INSTITUTE OF STUDIES AND RESEARCH IN RENEWABLE ENERGY (ISRRE),
NEW VALLABH VIDYANAGAR
SARDAR PATEL UNIVERSITY, VALLABH VIDYANAGAR, GUJARAT
FACULTY OF SCIENCE
COURSE OF STUDY I and II SEMESTER 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:
1. 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.
2. The record of the test examinations as well as seminars and quizzes will be maintained by the department.
3. 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. 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 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 III semester only if he/she has passed all the courses of I semester. Also candidate will be allowed to go to IV semester if he/she passes all the courses of II semester".

Sardar Patel University,
Vallabh Vidyanagar, Vallabh Vidya Nagar
Syllabus (Effective from the academic year June, 2013)
Institute of Studies and Research in Renewable Energy
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 Total/ Passing	External Total/ Passing	Total Total/ Passing
CORE COURSES								
1	PS01CREN01 Fundamental of Renewable Energy Technology	T	4	4	3	30	70/28	100/40
2	PS01CREN02 Solar Energy	T	4	4	3	30	70/28	100/40
3	PS01CREN03 Geothermal Energy and Biomass Energy	T	4	4	3	30	70/28	100/40
ELECTIVE COURSE								
4	PS01EREN01 Wind Energy	T	4	4	3	30	70/28	100/40
CORE COURSES								
5	PS01CREN04 Practical	P	4	6	3	30	70/28	100/40
6	PS01CREN05 Practical	P	4	6	3	30	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 aspects	T	4	4	3	30	70/28	100/40
2	PS02CREN02 Ocean Energy and Tidal Energy	T	4	4	3	30	70/28	100/40
3	PS02CREN03 Hydro Energy and Chemical Energy Sources	T	4	4	3	30	70/28	100/40
ELECTIVE COURSE								
4	PS02EREN01 Alternate Energy Sources	T	4	4	3	30	70/28	100/40
CORE COURSES								
5	PS02CREN04 Practical	P	4	6	3	30	70/28	100/40
6	PS02CREN05 Practical	P	4	6	3	30	70/28	100/40
7	PS02CREN06 Viva	-	1	-	-	-	50/20	50/20
	TOTAL		**25**					

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)

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.

Text Book:

1. Non-Conventional Energy Sources, Fourth Edition, G.D.Rai, Khanna Publishers,
2. Solar Energy Utilization, Fifth Edition, G.D.Rai. Khanna Publishers,

Reference Book:

1. Energy Technology, Non conventional, Renewable & Conventional, S. Rao and B.B. Parulekar, Third Edition, Khanna Publishers
2. Solar Energy- Fundamentals, Design, Modelling and Applications, G.N.Tiwari, Revised edition,, Narosa Publishing house Pvt.Ltd.

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, Duffie and Beckman, Wiley Publications,
2. Solar Energy- Fundamentals, Design, Modelling and Applications, G.N.Tiwari, Revised edition Narosa Publishing house Pvt.Ltd,

Reference Book:

1. Solar Energy Utilization, Fifth Edition, G.D.Rai. Khanna Publishers

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:

1. Energy Technology-Nonconventional, Renewable & Conventional , S. Rao and Dr. B. B. Parulekar, Khanna Publishers
2. Solar Energy Utilization, G. D. Rai, Khanna Publishers
3. Non-Conventional Energy Sources, G. D. Rai, Khanna Publishers

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
3. Biomass for Renewable Energy, Fuels, and Chemicals, Donald L. Klass, Reed, Elsevier India Private Limited
4. Geothermal Energy: An Alternative Resource for the 21st Century, K. Gupta and Roy Sukanta.
5. Geothermal Energy Systems: Exploration, Development, and Utilization , Ernst Huenges (Editor), Patrick Ledru (Editor).
6. Geothermal Heat Pumps: A Guide for Planning and Installing, Karl Oschner.

