



# GUJARAT TECHNOLOGICAL UNIVERSITY

Master of Engineering (Mechanical, Energy Engineering)

Subject Code: 3723917

Semester – II

Subject Name: Biomass Energy Conversion

Type of course: Program Elective

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.

Teaching and Examination Scheme:

Teaching Scheme			Credits C	Examination Marks				Total Marks
L	T	P		Theory Marks		Practical Marks		
				ESE (E)	PA (M)	ESE (V)	PA (I)	
3	0	2	4	70	30	30	20	150

Content:

Sr. No.	Content	Total Hrs
1	<b>Biomass:</b> Introduction, Biomass-modern energy carrier, resource and classification, Composition, analysis, moisture content, ash content and organic content of biomass, Availability, Agricultural and Forest residue 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.	8
2	<b>Biomass Conversion:</b> 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 <sup>nd</sup> law analysis of reacting system. <b>Thermochemical Conversion Process:</b> 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
3	<b>Biochemical Conversion Process</b> Introduction, basic principle of biomass conversion, Anaerobic digestion and fermentation, Stages of fermentation, Methanogens, physiology, biochemistry and microbiology of methenogenesis, the fermentative and H <sub>2</sub> 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	13



# GUJARAT TECHNOLOGICAL UNIVERSITY

## Master of Engineering (Mechanical, Energy Engineering)

Subject Code: 3723917

ethanol fermentation, Types of ethanol fermentation processes, Ethanol recovery, Conversion efficiency for independent and dependent plant. Removal technique of CO <sub>2</sub> , S and H <sub>2</sub> O. Applications of Biogas for in domestic, industries and vehicles. Ethanol as a fuel in I.C. Engine.
---

### Suggested Specification table with Marks (Theory):

Distribution of Theory Marks					
R Level	U Level	A Level	N Level	E Level	C Level
10	20	20	20	20	10

**Legends: R: Remembrance; U: Understanding; A: Application, N: Analyze and E: Evaluate C: Create and above Levels (Revised Bloom's Taxonomy)**

Note: This specification table shall be treated as a general guideline for students and teachers. The actual distribution of marks in the question paper may vary slightly from above table.

### Reference 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.

### Course Outcomes:

Sr. No.	CO statement	Marks % weightage
CO-1	To appraise biomass energy conversion resources, plantation, photosynthesis and for energy generation.	20%
CO-2	To discuss the combustion process, thermochemical conversion technologies, gasification system for biomass.	50%
CO-3	To appraise the biochemical conversion process, design the biogas plant, and fermentation and application of ethanol.	30%

### List of Experiments:

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 2<sup>nd</sup> 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.



# GUJARAT TECHNOLOGICAL UNIVERSITY

## Master of Engineering (Mechanical, Energy Engineering) Subject Code: 3723917

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.

**Major Equipment:** Different types of gasification plants, various types of bio-gas plant, Models of energy plantations.

**List of Open Source Software/learning website:** <http://ocw.mit.edu/courses/energy-courses/>,  
<https://nptel.ac.in/courses/102104057/>, <https://nptel.ac.in/courses/102104057/23>