GUJARAT TECHNOLOGICAL UNIVERSITY

Program Name: Engineering

Level: PG

Branch: Energy Engineering

Course / Subject Code : ME01075021

Course / Subject Name : Biomass Energy Conversion

w. e. f. Academic Year:	2024-25
Semester:	1st Semester
Category of the Course:	PEC

Prerequisite:	Knowledge of renewable energy
Rationale:	The course intends to provide knowledge of biomass energy, biomass energy conversion processes and devices, biomass energy applications to graduate students.

Course Outcome:

After Completion of the Course, Student will able to:

No	Course Outcomes	RBT level
1	Explain an overview of biomass system for bioenergy generation, bioenergy conversion and utilization methods.	Understand
2	Develop the designs of equipment/farm for biomass energy conversion and utilization.	Apply
3	Evaluate the environmental benefits of the biomass energy.	Analyze
4	Evaluate the consequences of biomass energy production and apprise the applications of the biomass energy.	Analyze

Teaching and Examination Scheme:

Teaching Scheme (in Hours)			Total Credits L+T+ (PR/2)	Assessment Pattern and Marks				Total Marks
				Theory		Tutorial / Practical		
L	T	PR	C	ESE (E)	PA / CA (M)	PA/CA (I)	ESE (V)	
3	0	2	4	70	30	20	30	150

Course Content:

Unit No.	Content	No. of Hours	% of Weightage
1.	**Biomass:** Introduction, Biomass-modern energy carrier, resource and classification, Composition, analysis, moisture content, ash content and organic content of biomass, Availability, Agricultural and Forest residue	9	19

	and method of data analysis, Aquatic and Marine biomass, Geographical distribution, surplus biomass, energy plantation/farm concept, Conceptual design, installation, operation and maintenance of energy farm, Photosynthesis process of biomass and its conversion related properties, Physical Conversion process of Biomass, dewatering, drying, size reduction, densification, palliating and briquetting.		
2.	**Biomass Conversion:** Basic principle of Direct combustion and pyrolysis process, heat transfer in direct combustion process, Process steps and thermodynamics of direct combustion and pyrolysis, Chemical reactions and stoichiometry for the combustion process, Enthalpy of formation, Enthalpy and internal energy of combustion, Adiabatic flame temperature, 2^{nd} law analysis of reacting system. **Thermochemical Conversion Process:** Introduction, basic principle, kinetics and thermodynamics of thermochemical conversion, Gasification of biomass, Chemistry of gasification, Types of gasification technologies (Fixed bed, fluidized bed, entrained bed), Approach to estimate the product of gasification, Downstream processing of gasification, Liquefaction of biomass, Types of liquefaction technologies and governing equations, Downstream process of liquefaction.	21	48
3.	**Biochemical Conversion Process** Introduction, basic principle of biomass conversion, Anaerobic digestion and fermentation, Stages of fermentation, Methanogens, physiology, biochemistry and microbiology of methanogenesis, the fermentative and H_2 producing bacteria, Factors affecting the methane formation, Biomass conversion to methane, Bio-gasification process, Factor affecting the bio-digestion, design, construction and layout of small scale biogas plant, Types of bio-gas plant, Principle of ethanol fermentation, Substrates preparation, metabolism and feed stock preparation for ethanol fermentation, Types of ethanol fermentation processes, Ethanol recovery, Conversion efficiency for independent and dependent plant. Removal technique of CO_2, S and H_2O. Applications of Biogas for in domestic, industries and vehicles. Ethanol as a fuel in I.C. Engine.	15	33
	Total	**45**	**100**

Suggested Specification Table with Marks (Theory):

Distribution of Theory Marks					
R Level	**U Level**	**A Level**	**N Level**	**E Level**	**C Level**
10	**30**	**35**	**25**	**-**	**-**

Where R: Remember; U: Understanding; A: Application, N: Analyze and E: Evaluate C: Create (as per Revised Bloom's Taxonomy)

References/Suggested Learning Resources:

(a) Books:

1. Biomass conversion process for energy and fuels, Samir S. Sofer and Oskar R. Zaborsky, Plenum Press.
2. Biomass for Renewable Energy, Fuels, and Chemicals, Donald L. Klass, Academic Press.
3. Introduction to Biomass Energy, Vaughn Nelson and Kenneth Stracher, CRC Press.
4. Thermochemical Conversion of Biomass for the Production of Energy and Chemicals, Wiley.
5. Introduction to Biomass Energy Conversion, Sergio C. Capareda, CRC Press.
6. Non-Conventional Energy Sources, G. D. Rai, Khanna Publishers.
7. Biogas Technology, B. T. Nijaguna, New Age International Publisher.
8. Reading material on "Technologies for converting waste agriculture biomass to energy, United Nations of Environment Programme, Osaka.

(b) Open-source software and website:

1. https://onlinecourses.nptel.ac.in/noc19_bt16
2. https://onlinecourses.nptel.ac.in/noc22_ch27
3. https://mnre.gov.in/bio-energy/
4. https://www.nibe.res.in/index.php
5. https://www.nrel.gov/bioenergy
6. https://www.energy.gov/eere/bioenergy
7. Vidya-mitra : ES: P07- Energy and environment (e-PGP): https://www.youtube.com/playlist?list=PL_a1TI5CC9REN0xlex5WePN54tmzLbYgZ

Suggested Course Practical List:

1. To study the various sources of biomass and its physical, chemical characteristics and photosynthesis of biomass.
2. To study the concept of Energy farm, its design, operation and maintenance.
3. To study the physical conversion processes for the biomass.
4. To study the stoichiometry of chemical reaction, Air-fuel ratio, enthalpy of formation, enthalpy of

combustion and 2nd law analysis for the chemical reaction.

5. To study the thermochemical conversion process of biomass, chemistry of gasification and types of gasification technologies.
6. To study the various liquefaction processes for the biomass and chemistry of liquefaction process.
7. To study the biochemical conversion process, construction and design of the biogas plant.
8. To study the process design for the preparation of feedstock preparation.
9. To study the process design for the distillation of ethanol or ethanol recovery.
10. To study the applications of biogas and ethanol in internal combustion engine.

List of Laboratory/Learning Resources Required:

Steam engine/steam turbine, Calorimeter, Wood pellet machine, Biomass pyrolysis laboratory apparatus

Suggested Project List:

Suggested Activities for Students: Student can take the visit of any rural area where more feedstock is available for biomass and can design the energy farm.

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