RENEWABLE ENERGY

Programme Structure

Course Code	Course Title	Lectures (L) Hours per week	Tutorial (T) Hours per week	Practical (P) Hours per week	Total Credits
SAE2151	Renewable Energy Conversion Systems	3	-	-	3
SAE2251	Introduction to Solar Thermal Engineering	2	-	2	3
SAE2351	Introduction to Solar Photovoltaic	2	-	2	3
SAE2451	Energy from Wastes	3	-	-	3
SAE2551	Renewable Energy for Heat Applications	3	-	-	3
SAE2651	Energy Audit and Energy Management	3	-	-	3
	TOTAL				**18**

RENEWABLE ENERGY

Syllabus

RENEWABLE ENERGY CONVERSION SYSTEMS

Course Code: SAE2151 **Credit Units: 03**

Course Objective:
Course provides introduction to different renewable energy sources.
Analyze the full range of renewable energy supplies needed for modern economies. Course will include power from sunshine, wind, and biomass.

Course Content

Module I
Current Energy Scenario, Principles of renewable energy, fundamentals, scientific principles of renewable energy, technical implications, social implications.

Module II
Solar radiation: Extraterrestrial solar radiation, components of radiation, geometry of earth and sun, geometry of collector and solar beam, measurements of solar radiation
Solar water heating system, solar air heaters, solar concentrators

Module III
Photovoltaic generation: Introduction, silicon p-n junction, photon absorption, solar radiation input, photovoltaic circuit properties and loads, limits to cell efficiency

Module IV
Principles of Ocean thermal energy conversion, Principles of Geothermal energy conversion, suitable sites and criteria, Advantages and disadvantages

Examination Scheme:

Components	CT	Assignment	V/Q	Attendance	EE(1)
Weightage (%)	15	5	5	5	70

Text & References:

- Renewable energy resources – J. W. Twidell
- Renewable energy engineering and technology-edited by V. V.N. Kishore
- Directory, Indian Windpower 2004, CECL, Bhopal.

INTRODUCTION TO SOLAR THERMAL ENGINEERING

Course Code: SAE2251 **Credit Units: 03**

Course Objective:
To cover areas related with the fundamentals of solar energy, various solar collectors, and Applications.

Course Contents:

Module I: Introduction
Solar spectrum, solar radiation, instruments (pyrheliometers, pyranometers), solar radiation on horizontal surface (estimation of average solar radiation, estimation of clear sky radiation), solar thermal energy conversion.

Module II: Flat plate collector
Flat plate collector (FPC) (glazing material, collector plates), classification (evacuated tubular collectors, Types of FPCs), testing of collectors,

Module III: Solar Concentrator
Characteristic parameters, classification, types of concentrators (tracking concentrator, non-tracking concentrators), geometrical optics in concentrators, working principle of concentrating collectors.

Module IV: Applications
Solar air heater, solar crop drying, solar cooker, solar water heating systems, heating of swimming pool by solar energy.

Solar Thermal Lab Experiments

1. Study a flat plate collector to know its components & function.
2. Determine the thermal efficiency of a with flat plate collector
3. Determine the thermal efficiency of an evacuated tube collector
4. Study the components of Concentrating Parabolic Collector and its function.
5. Determine thermal performance of a box type solar cooker with load

Examination Scheme:

	IA				EE	
Components	**CT**	**Assignment**	**LR**	**Attendance**	**Theory**	**Practical**
Weightage (%)	10	5	10	5	40	30

Note: IA –Internal Assessment, EE- External Exam, CT- Class Test, LR – Lab Record.

Text & References:

- Solar Energy: Fundamentals, design, modeling and applications, Authored by G. N. Tiwari
- Renewable Energy Engineering and Technology, Edited by V.V. N. Kishore

INTRODUCTION TO SOLAR PHOTOVOLTAIC

Course Code: SAE2351 **Credit Units: 03**

Course Objective:
This course covers the basic principles of Solar Photovoltaic energy systems, Grid and Off-grid connected PV systems and PV economics

Course Contents:

Module I: Basics of Solar Photovoltaics
Principle of photovoltaic conversion Photovoltaic generation: Introduction, silicon p-n junction, photon absorption, solar radiation input, photovoltaic circuit properties and loads

Module II: Review of Semiconductor Properties of Solar PV systems
Crystal structures and orientations, forbidden energy gaps, dynamics of electrons and holes, carrier density, carrier transport, generation and recombination of carriers due to light, direct and in-direct band gap semiconductors, basic device physics, p-n junction diode, solar cell output parameters.

Module III: Solar Photovoltaic energy conversion and utilization
Photovoltaic power generation systems,Off-grid systems,Grid connected systems, Organic solar cells, Electrochemical energy storage: Batteries

Module IV: Economic Benefits of Solar PV systems
Solar energy benefits, environmental benefits, solar energy cost and economic impact, understanding the cost of solar energy, economics of installing solar panel

Solar Photovoltaic Lab Experiments

1. Measure the V-I characteristics of a Photovoltaic cell
2. To study the illumination characteristics, power load characteristics, areal characteristics of a solar cell.
3. Measure the V-I characteristics of a Photovoltaic Panel subjected to variable load
4. To study the effect of angle of the panel on V-I characteristic of a Photovoltaic Panel
5. Measure the V-I characteristics of a Photovoltaic Panels connected in series and parallel without load.
6. Measure the V-I characteristics of a Photovoltaic Panels connected in series and parallel with load.

