PS4CREEMO2 **Environmental Management and Planning**

Unit 1 Role of NGO's public participation in environmental movements, Concepts of Environmental education and awareness Internationals environmental initiatives – the club of Rome report, Stockholm Declaration, environmental ethics.

Unit 2 Vehicular pollution and urban air quality, Fly ash utilization, Eutrophication and restoration of Indian lakes, Wet land conservation, Water crisis-conservation of water. Narmada dam, Tehri dam, Almetti dam.

Unit 3 Basic concepts of environmental planning, Environmental priorities in India, Land use planning: The land use plan (India). Soil surveys in relation to land use planning, Methods of site selection and evaluation, global imperatives, soil erosion, Formation and reclamation of Usar, alkaline and saline soil, waste lands and their reclamation, Desertification and its control.

Unit 4 Urban planning and rural planning for India. Sustainable development- principles and practices in relation to economics and ecology. Cost-benefit analysis- its relevance. Ramsar convention on wetlands, Vienna convention and Montreal Protocol, Kyoto protocol, Earth Summit, Agenda-21

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References

1. Natural Resource Conservation
   Owen and Chiras.
2. Environmental planning, policies and programs in India
   K.D. Saxena.
3. Conservation Ecology
   G.W.Cox.
4. Global Biodiversity
   W.R. L. IUCN.

PS4EREEMO1 **Statistical and Research Methods: Theory and Practical**

Sampling, Data collection and recording, Central tendency – concept; arithmetic mean, mode, median for ungrouped and, grouped data, Measures of dispersion: absolute and relative measures; range, standard deviation (grouped and ungrouped data), variance, quartile deviation, coefficient of variability.

Skewness, Kurtosis, Probability - normal, poisson and binomial, Statistical Methods: Hypothesis testing, significance and correlation, Correlation, Matrices, simultaneous linear equations; tests of hypothesis and significance.

Linear models and regressions, Pearson and other correlation coefficients, Multiple regressions, Distribution-Normal, t and chi square test, Difference among means: F-test: 1 way ANOVA; F-test: 2 ways ANOVA.

Computer applications in environmental modeling. Computer-based modeling: Linear, regression, validation and forecasting. Computer-based modeling for population and population studies.

References:

1. Biostatistical Analysis. Prentice Hall, N.J, (1998)
   Zar, Jerrold H.
2. Biometry, Freeman Press, N.Y. (1997)
   Sokal, Robert and James Rohlf
3. Statistics for Engineers and Scientists, 5th edn. MacMillan, N.Y. (1993)
   Walpole, R. and R. Myers
4. Environmental Statistics and Data Analysis, CRC Press, (1995)
   Wayne, R. Ott
5. Statistics for environmental science and management, Chapman and Hall / CRC, (2001)

Manly
6. The Statistical Sleuth, Duxbury Press, (1997)
Ramsay and Schafer

PS4EREEMO2 **Modelling of Solar Thermal system**

Unit 1: Solar Collector System Thermal Calculations

Introduction, Component Models, Collector heat exchanger factor, Duct and Pipe loss factors, Control system, Collector arrays: Series Connection, Performance of Partially Shaded collectors, Series arrays with sections having different orientations, Use of Modified Collectors Equations, System Models, Solar fraction and solar saving fraction.

Unit 2: Simulation in Solar Process Design

Introduction, Simulation program, Utility simulations, Information from Simulations, Thermal process simulation program, Simulation and Experiments, Meteorological Data, Limitations of Simulations.

Unit 3: Design of Active systems

Introduction to active and passive solar system, Review of Design Methods, The f-chart method, the f-chart for liquid systems, the f-chart for Air system, Service water heating system, the f-chart results, Parallel solar energy- heat pump systems.

Unit4: Design of Active, Passive and Hybrid Heating Systems

Design of active systems by utilizability methods- hourly utilizability, daily utilizability, the φ-Chart, f-chart method. Approaches to Passive Design, Solar – Load ratio method, Solar-Load Ratio method, Unutilizability Design method: direct gain, Unutilizability Design method: Collector-Storage walls. Hybrid systems: Active Collection with Passive storage, other hybrid systems

Reference Book:

1. Principles of Solar Engineering, 2nd Edition, Taylor & Francis, p.694. (2003)
D.Y. Goswami, F.Kreith and J.F. Kreider
2. Renewable Energy Resources, Second edition, Taylor & Francis, p.601, (2010)
J.Twidell & T. Weir.
3. Solar Engineering of Thermal Process, Fourth edition, Wiley Publications, p.910. (2013)
Duffie and Beckman
4. Solar Energy- Fundamentals, Design, Modelling and Applications, Revised edition 2013, Narosa Publishing house Pvt.Ltd, p.525, (2013)
G.N.Tiwari

