

**GUJARAT TECHNOLOGICAL UNIVERSITY (GTU)**  
**Competency-focused Outcome-based Green Curriculum-2021 (COGC-2021)**  
Semester-VI  
**Course Title: Clean and Renewable Energy Production Technology**  
(Course Code: 4360508)

Diploma programme in which this course is offered	Semester in which offered
Chemical Engineering	6th Semester

### 1. RATIONALE

The energy has become an important and one of the basic infrastructures for the economic development of the country. Diploma students undertaking this course are expected to understand the fundamentals of production of energy from different fossil fuels through cleaner routes as well as from renewable resources. It is intended to help the student to keep their knowledge upgraded with the current thoughts and newer technology options along with their advances in the field of the utilization of different types of energy resources for cleaner energy production.

### 2. COMPETENCY

The course should be taught and curriculum should be implemented with the aim to develop required skills so that students are able to acquire following competency:

- **To Supervise operation and use Renewable Energy as an indicator global development**
- **Understanding technology of Renewable Energy Production**

### 3. COURSE OUTCOMES (COs)

The theory, practical experiences and relevant soft skills associated with this course are to be taught and implemented, so that the student demonstrates the following industry oriented COs associated with the above mentioned competency:

- a) Identify types of energy as an indicator of global development
- b) Analyze various energy sources from coal, petroleum crude and gaseous fuels
- c) Apply concept of solar technology for energy production
- d) Apply concept of wind technology for energy production
- e) Apply concept of hydro and geothermal technology for energy production

### 4. TEACHING AND EXAMINATION SCHEME

Teaching Scheme (In Hours)			Total Credits (L+T+P/2)	Examination Scheme				
L	T	P		Theory Marks		Practical Marks		Total Marks
			C	CA	ESE	CA	ESE	
3	0	0	3	70	30	0	0	100

## 5. SUGGESTED PRACTICAL EXERCISES

The following practical outcomes (PrOs) are the sub-components of the COs. *Some of the PrOs marked “\*” (in approx. Hrs column) are compulsory, as they are crucial for that particular CO at the ‘Precision Level’ of Dave’s Taxonomy related to ‘Psychomotor Domain’.*

S. No.	Practical Outcomes (PrOs)	Unit No.	Approx. Hrs. required
<b>Not Applicable</b>			

### 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.

S.No.	Sample Performance Indicators for the PrOs	Weightage in %
1	Question answer or Writing steps exercise (Assignment)	30
2	Executing of exercise	30
3	Result	40
<b>Total</b>		<b>100</b>

## 6. MAJOR EQUIPMENTS/ INSTRUMENTS REQUIRED

S. No.	Equipment Name with Broad Specifications	PrO. No.
<b>Not Applicable</b>		

## 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 competency.

- a) Work as a leader/a team member.
- b) Follow ethical practices
- c) Observe safety measures
- d) Good house keeping
- e) Time management
- f) Practice environmentally friendly methods and processes.

The ADOs are best developed through 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:

- i. ‘Valuing Level’ in 1<sup>st</sup> year

- ii. 'Organization Level' in 2<sup>nd</sup> year.
- iii. '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 higher-level UOs could be included by the course teacher to focus on the attainment of COs and competency.

