COURSE STRUCTURE

B.Sc., Renewable Energy Management

Semester	Course	Title	No of hours allotted per week		Marks		Credits	
			Theory	Practical	Internal	External	Theory	Practical
I	1	Fundamentals of Energy	4	2	25	75	3	2
II	2	Solar Thermal and Photovoltaic Conversion	4	2	25	75	3	2
III	3	Wind, Hydro ,Ocean and Geothermal Energies	4	2	25	75	3	2
IV	4	Energy storage and conversion systems	4	2	25	75	3	2
II to IV	5	Biomass and Hydrogen Energies	4	2	25	75	3	2

SEMESTER- I

Fundamentals of Energy

OUTCOMES FOR THE COURSE - I

(Five units with each unit having 12 hours of Class Work)

The students will be able to:

A. Remembers and Explains in a systematic way

1. To understand the importance of energy, consumption trend, available options, future planning and increasing role of renewable energy. Review basic concepts of fluid mechanics, thermodynamics, alternating & direct currents and band theory of semiconductors.

B. Understands and uses

2. Ability to understand the applications of Bernoulli's equation, thermodynamic potentials, resonance circuits and Hall Effect.

C. Critically explains, judges and solves

3. Need for use of new and renewable energy sources, viscosity of a fluid, concept of entropy, power in ac circuits and variation of Fermi level in semiconductors.

D. Working in out of prescribed areas under a Co-curricular activity

4. Determination of surface tension and coefficient of viscosity for different liquids

E. Practical skills

5. Familiarization of viscosity, surface tension of fluids, Carnot engine, power factor of circuits and determination of Hall coefficient.

COURSE - I

Fundamentals of Energy

UNIT-I: Introduction to Energy and environmental effects (12Hours)

Energy -forms of energy- conventional energy sources- role of energy in economic development and social transformation - impact of exponential rise in energy usage on global economy- need for use of new and renewable energy sources- environmental degradation due to energy production and utilization.

UNIT-II: Fluid mechanics (12Hours)

Viscosity of a fluid - Coefficient of viscosity determination - stream line turbulent flow - equation of continuity - Bernoulli's equation – venture meter- dynamic lift - Torricelli's theorem- surface tension- molecular forces - determination of surface tension.

UNIT-III: Thermodynamics (12Hours)

Zeroth law of thermodynamics- First law of thermodynamics - Carnot engine and its efficiency - Second law of thermodynamics- Carnot theorem -concept of entropy-thermodynamic potentials internal energy-enthalpy -Helmholtz free energy-Gibbs free energy.

UNIT-IV: Direct and alternating currents (12Hours)

Concept of direct and alternating currents - growth and decay of current in LR and CR circuits-alternating current through pure resister, capacitor and inductor-LCR series and parallel resonant circuits-Quality factor -power factor of ac circuit.

UNIT-V: Band theory of semiconductors (12Hours)

Classification of solids-formation of semiconductors-carrier concentration in N type and P type semiconductors-density of electrons in the conduction band-variation of Fermi level with temperature and donor concentration-Hall effect- experiment, determination of coefficient and applications.

Reference Books

1. Non -Conventional Energy Resources, third edition by B. H. Khan, Mc Graw Hil Education Pvt. Ltd.
2. Unified Physics Volume I, II & III, S.L.Gupta and Sanjeev Gupta, Jai Prakash Nath Publications.
3. Engineering Physics, P.K.Palanisamy, Scitech Publications.

Practical Component: @ 2 hours/week/batch

Maximum marks for Semester Examination: 50 marks

1. Determination of Viscosity of a Liquid - Poiseulle's method
2. Determination of surface tension of a liquid using capillary rise method
3. Verification of growth and decay of LR/CR circuit
4. LCR series/parallel resonance circuit
5. Determination of power factor in an ac circuit
6. Determination of energy gap in a semiconductor material

CO-CURRICULAR ACTIVITIES

A. MEASURABLE

1. Assignments

2. Topics for student seminars

a) Need for use of new and renewable energy sources

b) Applications of Bernoulli's equation

c) Carnot engine and its efficiency

d) Growth and decay of current in LR and CR circuits

e) Hall effect

3. Quiz Programmes

4. Field studies

Conduct energy audit of your institute, suggest the ways how the conventional energy resources utilization can be minimized. Suggest the areas, where the non-conventional energy may be used by submitting the report.