PS4CREEMO3 **Practical**

1. Study of basic principles of environmental contaminant fate and transport modeling
2. Analyze the physical, chemical, biological and numerical theory underlying environmental models
3. Develop mass-balance-based mathematical and numerical models of contaminant fate across multiple media
4. Apply an environmental model to evaluate pollutant interactions with the environment and human health
5. Apply tools and data appropriately for model evaluation
6. To study F test
7. To study t test and chi square Test
8. To Study Air pollution control measures
9. To study water pollution control method
10. To study solid water pollution control measures

PS4EREEMO4 **Practical**

1. Prepare report on the analysis, (development), application, testing, and evaluation of an environmental fate and transport model
2. Study examples on skewnesss, kurtosis and probability
3. Study of statistical methods
4. Study computer application for environmental modeling
5. Practical on Research design
6. Practical on Publication and presentation
7. Heat loss test on built in storage water heater
8. Performance of single basin solar still
9. Testing solar cabinet dryer
10. Case study on any one dam

PS04CREN05 Project Work Dissertation Work

PS04CREN06 Viva

INSTITUTE OF STUDIES AND RESEARCH IN RENEWABLE ENERGY (ISRRE)
NEW VALLABH VIDYANAGAR

M. Sc. Renewable Energy: Energy Management (UNDER CBCS)

SEMESTER-IV

PS4CREEMA1 **Research Methodology**

Unit 1 General introduction and Research problem Formulation

History of Science & Technology: Importance of research, role of research, aims& objectives, research process, phases of research. Review of Research Literature: Purpose and use of literature review, locating relevant information, use of library & electronic databases, preparation & presentation of literature review, research article reviews, theoretical models and frame work. Identification of gaps in research, formulation of research problem, definition of research objectives.

Unit 2 Research Design

Qualitative Methods: Types of hypothesis and characterization. Quantitative Methods: Statistical methods for testing and evaluation. Characterization of experiments: Accuracy, reliability, reproducibility, sensitivity, Documentation of ongoing research.

Unit 3Research Publication & Presentation

Thesis, Research paper, Review Article & Technical Reports: Organization of thesis and reports, formatting issues, citation methods, references, effective oral presentation of research. Quality indices of research publication: impact factor, immediacy factor, H- index and other citation indices.

Unit4 Research Ethics and Morals

Issues related to plagiarism, collaborative models and ethics, acknowledgements. Intellectual Property Rights: copy rights, copy left: patents, Industrial designs, Trademarks.

Reference Books

1. Research Methodology, Methods & Techniques,Viswa Prakashan, 2nd Edition, 2009
   C.R. Kothari
2. Research Methods- A Process of Inquiry, Pearson Publications, 7th Edition, 2009,
   Graziano, A.M., Raulin, M.L
3. How to Write a Thesis, Tata McGraw Hill, 2nd Edition, 2010
   Murray, R
4. Writing For Academic Journals, McGraw Hill International, 2009
   Murray, R
5. Writing for Publication, Allyn & Bacon, 2005
   Henson, K.T
6. What is this thing called Science, Queensland University Press, 1999
   Chalmers, A.F
7. Methods &Techniques of Social Research, Himalaya publications, 2009
   Bhandarkar & Wilkinson
8. Doing your Research project, Open University Press, Berkshire, 4thEdition, 2005
   Bell J
9. A Handbook of Academic Writing, Tata McGraw Hill International
   Murray, R. and Moore, S

PS4CREEMA2 **Energy Efficiency and Analysis in Electrical Systems I**

Unit 1 Energy Efficiency in Electrical System

Introduction to electrical power supply-Power Generation Plant-Transmission and Distribution Lines-Cascade efficiency-Industrial End User, Electricity Billing, Electrical Load Management and Maximum Demand Control-Need-Step by Step Approach for Maximum Demand Control, Power Factor Improvement and Benefits, Automatic Power Factor Controller, Selection and Location of Capacitor, Capacitors for other Loads, Transformers-Types-Rating-Efficiency, Distribution losses in Industrial System, Transmission and Distribution (T & D) Losses in Power System, Technical Losses-Estimation-Causes-Measures, Commercial Loses-Measure to reduce

Unit 2 Electrical Efficiency in Electrical Motors

Introduction, Motor Types-Induction motor-Slip Ring Motors-Direct current motors-Synchronous Motor, Motor Characteristics-Speed- Power factor, Motor Efficiency, Test Field for Determining Efficiency, No Load Test, Stator and Rotor I^2R Loses, Stray Load Losses, Pointer for users, Energy Efficient Motors and loses, Technical aspect of Energy Efficient Motors, Factors affecting Energy Efficiency and Minimizing Motor Losses in Operation

