

**GUJARAT TECHNOLOGICAL UNIVERSITY (GTU)****Competency-focused Outcome-based Green Curriculum-2021 (COGC-2021)**

Semester- IV

Course Title: Bio Energy  
(Course Code: 4346403)

<b>Diploma programmer in which this course is offered</b>	<b>Semester in which offered</b>
Renewable Energy Engineering	Fourth

**1. RATIONALE**

India has declared the goal to achieve net zero emissions by 2070. As India's growth story unfold, its demand for energy and resources is set to rise. Energy use has doubled in the last 20 years and is likely to grow by least another 25% by 2030. India currently imports over 40% of its primary energy requirement, worth over USD 90 billion every year. Major sectors of Indian economy depend on imported fossil fuels. This necessitates shift towards technologies that enable enhanced share of renewable source and progressively reduce the reliance on fossil fuels

Bio energy is a form of renewable energy that is derived from recently living organic materials known as biomass, which can be used to produce transportation fuels, heat, electricity, and products. This course deals in detail about generation of electric power using bio resources. Bio energy is generated using biogas power plants. We can also help to improve our organic waste and forest management systems. Using waste for landfill has environmental benefits, treating animal manure can improve water quality and reduce artificial fertilizer use. This course deals in detail with basic concept of bio energy, biomass, energy conversion processes, bio gas power plants and bio fuels. Essential efforts are made in this course to develop a knowledge required to generate eco friendly power.

**2. COMPETENCY**

The purpose of this course is to help the student to attain the following industry identified competency through various teaching learning experiences:

- **Operation and maintenance of Biogas Power Plant.**

### 3. COURSE OUTCOMES (COs)

The practical exercises, the underpinning knowledge and the relevant soft skills associated with the identified competency are to be developed in the student for the achievement of the following COs.

- a) Understand biomass and bio energy
- b) Describe biomass energy conservation technologies
- c) Understand biogas power plant
- d) Explain the effect of bio fuel in current energy scenario

### 4. TEACHING AND EXAMINATION SCHEME

Teaching Scheme (In Hours)			Total Credits (L+T+P/2)	Examination Scheme				
				Theory Marks		Practical Marks		Total Marks
L	T	P	C	CA	ESE	CA	ESE	
3	0	2	4	30	70	25	25	150

(\*): Out of 30 marks under the theory CA, 10 marks are for assessment of the micro-project to facilitate integration of COs and the remaining 20 marks is the average of 2 tests to be taken during the semester for the assessing the attainment of the cognitive domain UOs required for the attainment of the COs.

**Legends:** *L*-Lecture; *T* – Tutorial/Teacher Guided Theory Practice; *P* - Practical; *C* – Credit, *CA* - Continuous Assessment; *ESE* - End Semester Examination.

### 5. SUGGESTED PRACTICAL EXERCISES

The following practical outcomes (PrOs) are the sub-components of the Course Outcomes (Cos). Some of the **PrOs** marked ‘\*’ are compulsory, as they are crucial for that particular CO at the ‘Precision Level’ of Dave’s Taxonomy related to ‘Psychomotor Domain’.

Sr. No.	Practical Outcomes (PrOs)	Unit No.	Approx. Hrs. Required
1	To study about types of renewable energy	I	2
2	To study operation of biogas plant	II	2
3	To study of floating drum type biogas plant	II	2
4	To study of fixed drum type biogas plant	II	2

5	To study of balloon type biogas plant	II	2
6	To study different types of gasifier	II	2
7	To study combustion process of biomass	II	2
8	Report on visit of biogas plant	III	8
9	To study the production process of bio-fuels	IV	2
10	To study about next generation bio-fuels	IV	4
			28

**Note**

- i. More **Practical Exercises** 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.
- ii. The following are some **sample** 'Process' and 'Product' related skills (more may be added/deleted depending on the course) that occur in the above listed **Practical Exercises** of this course required which are embedded in the COs and ultimately the competency.
- iii.

Sr. No.	Sample Performance Indicators for the PrOs	Weightage in %
1	Understanding of concepts	20
2	Explanation of conclusion	20
3	Student attitude towards learning	20
4	Quality of term work	20
5	Timely completion of term work	20
<b>Total</b>		<b>100</b>

**6. MAJOR EQUIPMENT/ INSTRUMENTS REQUIRED**

This major equipment with broad specifications for the PrOs is a guide to procure them by the administrators to user in uniformity of practical's in all institutions across the state.

Common Instruments related to Bio Energy

Sr. No.	Equipment Name with Broad Specifications	PrO. No.
1	Biogas Trainer kit	--

2	High performance liquid chromatography	--
3	GC for Gas Analysis	--
4	Fast protein liquid chromatography	--
5	Refrigerated centrifuge	--
6	Fermentor	--
7	Bio-photometer	--
8	Karl Fischer Titrator	--
9	Electro chemical workstation	--
10	Liquid gas chromatograph	--
11	Thermal gravimetric analyzer	--
12	FTIR Spectrometer	--

## 7. AFFECTIVE DOMAIN OUTCOMES

The following *sample* Affective Domain Outcomes (ADOs) are embedded in many of the above-mentioned COs and PrOs. More could be added to fulfill the development of this course competency.