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, Hybrid wind energy systems, **Economics of wind Energy**- fundamental of economics, Initial cost of wind energy project-cost of turbine-installation-transportation-grid connection-legal and other cost, Operating cost-running cost-maintenance cost, Comparison with other energy sources, Cost per unit-case study.

Unit 4 Offshore Wind Energy power

Introduction, offshore wind energy technology, future technological development, scenario for the future offshore development of wind power, new offshore concepts, National Offshore Wind Energy Policy of India-development in India, maritime zones-challenges-objectives-geographical coverage-essential components of development offshore wind energy.

References:

1. Energy Technology-Nonconventional, Renewable & Conventional , S. Rao and Dr. B. B. Parulekar, Khanna Publishers
2. Solar Energy Utilization, G. D. Rai, Khanna Publishers
3. Non-Conventional Energy Sources, G. D. Rai, Khanna Publishers

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 of the proximate analysis of the biomass
2. Study of the ultimate analysis of the biomass
3. Measurement of calorific value of biomass sample
4. To Study the fixed dome types bio-gas plants
5. To study the floating dome type biogas plants
6. Determination of thermal efficiency of biogas burner
7. To study the vapor dominated geothermal power plants
8. To study the liquid dominated geothermal power plants
9. To study the biogas duel fuel engine

PS01CREN06: VIVA VOCE

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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
2. Solar Energy Utilization, G. D. Rai, Khanna Publishers
3. Non-Conventional Energy Sources, G. D. Rai, Khanna Publishers
4. Renewable Energy Sources and Emerging Technologies , D. P. Kothari, K. C. Singal, Rakesh Ranjan, PHI Learning Private Limited, New Delhi
5. Thermal Energy Storage: Systems and Applications, Ibrahim Dincer, Marc A. Rosen
6. Energy Storage , Huggins, Robert, 1st Edition., XXVIII
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, S.K. Kataria & Sons.

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
2. Solar Energy Utilization , G. D. Rai, Khanna Publishers
3. Non-Conventional Energy Sources, G. D. Rai, Khanna Publishers
4. Nonconventional energy sources, Domkundwar, Dhanpat rai & Co.

References Books:

1. Renewable Energy Sources and Emerging Technologies , D. P. Kothari, K. C. Singal, Rakesh Ranjan, PHI Learning Private Limited, New Delhi
2. Alternative Energy Resources: The Quest for Sustainable Energy , Paul Kruger.
3. Non conventional Energy Sources , S.Hasan Saeed, Sharma, D K. S.K. Kataria & Sons.

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

Text Book:

1. Non-Conventional Energy Sources, G. D. Rai, Khanna Publishers
2. Nonconventional energy sources, Domkundwar,Dhanpat rai & Co.

References Books:

1. Renewable Energy Sources and Emerging Technologies, D. P. Kothari, K. C. Singal, Rakesh Ranjan, PHI Learning Private Limited, New Delhi
2. Non conventional Energy Sources , S.Hasan Saeed, Sharma, D K, S.K. Kataria & Sons.

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
2. Energy Technology-Nonconventional, Renewable & Conventional, S. Rao and Dr. B. B. Parulekar, Khanna Publishers
3. Solar Energy Utilization, G. D. Rai, Khanna Publishers

References Books:

1. Renewable Energy Sources and Emerging Technologies, D. P. Kothari, K. C. Singal, Rakesh Ranjan, PHI Learning Private Limited, New Delhi
2. Thermal Energy Storage: Systems and Applications, Ibrahim Dincer, Marc A. Rosen
3. Energy Storage , Huggins, Robert, 1st Edition. XXVIII
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. S.K. Kataria & Sons.

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. Study of different small Hydro-electric project installation with unique features
3. To study principle & operation of different types of fuel cells
4. To study Hydrogen as an alternative fuel for different application
5. To study different Hybrid System
6. To study different MHD Power generation systems
7. To study Thermo-Electric and Thermionic Power generation
8. To study Nuclear Fusion Energy System
9. To study biomass briquetting technologies

PS02CREN06: VIVA VOCE