Unit 3 Energy Efficiency in Lightning System

Introduction, Basic Parameters and Terms, Light Source and Lamp Types, Recommended Illuminance Levels for Various Tasks/Activities/location, Metod of Calculating Illuminancs-Lightning Design for Interiors-For Indoor and Outdoor, Energy Saving Opportunities, Energy Efficient Lightning Controls, Standard and Labeling Programme for FTL Lightning System,

Unit 4 Energy Efficiency in Fans and Blowers

Introduction, Fan Types, Centrifugal Fans-Types, Common Blower Types, Fan Selection Criteria, Flow Control, Performance Evaluation, Fan Performance Assessment, Air Flow Measurement, Measurements and Calculations, Calculation Gas Density, Fan Efficiency, Energy Savings opportunities

References:

1. Technology Menu on Energy Efficiency, NPC
2. NPC –In House Case Study
3. Electrical Energy Conservation Modules of AIP-NCP, Chennai
4. Technical Paper-18th International Conference on Electricity, Distribution, Turin 6-9 June 2005
5. DSM-www.tatpower.com
6. Energy Audit Report of NPC
7. BEE Publication
8. PCRA Publication
9. Office of Industrial Technologies, Department of Energy, USA
10. Best Practices Lightning Manual, BEE Code,2006
11. Lightning Handbook
12. SADC Industrial Energy management Project
13. **www.bee-india**
14. http://www.energymanagertraining.com

PS4EREEMA1 **Energy Efficiency and Analysis in Electrical Systems II**

Unit 1 Energy Efficiency in Compressed Air System

Introduction, Compressor types, Compressor Performance, Compressed Air System Components, Factors for Efficient Operation of Compressor-Location-Cool Air Intake-Dust Free Air Intake-Dry Air Intake-Elevation-Cooling Water Circuit-Pressure Setting-Capacity Control of Compressors, Avoiding misuse of compressed air and Air Leaks, Wastage, Leak Quantification, Leak Detections by Ultrasonic Leak Detector, Line Moisture

separator and Traps, Compressed Air, Filters, Regulators, Lubricators, Dryer Compressor Capacity Assessment, Check List for Efficiency

Unit 2 Energy Efficiency in HVAC and Refrigeration System

Introduction, Psychrometric and Air Conditioning Process, Psychrometric Chart, Air Conditioning System, Refrigeration Systems, Types of Refrigeration Systems, Common Refrigerant and properties, Selection of suitable Refrigeration System, Performance Assessment, of Refrigeration Plants, Integrated Part Load Value (IPLV), Factors Affecting Performance and Energy Efficiency of Refrigeration Plants, Standard and Labeling of Room Air Conditioners, Energy Saving opportunities

Unit 3 Energy Efficiency in Pump and Pumping System

Pump System, Centrifugal Pump, System characteristics, Pump Curve, Factor Affecting Pump Performance, Efficient Pumping System Operation, Flow Control Strategies, Pumps in Parallel Switched to meet Demand, Stop/Start Control, Flow Control Valve, Bypass Control, Fixed Flow Reduction, Meeting Variable Flow Reduction-Variable Speed Drives (VSD), and Energy Conservation Opportunities

Unit 4 Energy Efficiency in Cooling Tower

Introduction, Cooling Tower Types, Components of Cooling Tower, Tower Materials, Cooling Tower Performance, Factors Affecting Cooling Tower Performance, Efficient System Operation, Performance Assessment of Cooling Towers, Energy Saving opportunities

References:

1. Technology Menu for Energy Efficiency, NCP
2. PCRA Publication
3. www.hydraulicpneumatic.com
4. ASHRAE Handbook
5. British Pump manufacturer Association
6. Energy Audit Report, NPC
7. BEE –EMC Inputs
8. ITT-Goulds Pumps
9. www.pumped101.com
10. Case Studies, NPC
11. http://www.energymanagertraining.com

PS4EREEMA2 **Energy Efficiency and Analysis in Thermal Utilities**

Unit 1 Fuel and Combustion

Introduction to fuel, Combustion-3T of Combustion, Combustion of Oil, Combustion of Coal, Combustion of Coal, Combustion of Gas, Combustion of Biomass, Draft System, Natural draft-mechanical Draft-Balanced Draft, Mechanical Draft, Induced Draft-Forced Draft, Combustion Control

