S.No.	Topic	No. of Lectures
5.	Gray surface, sky radiation, radiation heat transfer coefficient	2
6.	Reflectivity, Transitivity, Transmittance Absorption	2
7.	Selective surfaces and materials as solar energy collectors	2
8.	Heat capacity effect, time constant measurement of solar energy	2
9.	Design and efficiency calculations of Solar thermal energy collectors	4
10.	F chart method utility for Designing Solar Thermal Water Heating Systems	2
11.	Techno-economic feasibility of solar thermal energy in cooking, drying of food products, space heating and cooling.	4
12.	Economic feasibility of solar thermal energy in refrigeration, architecture, absorption cooling, thermal power generation.	4
	Total	**30**

IX. List of Practicals

S.No.	Topic	No. of Practicals
1.	Measurement of Solar radiation	1
2.	Estimation of solar energy by model applications	2
3.	Design of solar energy collectors	2
4.	Study of materials used in solar system	1
5.	Energy balance in solar energy collectors	2
6.	Efficiency calculation of collectors	2
	Total	**10**

X. Suggested Reading

- Bansal NK, Kleeman MK and Meliss M. 1990. *Renewable Energy Sources and Conversion Technologies*.Tata McGraw-Hill Pub. Co. Ltd, Delhi.
- Duffie JA and Beckman WA. 2006. *Solar Thermal Engineering Process*. John Wiley & Sons, New Jersey.
- Hsien JS. 2014. *Solar Energy*. Prentice Hall Inc., New Jersey.
- Garg HP. 1990. *Advances in Solar Energy Technology*. Springer Publishing Company, Dordrecht, Netherland.
- Kalogirou SA. 2013. *Solar Energy Engineering*. Academic Press, Cambridge, Massachusetts.
- Kishore VVN. 2008. *Renewable Energy Engineering and Technology–A Knowledge Compendium*. TERI Press, New Delhi, India.
- Pai BR and Ramaprasad MS. 1991. *Power Generation through Renewable Sources of Energy*. Tata McGraw-Hill Pub. Co., New Delhi.
- Sukhatme SP and Nayak J. 2008. S*olar Energy: Principles of Thermal Collection and Storage*. Tata McGraw-Hill Publishing Company Limited, New Delhi, India.

I. Course Title : Biomass Energy Conversion Technologies

II. Course Code : REE 503

III. Credit Hours : 2+1

IV. Aim of the course

To understand the bio-conversion technologies and fuels system, types of biomass derived fuels and energy, thermo-chemical conversion of biomass to heat and power, value adding of agro-residues.

V. Theory

Unit I

Biomass characterization: Types and resources, sustainability issues, assessment tools and methodologies, biomass fuel characterization, Biomass supply chain concept. Direct use of biomass: Size reduction, baling, pelletization, briquetting technologies.

Unit II

Biochemical conversion of biomass: Feedstock, process design, operation, optimized process parameters and utilization for biogas and bioethanol production.

Unit III

Biomass combustion: Stoichiometric air requirement, chemistry of combustion, design of combustion system, combustion zones, flame structure, stability, emissions. Co-firing of biomass.

Unit IV

Thermo-chemical conversion of biomass: Feedstock, chemistry, reactor design, operation, optimized process parameters and utilization for gasification, carbonization, torrefaction and pyrolysis.

Unit V

Cogeneration technologies: Cycles, topping, bottoming, selection, problems, applications. Waste heat recovery: Estimation, systems, design and application.

VI. Practical

Biomass characterization.Design of bioreactors.Study of techno-economical feasibility of bio-chemical conversion process.Performance evaluation of combustion gadgets, gasifiers and pyrolytic converters.Design of waste heat recovery system.

VII. Learning outcome

The students is enable to extract the energy from biomass and acquainted the skill to know how to choose the suitable biomass fuels for different industrial applications with design and economics of the system.

VIII. Lecture Schedule

S.No.	Topic	No. of Lectures
1.	Biomass characterization: Types and resources, sustainability issues, assessment tools and methodologies, biomass fuel characterization, Biomass supply chain concept.	3
2.	Direct use of biomass	1
3.	Size reduction, baling, pelletization, briquetting technologies.	2
4.	Biochemical conversion of biomass	1
5.	Feedstock, process design, operation, optimized process parameters.	2
6.	Utilization for biogas and bioethanol production.	1
7.	Biomass combustion	1
8.	Stoichiometric air requirement, chemistry of combustion.	3
9.	Design of combustion system.	2
10.	Combustion zones, flame structure, stability, emissions.	2
11.	Co-firing of biomass.	1
12.	Thermo-chemical conversion of biomass: Feedstock, chemistry.	2
13.	Reactor design.	1

S.No.	Topic	No. of Lectures
14.	Operation, optimized process parameters and utilization for gasification, carbonization, torrefaction and pyrolysis.	2
15.	Cogeneration technologies: Cycles, topping, bottoming, selection.	2
16.	Cogeneration Problems and applications.	2
17.	Waste heat recovery	2
18.	Estimation, systems, design and application.	2
	Total	**32**

IX. List of Practicals

S.No.	Topics	No. of Practicals
1.	Characterization of biomass	2
2.	Design of bio-reactors	1
3.	Determination of techno-economical feasibility of bio-chemical conversion process.	2
4.	Performance evaluation of combustion gadgets	1
5.	Performance evaluation of gasifiers	1
6.	Performance evaluation of pyrolytic converters	1
7.	Design of waste heat recovery system	2
	Total	**10**

X. Suggested Reading

- Chakravorty A. 1985. *Biogas Technology & other Alternative Technologies*. Oxford & IBH Publication Ltd, Delhi.
- Chaturvedi P. 1995. *Bio-Energy Resources: Planning, Production and Utilization*. Concept Pub. Co., New Delhi.
- Goswami DY. 1986. *Alternative Energy in Agriculture*.Vol. II (Ed), CRC, Press Inc., Florida, USA.
- Stout BA. 1984. *Biomass Energy Profiles*. FAO Agril. Services Bulletin No.54., Elsevier Science Publishers Ltd, England.
- Twidell JW and Weir AD. 2006. *Renewable Energy Sources*. E & F N Spon Ltd, New York.
- Vimal OP. 1984. *Energy from Biomass*.Agrcole Publishing Academy, New Delhi.

I. Course Title : Energy Auditing, Conservation and Management

II. Course Code : REE 504

III. Credit Hours : 2+1

IV. Aim of the course

To acquaint and equip about the sources of energy, conservation of energy and its management. Study of energy efficiency, energy planning, forecasting and energy economics.

V. Theory

Unit I

Energy conservation: Concepts, energy classification, equivalents, scenario, energy pricing, importance. Energy conservation act.

Unit II

Energy auditing and economics: Energy management, energy audit strategy, types. Energy performance: Bench marking, fuel substitutions, energy audit instruments,