5. Study projects

Visit to the website of Ministry of New and Renewable Energy, Government of India http://mnre.gov.in/ and make a study on Developmental Impact and Sustainable Governance Accepts of Renewable Energy Projects.

B.GENERAL

1. Group Discussions

2. Usage of Flicker Cards

RECOMMENDED CONTINUOUS ASSESSMENT METHODS

Some of the following suggested assessment methodologies could be adopted

1. The oral and written examinations (Scheduled and surprise tests)
2. Closed-book and open-book tests
3. Problem-solving exercises
4. Practical assignments and laboratory reports
5. Observation of practical skills
6. Individual and group project reports
7. Efficient delivery using seminar presentations
8. Viva voce interviews
9. Computerized adaptive testing, literature surveys and evaluations
10. Peers and self-assessment outputs from individual and collaborative work

SEMESTER –II

Solar Thermal and Photovoltaic Conversion

OUTCOMES FOR THE COURSE -II

(Five units with each unit having 12 hours of Class Work)

The students will be able to:

A. Remembers and Explains in a systematic way

1. Understanding of Spectral distribution of solar radiation measurement, solar collectors, fabrication of photovoltaic solar cells, single crystal and multi silicon cells and solar PV modules from solar cells.

B. Understands and uses

2. Ability to understand estimation of radiation, various applications of solar collectors, solar cells, stand alone, grid and hybrid connected PV systems.

C. Critically explains, judges and solves

3. Solar hot water system, solar furnace, solar green house, solar distillation, solar refrigeration and installation of solar PV system.

D. Working in out of prescribed areas under a Co-curricular activity

4. Fabrication of solar collectors, solar PV system for pole mounted street lights and water pumping systems.

E. Practical skills

5. Familiarization of solar radiation measurement, applications of solar collectors and application of solar PV system.

COURSE –II

Solar Thermal and Photovoltaic Conversion

UNIT-I: Solar Radiation (12Hours)

Structure of Sun-Spectral distribution of solar radiation-Solar constant- Concept of declination, hour angle, inclination angle, zenith angle, azimuth angle, tilt angle, angle of incidence-measurement of solar radiation using pyranometer and pyrheliometer- estimation of direct and diffused radiation.

UNIT-II: Flat plate and concentrating collectors (12Hours)

Solar collectors - classification - flat plate collectors- construction, working, energy balance equation, efficiency, factor affecting the performance -advantages, disadvantages and applications. Concentrating collectors classification, design, performance analysis - comparison between flat plate collectors and concentrating collectors - Paraboloidal dish collector.

UNIT-III: Solar thermal applications (12Hours)

Solar hot water system (SHWS) - natural circulation solar water heater- forced circulation solar water heater - space heating active and passive methods - space cooling concepts-working of box type, paraboloidal dish type and advanced solar cookers - solar furnace-solar greenhouse- solar dryer-solar distillation-solar refrigeration.

UNIT-IV: Solar photovoltaic cell fabrication (12 Hours)

Photovoltaic effect- fabrication of solar cell- solar cell characteristics, equivalent circuit, energy loses and efficiency - classification- production of single crystal silicon Czokralski (CZ) and Float Zone (FZ) methods-thin film solar cells- CdTe / CdS solar cell formation- multi junction solar cell - basic concept of dye sensitized solar cell and quantum dot solar cell.

UNIT-V: Solar photovoltaic modules and applications (12 Hours)

Solar PV module from solar cells - series and parallel connection of cells - mismatch in cell /module - use of bypass and blocking diodes - design and structure of PV modules- fabrication of PV module - current, voltage and power characteristics of PV module- stand-alone PV system - grid connected PV system - hybrid PV system -system installation, operation and maintenance of PV system.

Reference Books

1. Solar Energy Utilization, G. D. Rai, Khanna Publishers
2. Non -Conventional Energy Resources, third edition by B. H. Khan, Mc Graw Hil Education Pvt. Ltd.
3. Non -Conventional Energy Sources and Utilization, Er.R.K.Rajput, S.Chand Publishers
4. Solar Photovoltaics - Fundamentals, Technologies and Applications, third edition by Chetan Singh Solanki, PHI Learning Pvt. Ltd.
5. Science and Technology of Photovoltaics, second edition by P. Jayarama Reddy, BS Publications.