Unit	Unit Outcomes (UOs) (4 to 6 UOs at different levels)	Topics and Sub-topics
<b>Unit – I</b> Introduction of energy	1a. Explain energy as an indicator of development	1.1 Define energy and importance of energy 1.2 Define clean energy and renewable energy 1.3 Explain Need of the clean and renewable energy
	1b. Explain World and Indian energy scenario	1.4 Explain World and Indian energy scenario
	1c. Comparison Routes for clean energy from fossil fuels and renewable energy	1.5 Comparison Routes for clean energy from fossil fuels and renewable energy
<b>Unit– II</b> Energy source from coal, petroleum and gaseous fuels	2a. Explain coal as a Source of Energy	2.1 Coal and its composition 2.2 Describe origin of coal 2.3 Types and properties of coal 2.4 Describe Coal pricing 2.5 Characterization of coal 2.5.1 Proximate analysis 2.5.2 Ultimate analysis
	2c. Explain petroleum as a source of energy	2.6 Define petroleum and its composition 2.7 Describe origin of petroleum 2.8 Types of petroleum 2.9 Properties of petroleum products 2.10 Pricing of petroleum 2.11 Characterization of petroleum 2.11.1 Density and API 2.11.2 Cetane and Octane number, 2.11.3 Aniline point and Diesel index 2.11.4 Reid vapor pressure
	2c. Gaseous Fuels: Properties and Routes for Energy Production	2.12 Types of gaseous fuels 2.13 Properties of gaseous fuels 2.14 Naturally available gaseous fuels 2.15 Applications of gaseous fuels
	2d. Numerical problem based on Energy source from coal, petroleum crude	2.16 Numerical problem based on Energy source from coal, petroleum crude

<b>Unit– III</b> Solar energy production	3a. Explain solar energy 3b. Explain total energy received from the sun 3c. Explain Solar Insolation 3d. List out application of solar energy 3e. Explain Techniques for solar energy production	3.1 Sun as a source of energy 3.2 Solar radiation and spectrum 3.3. Explain: 3.3.1 Angle of incidence 3.3.2 Tilt angle 3.3.3 Hour angle 3.3.4 Angle of declination 3.3.5 Latitude 3.4 Application of solar energy 3.5 Advantage and disadvantage of solar energy 3.6 Techniques for solar energy production or conversion to usable form 3.6.1 Solar thermal 3.6.2 Solar photovoltaic.
	3f. Numerical based on Solar energy production	3.7 Numerical based on Solar energy production
<b>Unit– IV</b> Wind energy production	4a. Explain Wind as a source of energy 4b. Types of wind machines 4c. Explain energy production from wind 4d. Explain Wind mills 4e. Explain wind energy in India	4.1 Wind as a source of energy 4.2 Wind energy system 4.3 Types of wind machines 4.4 Energy production from wind 4.5 Wind energy computation and the nature of wind 4.6 Describe Horizontal axis windmill and vertical axis windmill 4.7 Advantage and disadvantage of windmill 4.8 Wind energy in India and future of wind energy
	4f. Numerical based on wind energy production	4.9 Numerical based on wind energy production
<b>Unit– V</b> Production of hydro and geothermal energy	5a. Explain energy production from hydro 5b. Classify hydro power 5c. Mechanism of hydro energy production 5d. Explain Hydropower in India and world	5.1 Hydrologic cycle as a renewable energy source 5.2 Mechanism of hydro energy production 5.3 Components of hydro power plants and their role 5.4 Classification of hydro power 5.5 Advantages and disadvantages of hydropower 5.6 Hydropower in India and world

	5e. Explain energy production from geothermal 5f. Mechanism of conversion of geothermal energy to electricity	5.7 Geothermal energy as a source of renewable energy 5.8 Application routes of geothermal energy 5.9 Mechanism of conversion of geothermal energy to electricity 5.10 Different types of electricity production plant or scheme 5.11 Advantages and disadvantages geothermal energy 5.12 World scenario and Indian scenario geothermal energy
	5g. Numerical problem based on hydro and geothermal energy production	5.13 Numerical problem based on hydro and geothermal energy production

## 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	Introduction of energy	4	3	4	0	7
II	Energy source from coal, petroleum and gaseous fuels	12	7	8	5	20
III	Solar energy production	8	4	6	4	14
IV	Wind energy production	8	4	6	4	14
V	Production of hydro and geothermal energy	10	6	5	4	15
<b>Total</b>		<b>42</b>	<b>24</b>	<b>29</b>	<b>17</b>	<b>70</b>

**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 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:

Following is the list of proposed student activities like:

1. Assignments
2. Technical Quiz/MCQ Test
3. Presentation on some course topic
4. I-net based assignments
5. Undertake micro-Project in team/individually