Examination Scheme:

	IA				EE	
Components	**CT**	**Assignment**	**LR**	**Attendance**	**Theory**	**Practical**
Weightage (%)	10	5	10	5	40	30

Note: IA –Internal Assessment, EE- External Exam, CT- Class Test, LR – Lab Rec

Text & References:

- G.N.TiwariSolar Energy, Fundamentals design, modeling and Applications. Narosa, 2002
- Martin A. Green, Solar Cells-Operating Principles, Technology, and System Applications M.
- S. Tyagi, Introduction to Semiconductor Materials and Devices

ENERGY FROM WASTES

Course Code: SAE2451 **Credit Units: 03**

Course Objective: The objectives of this course are as follows:

a) To provide a thorough understanding of various renewable feedstocks, their availability and attributes for biofuels production.

b) To provide a thorough understanding of the broad concept of second and third generation biofuel production from biomass and other low-cost agri-residues and biowastes.

c) To provide students with tools and knowledge necessary for biofuel facility operations.

d) To teach our students to analyze and design processes for biofuel production.

Course Content

Module-I: Biomass

Properties of biomass, sources of biomass, photosynthesis, broad classification, agro and forestry residues utilization through conversion routes:biological, chemical and thermochemical

Module-II: Bio conversion mechanism

Bioconversion mechanism, source of waste undergoing bio-treatment,energetic and rate processes of major biological significance

Module-III: Thermochemical Conversion

Thermochemical conversion of biomass, energy balance, conversion to solid, liquid and gaseous fuels

Module-IV: Chemical Conversion

Chemical conversion process, hydrolysis, pretreatments and hydrogenation, solvent, extraction of hydrocarbons

Examination Scheme:

Components	CT	HA	S/V/Q	Attendance	EE
Weightage%	10	8	7	5	70

CT – Class Test, S/V/Q – Seminar/Viva/Quiz, HA – Home Assignment, EE – End Semester Examination

Text & References:

- Biomass for renewable energy, fuels and chemicals by Donald L. Klass
- Biorenewable Resources: Engineering New Products from Agriculture. Robert C. Brown. Wiley-Blackwell Publishing (2003).
- Renewable Energy Resources: Basic principles & applications. G.N.Tiwari and M.K.Ghosal

RENEWABLE ENERGY FOR HEAT APPLICATIONS

Course Code: SAE2551 **Credits Units: 03**

Course Objective:
At the end of the course the students should be able to: Understand the factors that influence the use of solar radiation as an energy source; know the various active and passive technologies that are available for collecting solar energy; have the ability to apply design principles to selection of an appropriate solar energy installation to meet requirements.

Course Contents:

Module I: Passive Solar Heating Systems
Choosing the Type of Passive System, Advantages and Disadvantages of Passive Solar Systems, Direct Gain Systems, Thermal storage, Sizing Thermal Storage.

Module II: Active Solar Heating Systems
Space Heating- Liquid and Air Systems, System Design Principles, Sizing of Collectors and Thermal Storage. Domestic Hot Water Heating- Thermo-siphoned and Pumped Circulation Systems, Domestic Hot Water Heating Loads,

Module III: Green Buildings
Introduction, factors affecting climate, Climatic zones and their characteristics, Implications of climate on building design, Principles of energy conscious buildings, Building Envelope, Passive Heating, Passive Cooling, Daylighting, Building Materials

Examination Scheme:

Components	CT(2)	Assignment	V(1)	Attendance	EE(1)
Weightage (%)	15	5	5	5	70

Text & References:

- Principle of Solar Engineering" by D. Yogi Goswami, Frank Kreith and Jan F. Kreider, 2nd ed. Taylor & Francis, 2000, ISBN-10: 1-56032-714-6, ISBN -13:978-156032-714-1.
- Fundamentals of Heat and Mass Transfer" by Frank P. Incropera and David P. DeWitt, John Wiley & Sons, Inc., 6th Ed., 2006
- Solar Heating and Cooling" by John F. Kreider and Frank Kreith, 2nd ed., Hemisphere Publishing Corp, 1982
- The Passive Solar Energy Book" by Edward Mazria, Rodale Press, 1979
- Solar Radiation Data Manual for Flat-Plate and Concentrating Collectors" National Renewable Energy Laboratory, 1994,
- Modeling Daylight Availability and Irradiance Components from Direct and Global Irradiance" by R. Perez, P. Ineichen, R. Seals, J. Michalsky and R. Stewart, Solar Energy 44 (5) pp. 271-289
- 2009 ASHRAE Handbook – Fundamentals (Inch-Pound Edition), American Society of Heating, Refrigerating and Air-Conditioning Engineers, Inc. (Stevens E-book on line)

ENERGY AUDIT AND ENERGY MANAGEMENT

Course Code: SAE2651 **Credit Units: 03**

Course Objective:
This course covers the basic principles of energy management, energy auditing ,economics of Renewable energy systems.

Course Contents:

Module I: Renewable Energy Economics
Energy scenario, environmental policies, energy policies, economics of energy infrastructure, rural renewable energy economics.

Module II: Energy Audit
Energy Audit concepts, Elements, Measurements, Mass and energy balances, Evaluation of energy conserving opportunities, case study.

Module III: Economic Benefits of Solar Energy
Solar energy benefits, environmental benefits, solar energy cost and economic impact, understanding the cost of solar energy, economics of installing solar panel

Module IV: Solar Industrial Economics
Solar power plants, integration with industrial process, integration with grid, storage of energy, economics.

ExaminationScheme:

Components	CT(2)	Assignment	V(1)	Attendance	EE(1)
Weightage (%)	15	5	5	5	70

Text & References:

1. Renewable Energy: Power For A Sustainale Future, Second Ed. Edited By Godfrey Boyle

2. Solar Engineering Of Thermal Processes - J. A. Duffie, W. A. Beckman, Solar Energy Laboratory Lecture Notes