Practical Component: @ 2 hours/week/batch

Maximum marks for Semester Examination: 50 marks

1. Measurement of direct solar radiation using pyrheliometer / pyranometer
2. Measurement of efficiency of solar flat plate collector
3. Performance testing of solar cooker unit
4. Study of solar cell characteristics
5. Effect of tilt angle on the efficiency of solar photovoltaic panel.
6. Study on solar photovoltaic panel in series/parallel combination.

CO-CURRICULAR ACTIVITIES

A. MEASURABLE

1. Assignments

2. Topics for student seminars

a) Efficiency of flat plate collectors and concentrating collectors

b) Space heating and cooling concepts

c) Solar green house and solar pond electric power plant

d) Photovoltaic effect and fabrication of solar cell

e) Fabrication of solar PV module from solar cells

f) Concept of standalone grid connected and hybrid PV system

3. Quiz programmes

4. Field studies

Visit to solar power plant/ solar water pump /solar water heaters /solar street lights available in your locality or nearer to your institute. By understanding working principles submit a report.

5. Study projects

Visit to the website of Ministry of New and Renewable Energy, Government of India http://mnre.gov.in/ and make a study on Developmental impact and sustainable governance accepts of Renewable Energy Projects.

B.GENERAL

1. Group Discussions
2. Usage of Flicker Cards

RECOMMENDED CONTINUOUS ASSESSMENT METHODS

Some of the following suggested assessment methodologies could be adopted

1. The oral and written examinations (Scheduled and surprise tests)
2. Closed-book and open-book tests
3. Problem-solving exercises
4. Practical assignments and laboratory reports
5. Observation of practical skills
6. Individual and group project reports
7. Efficient delivery using seminar presentations
8. Viva voce interviews
9. Computerized adaptive testing, literature surveys and evaluations
10. Peers and self-assessment outputs from individual and collaborative work

SEMESTER –III

Wind, Hydro, Ocean and Geothermal Energies

OUTCOMES FOR THE COURSE- III

(Five units with each unit having 12 hours of Class Work)

The students will be able to:

A. Remembers and Explains in a systematic way

1. Understanding of wind resources, principles of wind conversion technologies, ocean energy sources and geothermal resources.

B. Understands and uses

2. Ability to understand production of wind, hydro, ocean and geothermal energies energy, its mechanism of production and its applications.

C. Critically explains, judges and solves

3. Draw assumptions in understanding of grid connected & off grid connected applications of wind energy ,ocean thermal energy conversion and performance analysis of thermo electric power generator.

D. Working in out of prescribed areas under a Co-curricular activity

4. Preparation of model of wind turbine and observation of environmental impacts due to usage of ocean thermal energy and geothermal energy.

E. Practical skills

5. Understanding the design of wind turbine, energy generation. Able to know the power generation from tidal plants and geothermal sources.

COURSE –III

Wind, Hydro, Ocean and Geothermal Energies

UNIT-I: Wind generation and measurement (12 Hours)

Wind generation- meteorology of wind- world distribution of wind- wind speed variation with height-wind speed statistics-wind energy conversion principles-classification and characteristics of WECS-wind measurements: Eolian features- rotational anemometers- other anemometers- wind measurements with balloons.

UNIT-II: Wind Energy Applications (12 Hours)

Wind turbine design considerations- horizontal axis machines, vertical axis machines, advantages and drawbacks- theoretical simulation of wind turbine characteristics-wind pumps- performance analysis- design concept and testing- principle of wind energy generation- economics of wind energy utilization- wind energy in India- environmental impacts of wind farms.

UNIT-III: Small Hydropower Systems (12 Hours)

Overview of micro- mini and small hydro systems- hydrology- elements of pumps and turbine-selection and design criteria of pumps and turbines-site selection -speed and voltage regulation-investment issues load management and tariff collection- potential of small hydro power in India-wind and hydro based stand-alone hybrid power systems.