- a) Work as a leader/a team member(while doing a micro-project)
- b) Follow safety practices while using Electrical supply and electrical equipment.
- c) Practice environmental friendly methods and processes. (Environment related)

The ADOs are best developed through the laboratory/field based exercises. Moreover, the level of achievement of the ADOs according to Krathwohl's 'Affective Domain Taxonomy' should gradually increase as planned below:

- 'Valuing Level' in 1<sup>st</sup> year
- 'Organization Level' in 2<sup>nd</sup> year
- 'Characterization Level' in 3<sup>rd</sup> year.

## 8. UNDERPINNING THEORY

The major underpinning theory is given below based on the higher level UOs of *Revised Bloom's taxonomy* that are formulated for development of the COs and competency. If required, more such UOs could be included by the course teacher to focus on attainment of COs and competency.

Unit	Unit Outcomes (UOs)	Topics and Sub-topics
<b>Unit -I Bio Energy</b>	<ul style="list-style-type: none"> <li>• Describe sources of biomass, advantages, disadvantages and applications</li> </ul>	<ul style="list-style-type: none"> <li>• Introduction of Bio energy</li> <li>• Biomass sources, types of biomass</li> <li>• Energy from biomass</li> <li>• Advantages and Disadvantages of biomass</li> <li>• Limitations of biomass</li> <li>• Bio energy applications</li> </ul>
<b>Unit-II Biomass Energy Conversion Technologies</b>	<ul style="list-style-type: none"> <li>• Explain about conversion</li> <li>• Describe chemical process and gasification of biomass</li> </ul>	<ul style="list-style-type: none"> <li>• Introduction of biomass conversion</li> <li>• Types of biomass conversion technologies: Direct combustion process, Thermo combustion process &amp; Biochemical process</li> <li>• Direct combustion process</li> <li>• Thermo chemical processes: pyrolysis, carbonization, catalytic, gasification-types of gasifier</li> <li>• Bio chemical processes: Anaerobic digestion, methane production in landfills, Ethanol fermentation, Bio diesel</li> </ul>

<b>Unit-III</b> <b>Biogas power plant</b>	<ul style="list-style-type: none"> <li>• Understand biogas power plant, construction and its operation</li> <li>• Explain different factors which affects the production of bio gas</li> </ul>	<ul style="list-style-type: none"> <li>• Principle of gas production</li> <li>• Composition of bio gas</li> <li>• Types of bio gas plants: Balloon plant, fixed dome plant &amp; floating drum plant</li> <li>• Bio gas plant operation: Feeding, seeding, stirring and gas collection</li> <li>• Factors affecting gas production: Temperature, pH, nutrients, toxic materials, retention time</li> <li>• Plant installation, construction material and design</li> <li>• Advantages and disadvantages</li> </ul>
<b>Unit-IV</b> <b>Bio fuels</b>	<ul style="list-style-type: none"> <li>• Understand Bio fuel, its classification.</li> <li>• Distinguish advance generation bio fuel</li> </ul>	<ul style="list-style-type: none"> <li>• Introduction of Bio-fuels</li> <li>• Broad classification of bio-fuel, first, second, third and fourth generation bio-fuel</li> <li>• Market barriers and sustainability and economy of bio-fuels</li> <li>• Bio-fuel emissions</li> <li>• Advantages and challenges of bio-fuels</li> <li>• Global scenario and future of bio-fuels</li> <li>• Bio-fuel policy in India</li> </ul>

### 9. SUGGESTED SPECIFICATION TABLE FOR QUESTION PAPER DESIGN

Unit No.	Unit Title	Teaching Hours	Distribution of Theory Marks			
			R Level	U Level	A Level	Total Marks
I	Bio Energy	6	4	4	--	8
II	Biomass energy conversion technologies	16	10	18	--	28
III	Biogas power plant	12	8	8	6	22
IV	Bio fuels	8	8	4	--	12
Total		42	30	34	6	70

**Legends:** R=Remember, U=Understand, A=Apply and above (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.

## 10. SUGGESTED STUDENT ACTIVITIES

Other than the classroom and laboratory learning, following are the suggested student-related *co-curricular* activities which can be undertaken to accelerate the attainment of the various outcomes in this course. Students should perform following activities in group (or individual) and prepare reports of about 5 pages for each activity. They should also collect/record physical evidences for their (student's) portfolio which may be useful for their placement interviews:

- a) Present seminar on various topics from course content
- b) Present seminar on recent technologies used for renewable energy
- c) Group discussion on current scenario of bio energy.