#### 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) Massive open online courses (*MOOCs*) may be used to teach various topics/subtopics.
- b) Guide student(s) in undertaking micro-projects/activities.
- c) Different types of teaching methods i.e. video demonstration, activity based learning, case study, m-learning need to be employed by teachers to develop the outcomes.
- d) *Some of the topics/sub-topics* which is relatively simpler or descriptive is to be given to the students for *self-learning* but to be assessed using different assessment methods.
- e) Teachers need to ensure to create opportunities and provisions for *co-curricular activities*.
- f) Guide students to address issues on environment and sustainability with reference to using the knowledge of this course

#### 12. SUGGESTED MICRO-PROJECTS

**Only one micro-project** is planned to be undertaken by a student that needs to be assigned to him/her at the beginning of the semester. In the first four semesters, the micro-project is 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 the integration of PrOs, UOs, and ADOs. Each student will have to maintain dated work diary consist in go find individual contributions 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 (so that they develop industry-oriented COs).

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

1	Prepare chart/model of renewable energy
2	Prepare chart of Characterization of coal
3	Prepare chart/model types of Horizontal axis windmill
4	Draw suitable chart for techniques for solar energy production
5	Prepare 15-20 slides power point presentation showing geothermal energy as a

	source of renewable energy
6	Prepare 15-20 slides power point presentation on hydro energy production
7	Prepare 15-20 slides power point presentation on types of wind machines
8	Prepare a demonstrative model of Horizontal axis windmill, vertical axis windmill
9	Prepare a demonstrative model of wind energy
10	Prepare Working model of wind energy/Solar energy

### 13. SUGGESTED LEARNING RESOURCES

S. No.	Title of Book	Author	Publication with place, year and ISBN
1	Energy Sources	G. D. Rai	2nd Ed. by Khanna Publications, New Delhi
2	Energy Technology	Rao & Parulaker	Khanna Publications
3	Renewable Energy Resources	Twidel, J. and Tony W.	Second Edition, Taylor & Francis 2006
4	Energy Management and Conservation	Kreith F., Goswami D.Y.	CRC Press 2008
5	Solar Energy: Principles of thermal Collection and Storage	Sukhatme S., J Nayak J.	3 rd Ed., Tata McGraw-Hill Pulishing Company Ltd. 2008
5	Sustainable utilization of natural resources	Mondal P and Dalai A	CRC Press 2017
6	Renewable Energy Engineering	J.P. Hadiya and H.G. Katariya	Books India Publications Second edition 2018

### 14. SOFTWARE/LEARNING WEBSITES

<https://archive.nptel.ac.in/courses/103/107/103107157/>

[www.vlab.co.in](http://www.vlab.co.in)

<https://ndl.iitkgp.ac.in>

<https://youtu.be/wsz-LEFuLdc>

<https://www.un.org/en/climatechange/what-is-renewable-energy>

<https://www.nationalgrid.com/stories/energy-explained/what-is-green-energy>

### 15. PO-COMPETENCY-CO MAPPING

Semester VI	Clean and Renewable Energy Production Technology (4360508)						
	POs						
Competency & Course Outcomes	PO 1 Basic & Discipline specific	PO 2 Proble m Analysi	PO 3 Design/ developme nt of	PO 4 Engineering Tools, Experimenta	PO 5 Engineerin g practices for society,	PO 6 Project Manage ment	PO 7 Life- long learning

	knowledge	s	solutions	tion & Testing	sustainability & environment		
<b>Competency</b>	<b>To Supervise operation and Identify types of energy as an indicator global development</b>						
Identify types of energy as an indicator of global development	2	1	1	-	2	1	2
Analyze various energy sources from coal, petroleum crude and gaseous fuels	2	3	3	1	2	1	2
Apply concept of solar technology for energy production	1	3	3	-	2	1	2
Apply concept of wind technology for energy production	1	3	3	-	2	1	2
Apply concept of hydro and geothermal technology for energy production	1	3	3	-	2	1	2

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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1	Mr. R.P. HADIYA (Lecturer in chemical Engineering)	GOVERNMENT POLYTECHNIC, RAJKOT	-	rphadiya@yahoo.co.in
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