UNIT-IV: Ocean thermal and Tidal energies (12 Hours)

Ocean thermal energy conversion-working principle-resource and site requirements-electricity generation methods from OTEC -advantages , disadvantages and applications of OTEC- origin and nature of tidal energy- merits and limitations-tidal energy technology-tidal range power-wave energy - basics of wave motion-power in waves.

UNIT-V: Geothermal Energy (12 Hours)

Structure of earth’s interior-geothermal system- geothermal gradients - classification of geothermal resources- energy content and energy extraction analysis of geothermal resources- exploration and development of geothermal resources -advantages , disadvantages and applications of geothermal energy -geothermal energy in India.

Reference Books

1. Non-conventional Energy Sources, G.D.Rai, Khanna Publishers, New Delhi
2. Non -Conventional Energy Resources, third edition by B. H. Khan, Mc Graw Hil Education Pvt. Ltd.
3. Non -Conventional Energy Sources and Utilization, Er.R.K.Rajput, S.Chand Publishers.

Practical Component: @ 2 hours/week/batch

Maximum marks for Semester Examination: 50 marks

1. Estimation of wind speed using anemometer.
2. Study the characteristics of wind.
3. Determination of characteristics of a wind generator
4. Study the effect of number and size of blades of a wind turbine on electric power output.
5. Performance evaluation of vertical and horizontal axes wind turbine rotors.
6. Study the effect of wave amplitude and frequency on the wave energy generated.

CO-CURRICULAR ACTIVITIES

A. MEASURABLE

1. Assignments

2. Topics for student seminars

a) Wind generation and wind energy conversion principles
b) Economics of wind energy utilization
c) Micro- mini and small hydro systems
d) Ocean thermal energy conversion
e) Geothermal resources

3. Quiz programmes

4. Field studies

Visit to wind mills / hydroelectric power plants available in your locality or nearer to your institute and understand working of the plant and note the power generation by these plants, by submitting report.

5. Study projects

Visit to the website of Ministry of New and Renewable Energy, Government of India http://mnre.gov.in/ and make a study on Developmental impact and sustainable governance accepts of Renewable Energy Projects.

B. GENERAL

1. Group Discussions
2. Usage of Flicker Cards

RECOMMENDED CONTINUOUS ASSESSMENT METHODS

Some of the following suggested assessment methodologies could be adopted

1. The oral and written examinations (Scheduled and surprise tests)
2. Closed-book and open-book tests
3. Problem-solving exercises
4. Practical assignments and laboratory reports
5. Observation of practical skills
6. Individual and group project reports
7. Efficient delivery using seminar presentations
8. Viva voce interviews
9. Computerized adaptive testing, literature surveys and evaluations
10. Peers and self-assessment outputs from individual and collaborative work

SEMESTER -IV

OUTCOMES FOR THE COURSE -IV

Energy storage and conversion systems

(Five units with each unit having 12 hours of Class Work)

The students will be able to:

A. Remembers and Explains in a systematic way

1. Familiarity with various energy storage systems, different types of batteries, supercapaciters, direct energy conversion devices and fuel cells .

B. Understands and uses

2. Ability to understand about different types of batteries, supercapaciters and fuel cells.

C. Critically explains, judges and solves

3. Different applications of energy storage systems and importance of Ragone plot.

D. Working in out of prescribed areas under a Co-curricular activity

4. Fabrication of primary batteries with different electrode materials.

E. Practical skills

5. Understanding the operation of different types batteries, super capacitors and fuel cells.

COURSE –IV

Energy storage and conversion systems

Unit-I: Energy Storage (12 Hours)

Need of energy storage - flywheel storage- electrical and magnetic energy storage- capacitors - electromagnets- chemical energy storage- thermo chemical- photochemical- biochemical - electrochemical- fossil fuels and synthetic fuels- hydrogen for energy storage -ragone plot of energy storage devices.

Unit-II: Batteries (12 Hours)

Batteries-classification of batteries-difference between primary and secondary batteries- manganese dioxide batteries -lead acid batteries - nickel cadmium batteries- lithium ion batteries- applications of batteries.

Unit-III: Magnetic and electric energy storage systems (12 Hours)

Superconducting magnet energy storage system(SMES) -concept of supercapacitor- classification of supercapacitors- working of electrochemical double layer capacitors (EDLC) , Pseudo capacitors and hybrid suercapaciters - difference between capacitor, supercapacitor and battery - advantages, disadvantages and applications of supercapacitors.

