GUJARAT TECHNOLOGICAL UNIVERSITY

Program Name: Diploma Engineering

Level: Diploma

Branch: Chemical Engineering

Subject Code: DI04005061

Subject Name: Waste to Energy Conversion Technology

w.e.f Academic Year:	2025-26
Semester:	4th
Category of the Course:	Professional Elective - I

Prerequisite:	Foundational knowledge of waste, chemical engineering basic principles, unit operations, and unit processes is required.
Rationale:	The objective of the course is to provide insights into waste management options by reducing the waste destined for disposal and encouraging the use of waste as a resource for alternate energy production. This course is designed to provide an understanding of the various aspects of Waste to Energy. The various sources of waste generation are analyzed with a focus on its potential for energy production. The need for characterization of wastes will be discussed along with the existing norms for waste utilization for alternate energy source. Various Technological options available for the production of energy form waste.

Course Outcome:

After Completion of the Course, Student will able to:

No.	Course Outcomes	RBT Level
01	Identify different wastes as an energy source.	R/U
02	Understand the concept of Thermo-chemical process for energy conversion.	R/U/A
03	Understand the concept of Bio-chemical process for energy conversion.	R/U/A
04	Apply concept of Bio-chemical process for energy conversion.	A

**Revised Bloom's Taxonomy (RBT)*

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(M)	PA(I)	ESE (V)	
3	1	0	4	70	30	00	00	100

Course Content:

Unit No.	Content	No. of Hours	% of Weightage (Marks)
Unit:1 Introduction of Waste	1.1 Definition & types of waste. 1.2 Classification of solid waste 1.3 Classification of Liquid waste 1.4 Composition of different solid wastes. 1.5 Composition of different liquid wastes. 1.6 Important quality parameters of Solid waste. 1.7 Important quality parameters of Liquid waste. 1.8 Important quality parameters of Gaseous waste. 1.9 Wastes suitable for energy production 1.10 Importance of waste to energy conversion. 1.11 Different Routes for energy production from wastes 1.12 Define Biochemical Conversion and Thermo- chemical Conversion 1.13 Global and Indian Scenario of waste collection and its management. 1.14 Present Status and future scope of waste to Energy conversion in India.	**6**	**13% (9)**
Unit:2 Characterization of waste	2.1 Characterization of solid waste. 2.1.1 Physical properties of Solid waste. 2.1.2 Chemical Properties of Solid waste. 2.1.3 Proximate analysis of solid waste. 2.1.4 Ultimate analysis of solid waste. 2.2 Characterization of Liquid waste. 2.2.1 Physical Characteristics of Liquid waste. 2.2.2 Chemical Characteristics of Liquid waste. 2.2.3 Biological Characteristics of Liquid waste. 2.3 Numerical based on measurement of BOD, COD, DO, TOC, TSS, TS, VS, moisture content, Density, volatile matter, ash and fixed carbon content, calorific value.	**6**	**14% (10)**
Unit:3 Waste to energy Technologies: Thermo-chemical Conversion	3.1 Types of thermo chemical conversion from waste. 3.2 Definition and scope of combustion /incineration. 3.3 Advantages and Disadvantages of combustion 3.4 Air requirement for combustion and concept of excess air. 3.5 Factors affecting the efficiency of Combustions. 3.6 Environmental and health impacts of incineration. 3.7 Mass burn Combustion (Incineration) 3.8 Fluidized bed combustion 3.9 Rotary Kiln Combustion.	**18**	**31% (22)**

	3.10 Moving Grate Combustion 3.11 Concept of gasification 3.12 Advantages and Disadvantages of Gasification. 3.13 Factors affecting the efficiency of Gasification 3.14 Introduction of Syn- gas & producer gas 3.15 Fixed bed Gasification (updraft, down draft) 3.16 Fluidized bed Gasification (BFB, CFB) 3.17 Entrained flow Gasification 3.18 Plasma Gasification 3.19 Comparison between incineration and Gasification 3.20 Definition and mechanism of Pyrolysis 3.21 Advantages and Disadvantages of Pyrolysis. 3.22 Slow Pyrolysis 3.23 Fast Pyrolysis 3.24 Flash Pyrolysis 3.25 Pyrolysis products 3.26 Product selectivity and factors affecting it 3.27 Properties of bio oil and need of its up gradation 3.28 Utilization of pyro-char and gases. 3.29 Numerical based on air requirement, efficiency calculations.		
Unit:4 Waste to energy technologies: Biochemical Conversion:1	4.1 Definition & Types of Bio-chemical conversion of waste. 4.2 Waste (feedstock) suitable for biochemical conversion. 4.3 Possible outcome (energy source) in biochemical conversion. 4.4 Mechanism of anaerobic digestion 4.5 Flow sheet for anaerobic digestion of wastes. 4.6 Anaerobic digesters construction, working and factors affecting the performance of digestor. 4.7 Properties of biogas (Calorific value and composition) 4.8 Factors affecting biogas yield. 4.9 Definition of fermentation with its chemistry. 4.10 Different sugar sources available in waste. 4.11 Block diagrams for ethanol production from different sources of sugar. 4.12 Production of ethanol from starchy crops (corn). 4.13 Butanol production from LCB.	**8**	**26% (18)**
Unit:5 Waste to energy technologies: Biochemical Conversion:2	5.1 Definition of Transesterification with its chemistry. 5.2 Transesterification process and Organic wastes for transesterification 5.3 Classification of methods for production of biofuel (biodiesel) from oil bearing waste. 5.4 Important properties of biodiesel. 5.5 Basics of Photo-biological Conversion and organisms involved. 5.6 Process Conditions and Optimization for the process. 5.7 Benefits of algal biomass. 5.8 Types of microalgae.	**7**	**16% (11)**