The student should be encouraged to get their work assessed by the concerned teacher progressively during the term and at the end of the term the whole work should be submitted to the concerned teacher.

## 11. SUGGESTED SPECIAL INSTRUCTIONAL STRATEGIES (if any)

These are sample strategies, which the teacher can use to accelerate the attainment of the various outcomes in this course:

- a) Guide student(s) in undertaking micro-projects.
- b) Show animation/ video related to course content.
- c) Visit nearby biogas power plant

## 12. SUGGESTED MICRO-PROJECTS

**Only one micro-project** is planned to be undertaken by a student that needs to be assigned to him/her in the beginning of the semester. In the first four semesters, the micro-projects are group-based (group of 3 to 5). However, **in the fifth and sixth semesters**, the number of students in the group should **not exceed three**.

The micro-project could be industry application based, internet-based, workshop-based, laboratory-based or field-based. Each micro-project should encompass two or more COs which are in fact, an integration of PrOs, UOs and ADOs. Each student will have to maintain dated work diary consisting of individual contribution in the project work and give a seminar

presentation of it before submission. The duration of the micro project should be about **14-16 (fourteen to sixteen) student engagement hours** during the course. The students ought to submit micro-project by the end of the semester to develop the industry-oriented COs.

A suggestive list of micro-projects is given here. This has to match the competency and the COs. Similar micro-projects could be added by the concerned course teacher:

- a) Prepare chart of types of biomass feedstock
- b) Prepare chart of biomass conversion processes
- c) Prepare chart of different types of gasifiers
- d) Prepare layout of biogas power plant
- e) Prepare chart of 1<sup>st</sup>, 2<sup>nd</sup>, 3<sup>rd</sup> and 4<sup>th</sup> generation bio-fuels.

### 13. SUGGESTED LEARNING RESOURCES

Sr. No	Title of Book	Author	Publication with place, year and ISBN
1	Bio energy and Bio fuels	Ozcan Konur	CRC PRESS, 2021, ISBN 9781032236438
2	Hand Book On Bio fuel, Ethanol And Bio energy Based Products	P. K. Chattopadhyay	ASIA PACIFIC BUSINESS PRESS INC, 2022, ISBN 9788195370184
3	Biomass for bio energy and biomaterials	Nidhi adlakha, Rakesh bhatnagar, Syed shams yajdani	CRC PRESS, 2021, ISBN 978-0367745554
4	Biomass : as renewable source of energy	Bibhu Prasad Ganthia, Anita Pritam, Asutosh Parida, Selva Suman Ray	Kindle Edition 2021, ASIN B09GNFS9S3
5	Bio fuel technology handbook	Dominik rutz & rainer janssen	WIP Renewable Energies, 2008
6	Biogas Plants	Ludwig Sasse	Deutsches Zentrum für Entwicklungstechnologien GATE, 1988

### 14. SOFTWARE/LEARNING WEBSITES

- <https://www.classcentral.com/course/swayam-bioenergy-7896>
- <https://www.nrel.gov/research/re-biomass.html>
- <https://www.energy.gov/eere/bioenergy/educational-resources-bioenergy-classroom>
- <https://www.nationalgeographic.org/encyclopedia/biomass-energy/>

- <https://www.eesi.org/topics/bioenergy-biofuels-biomass/description>
- <https://www.iea.org/energy-system/renewables/bioenergy>
- <https://mnre.gov.in/bio-energy-overview/>
- <https://www.irena.org/Energy-Transition/Technology/Bioenergy-and-biofuels>
- <https://www.energy.gov/eere/bioenergy/biofuel-basics>
- <https://nitsri.ac.in/Department/Chemical%20Engineering/BRTL12.pdf>
- <https://www.hrpub.org/>
- <https://www.nibe.res.in/>
- <https://biourja.mnre.gov.in/>

### 15. PO-COMPETENCY-CO MAPPING:

Semester IV	Bio Energy (Course Code: 1346403)						
	POs						
Competency & Course Outcomes	PO1	PO2	PO3	PO4	PO5	PO6	PO7
		Basic & Discipline specific knowledge	Problem Analysis	Design/development of solution	Engineering Tools, Experimentation & Testing	Engineering practices for society, sustainability & environment	Project Management
<b>Competency</b>	<b>Operation and maintenance of Biogas Power Plant</b>						
<b>Course Outcomes</b>							
Co1.Understand biomass and bio-energy	2	--	--	--	1	--	--
Co2.Describe the biogas conversion technology	2	1	--	1	2	--	1
Co3.Understand biogas power plant	1	--	1	1	2	1	1
Co4.Explain the effect of bio-fuel in current energy scenario	1	--	--	--	2	--	1

Legend: '3' for high, '2' for medium, '1' for low and '-' for no correlation of each CO with PO.

### 16. COURSE CURRICULUM DEVELOPMENT COMMITTEE

#### GTU Resource Persons

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