Unit-IV: Direct energy conversion (12 Hours)

Direct energy conversion devices-thermoelectric effects-thermoelectric power generator, construction, working, expression for efficiency, advantages and disadvantages -thermionic generator construction, working, expression for efficiency, advantages and disadvantages-magneto hydro dynamic(MHD) generation-MHD generator , power output of MHD generator-advantages and disadvantages MHD system.

Unit-V: Fuel Cells (12 Hours)

Concept of fuel cell - classification of fuel cells- working of alkaline fuel cell, phosphoric acid fuel cell, polymer electrolyte membrane fuel cell ,molten carbonate fuel cell and solid oxide fuel cell - characteristics and efficiency of fuel cell- advantages ,disadvantages and applications of fuel cells.

Reference Books

1. Fundamentals of Energy Storage, J. Jensen , B. Squrensen, John Wiley, NY
2. Electrochemical Power Sources: Primary and Secondary Batteries , P. Peregrines, IEE
3. Supercapacitors: Materials, Systems, and Applications ,Kindle Edition, Francois Beguin , Elzbieta Frackowiak ,Wiley-VCH
4. Non -Conventional Energy Sources and Utilization, Er.R.K.Rajput, S.Chand Publishers
5. Non -Conventional Energy Resources, third edition B. H. Khan, Mc Graw Hil Education Pvt. Ltd

Practical Component: @ 2 hours/week/batch

Maximum marks for Semester Examination: 50 marks

1. Study of charge and discharge characteristics of storage battery.
2. Study of charging and discharging behavior of a capacitor.
3. Study of charging characteristics of a Ni-Cd battery using solar photovoltaic panel.
4. Performance estimation of a fuel cell.
5. Study of effect of temperature on the performance of fuel cell
6. Study of voltage - current characteristics of Fuel Cell

CO-CURRICULAR ACTIVITIES

A.MEASURABLE

1. **Assignments**
2. **Topics for student seminars**

a) Need for energy storage , different types of energy storage systems
b) Different types of batteries and their applications
c) Working of supercapacitors
d) Direct energy conversion devices
e) Working of different types of fuel cells

3. **Quiz programmes**

4. **Field studies**

Visit to battery plants/ fuel cell plants available in your locality or nearer to your institute and understand working principles and submitting report.

5. **Study projects**

Visit to the website of Ministry of New and Renewable Energy, Government of India http://mnre.gov.in/ and make a study on Developmental impact and sustainable governance accepts of Renewable Energy Projects

B. GENERAL

1. Group Discussions
2. Usage of Flicker Cards

RECOMMENDED CONTINUOUS ASSESSMENT METHODS

Some of the following suggested assessment methodologies could be adopted

1. The oral and written examinations (Scheduled and surprise tests)
2. Closed-book and open-book tests
3. Problem-solving exercises
4. Practical assignments and laboratory reports
5. Observation of practical skills
6. Individual and group project reports
7. Efficient delivery using seminar presentations
8. Viva voce interviews
9. Computerized adaptive testing, literature surveys and evaluations
10. Peers and self-assessment outputs from individual and collaborative work

SEMESTER- II to IV

OUTCOMES FOR THE COURSE -V

Biomass and Hydrogen Energies

(Five units with each unit having 12 hours of Class Work)

The students will be able to:

A. Remembers and Explains in a systematic way

1. Familiarity with the main sources of biomass and hydrogen energy and productivity in a quantitative manner in order to assess the effectiveness of agricultural and other biomass production systems.

B. Understands and uses

2. Have a broad knowledge of the main sources of biomass, the origins of these sources and the means by which they can be exploited for energy generation.

C. Critically explains, judges and solves

3. Able to concise and regulate the analysis of benefits and problems relating to the use of different forms of biomass and hydrogen energies.

D. Working in out of prescribed areas under a Co-curricular activity

4. Production of biogas and bio fuels

E. Practical skills

5. Have a detailed quantitative understanding of production of biogas, bio fuels and hydrogen energy.

SEMESTER- II to IV

COURSE –V

Biomass and Hydrogen Energies

UNIT-I: Biomass Resources (12 Hours)

Introduction to biomass - sources of biomass - photosynthesis process -biomass conversion technologies- physical method, incineration, thermo chemical and biochemical conversion- properties of biomass-applications of biomass.