	5.9 Lipid content and its conversion. 5.10 Reactor systems for cultivation/ growth of microalgae 5.11 Important energy production routes for algal biomass. 5.12 Up gradation of algal oil to bio diesel using homogenous and heterogeneous catalysts. 5.13 Applications of bio oil.		
	Total	**45**	**100% (70Mark)**

Suggested Specification Table with Marks (Theory):

Distribution of Theory Marks (in%)					
R Level	**U Level**	**A Level**	**N Level**	**E Level**	**C Level**
18	**32**	**20**	**-**	**-**	**-**

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

Note*:* This specification table provides general guidelines to assist students for their learning and to teachers to teach and question paper designers/setters to formulate test items/questions to assess the attainment of the UOs. The actual distribution of marks at different taxonomy levels (of R, U and A) in the question paper may slightly vary from above table.

Suggested Tutorials for the Course:

Sr. No.	**Suggested tasks.**
1.	Prepare a table/chart showing composition (%) of various solid wastes like household, industrial.
2.	Draw a schematic to show gasification process and products.
3.	Create a basic demo model of an incinerator.
4.	Calculate moisture, volatile matter, fixed carbon, ash content, and elemental composition (C, H, O, N, S) of a given waste sample.
5.	Use given data (HHV/LHV) of waste components to calculate the overall calorific value of a mixed waste sample.
6.	Given input composition and reaction data, calculate the volume percentages of CO, H2, CH4, and CO2 in producer gas.
7.	Prepare chart of waste to Energy conversion in India
8.	Prepare chart/model types of Combustor.
9.	Calculate the volume and retention time needed for composting municipal solid waste
10.	Calculate thermal efficiency using input fuel energy vs. output electrical/thermal energy.

11.	Prepare 15-20 slides power point presentation Characterization of wastes
12.	Calculate BOD from initial and dissolved oxygen (DO) readings in wastewater samples.
13.	Calculate COD.
14.	Prepare a demonstrative model of any waste to energy conversion technology equipment.
15.	Determine alkalinity of a wastewater sample using titration data and express in mg/L as CaCO3
16.	Analyze a real or hypothetical WTE plant's data and prepare a presentation including flow diagrams, energy balance, and environmental impact.

Note

i. More Tutorials can be designed and offered by the respective course teacher to develop the industry-relevant skills/outcomes to match the COs. The above table is only a suggestive list. Course teacher can select an.

References/Suggested Learning Resources:

(a) Books:

Sr. No.	Title of Book	Author	Publication with the place, year and ISBN
1	Waste-to-Energy: Technologies and Project Implementation	Marc J Rogoff Dr and Francois Screve	William Andrew; 2nd edition (15 June 2011)
2	Biogas Technology	Khandelwal K. C. and Mahdi S. S	Vol. I & II Tata McGraw Hill Publishing Co. Ltd., 1983
3	Solid Waste Engineering	Vesilind P.A. and Worrell W. A	2nd Ed. Cengage India (2016)
4	Thermo-chemical Processing of Biomass: Conversion into Fuels, Chemicals and Power	Robert C. Brown,	John Wiley and Sons, USA (2019)
5	Municipal Solid Waste to Energy Conversion processes	Young G.C	John Wiley and Sons

(b) Open sources of software and website:

a) https://onlinecourses.nptel.ac.in/noc23_ch05/
b) https://www.teriin.org/projects/green/pdf/National-Waste.pdf
c) https://srict.in/UploadedFiles/131915923741960000.pdf
d) https://www.slideshare.net/slideshow/characteristics-of-solid-waste/245562548
e) https://scienceinfo.com/characteristics-of-wastewater/

f) https://environmental-geology-dev.pressbooks.tru.ca/chapter/liquid-wastes/
g) https://www.sciencedirect.com/topics/engineering/thermal-conversion
h) http://kcl.digimat.in/nptel/courses/video/103107125/lec7.pdf
i) https://mnre.gov.in/en/waste-to-energy-overview/
j) https://www.eai.in/ref/ae/wte/typ/clas/india_industrial_wastes.html
k) Ministry of New & Renewable Energy - Government of India (mnre.gov.in)
l) http://www.ottusa.com/synthetic_fuel/synthetic_fuel

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