Unit 2 Energy Efficiency in Boiler

Introduction, Specification, Indian Boiler Regulation, Boiler System, Boiler Types and Classification, Performance Evaluation of Boiler, Evaporative Ratio, Efficiency, Direct and indirect Method, Boiler Blow Down, Improving Boiler Availability, Reducing Leakage, Soot Blowing and Soot Deposition Reduction, Preservation of boiler, Cold Startup and Shut Down, Thermic Fluid Heaters, Energy Conservation Opportunities

Unit 3 Energy Efficiency in Furnace

Types and Classification of Different Furnaces, characteristic of Efficient furnace, Typical Furnace System-Forging Furnace-Rerolling Mill Furnace, Heat Transfer in Furnace, Types of Continuous Reheating Furnace-Pusher Type-Walking Hearth-Rotary Hearth-Induction Furnace-Cupola Furnace, Factors Affecting Furnace Efficiency, Hot air Generator, Performance Evaluation of Fuel Fired Furnace, General Fuel Economy Measures in Furnace

Unit 4 Cogeneration and Waste Heat Recovery

Need for Cogeneration, Principles of Cogeneration, Technical Option for Cogeneration, Classification of Cogeneration System, factors Influencing Cogeneration, Important Technical Parameter for Cogeneration, Typical Cogeneration Performance parameter, Advantage and Disadvantage of Various Cogeneration System, Waste Heat recovery, Classification and Application, Benefits of Waste Heat recovery, Commercial Waste Heat Recovery System-Recuperators, Radiation, Regenerators, Heat Wheel, Economizer, Shell and Tube Heat Exchanger, Plate Heat Exchanger, Run Around Coil Exchanger, Waste Heat Boiler, heat pump, Direct Contact Heat Exchanger

References:

1. Combustion Engineering and Fuel Technology, Oxford and IBH Publishing Company, A.K Shaha
2. Biomass as a Fuel in Small Boilers-APO 2009, ISBN-92-833-7078-3
3. Steam Boiler Room Questions and Answers, Third Edition Stephen M. Elonka and Alex Higgs
4. Steam Boiler Operation, Prentice-Hall Inc. , New Jersey, 1980 James J Jackson
5. Boiler, McGraw Hill Book Company, US, 1961 Carl D Shield
6. Industrial Heat Generation and Distribution, NIFES Training Manual Issues for CEC-India Energy Bus Project
7. Practical Boiler Water Treatment, McGraw Hill Inc, New York, 1962 Leo I Pincus
8. Technical Papers, Boiler Congress-2000 Seminar 11-12 January
9. Industrial Boiler, Longman Scientific and Technical, New York David Gunn and Robert Horton
10. Efficient operation of Boiler by National Productivity Council
11. www.eren.doe.gov
12. www.oit.doe.gov/bestpractices
13. www.pcra.org
14. www.energyefficiency.gov.uk
15. www.actionenergy.org.uk
16. www.altenergy.com
17. NPC Study report
18. Cogeneration-Training Material by NIFES, UK
19. Energy Cogeneration Handbook: Criteria for Central Plant Design, industrial Press Inc, NY George Polimeros
20. www.unescap.org/enrd/energy/co-gen
21. www.cogen/org/download/project/EDUCOGEN_Cogen_Guide.pdf
22. www.energysolution.org/distgen/appguid.microturbine
23. Fuel Economy in Furnaces and Waste Heat recovery-PCRA

24. Heat Recovery System, FN Span, London, 1979
    DA Reay
25. www.bhes.com/frbbohome.htm
26. www.portalenergy.com
27. www.seav.vic.gov.au/ftp/advice/business/info_sheet/heatrecoveryinfo_0_a.pdf
28. http://www.energymanagertraining.com

PS4CREEMA3 **Practical**

1. Study on research design methodology
2. Study on publication and presentation
3. To write technical paper on renewable energy for publication
4. Study on electrical motor and example on electrical motor
5. Study on fans and blowers and examples on fans and blower
6. Study on compressed air system and examples on compressed air system
7. Estimation of net refrigeration capacity (HVAC)
8. Study on pumps and examples on pumps
9. Study on cooling tower and examples cooling tower
10. Study on compressor modulation

PS4EREEMA4 **Practical**

1. Study on stochiometry calculations and examples on stochiometry
2. Study and examples on boiler
3. Study on furnace and examples on furnace
4. Study on cogeneration and examples on cogeneration
5. Study on waste heat recovery
6. Study material and energy balance and examples
7. Performance assessment of lightning system
8. To study major areas and equipments in thermal power plant
9. Study of heat exchangers and its types

PS4CREEMA5 Project Work/ Dissertation
PS4CREEMA6 Viva