UNIT-II: Production of Biogas (12 Hours)

Introduction to biogas- biogas plants - main components in biogas plant-classification of biogas plants - floating drum type , Janatha model and Deenabandhu biogas plants - factors affecting generation of biogas - properties and applications of biogas-problems related to biogas plants-commissioning and management of biogas plant.

UNIT-III: Gasification and Waste to Energy (12 Hours)

Gasifiers- classification of gasifiers -fixed bed gasifiers-fluidised bed gasifiers -waste to energy incineration process- energy from urban waste- power generation from landfill gas - power generation from liquid waste.

UNIT-IV: Bio Fuels (12 Hours)

Bio fuels -types of bio fuels - production of ethanol, biodiesel and producer gas - properties and applications of bio fuels -production and importance of E85 fuel - bio fuels in Indian scenario.

Unit-V: Hydrogen Energy (12 Hours)

Importance of hydrogen energy - properties of hydrogen-advantages and disadvantages of hydrogen as fuel- production of hydrogen - electrolysis of water- hydrogen storage options-compressed and liquefied gas tanks -problems in hydrogen transport and distribution - applications of hydrogen energy.

Reference Books

1. Bio Energy Technology Thermodynamics and costs, David Boyles, Ellis Hoknood, Chichester, 1984.
2. Non-Conventional Energy Sources, G.D.Rai, Khanna Publications.
3. Non-Conventional Energy Resources, B.H. Khan, Tata Mc Graw Hill Publications.
4. Biogas Technology –a Practical Handbook, K.C. Khandelwal, S.S. Mahdi, Tata Mc Graw Hill Publications.

Practical Component: @ 2 hours/week

Topics for study project

1. Production of Biogas using different methods
2. Production of energy from solid and liquid waste
3. Production and applications of E85 FUEL
4. Production Biodiesel from Non-Edible Oil Seeds

One topic should be chosen by the student for the submission of study project

Evaluation process for project work

Dissertation preparation	:	30 Marks
Student presentation	:	10 Marks
Viva- voce	:	10 Marks

CO-CURRICULAR ACTIVITIES

A. MEASURABLE

1. Assignments

2. Topics for student seminars

a. Sources for Biomass, properties, conversion technologies and applications
b. Production of biogas
c. Conversion of energy from solid and liquid waste
d. Production of bio fuels
e. Advantages and disadvantages of hydrogen as fuel

3. Quiz programmes

4. Field studies

Visit to biogas plant/ bio fuel plant /conversion of waste to energy plant available in your locality or nearer to your institute and understand working of the plant and note the power generation by these plants ,by submitting report .

5. Study projects

Visit to the website of Ministry of New and Renewable Energy, Government of India http://mnre.gov.in/ and make a study on Developmental impact and sustainable governance accepts of Renewable Energy Projects.

B. GENERAL

1. Group Discussions
2. Usage of Flicker Cards

RECOMMENDED CONTINUOUS ASSESSMENT METHODS

Some of the following suggested assessment methodologies could be adopted

1. The oral and written examinations (Scheduled and surprise tests)
2. Closed-book and open-book tests
3. Problem-solving exercises
4. Practical assignments and laboratory reports
5. Observation of practical skills
6. Individual and group project reports
7. Efficient delivery using seminar presentations
8. Viva voce interviews
9. Computerized adaptive testing, literature surveys and evaluations
10. Peers and self-assessment outputs from individual and collaborative work

B.Sc., Renewable Energy Management

Model question paper for all papers

Semesters - I to IV

Time: 3 Hours **Max. Marks: 75**

SECTION –A

Answer any five of the following questions (5 X 5 = 25Marks**)**

1.
2.
3.
4.
5.
6.
7.
8.
9.
10.

SECTION – B

Answer any FIVE of the following questions (5 X 10 = 50 Marks)

11.
12.
13.
14.
15.
16.
17.
18.
19.
20.

Instruction to Paper Setter

Two questions must be given from each Unit in Section-A and Section-B