GUJARAT TECHNOLOGICAL UNIVERSITY, AHMEDABAD, GUJARAT

Competency-focused Outcome-based Green Curriculum-2021 (COGC-2021) Semester-I

Course Title: Basics of Renewable Energy (Code: C4316402)

Diploma program in which this course is offered	Semester in which offered
Renewable Energy	First

1. RATIONALE

The energy has become an important and one of the basic infrastructures for the economic development of the country. It is imperative for the sustained growth of the economy. This course envisages the new and renewable source of energy, available in nature and to expose the students on sources of energy crisis and the alternates available, also stress up on the application of nonconventional energy technologies.

2. COMPETENCY

The course content should be taught with the aim to develop different types of skills so that students are able to acquire following competency:

Apply basic concepts, laws and principles about the renewable energy sources for sustainable development.

3.COURSE OUTCOMES

The theory should be taught and practical should be carried out in such a manner that students are able to acquire different learning outcomes in cognitive, psychomotor and affective domain to demonstrate following course outcomes.

CO1. Interpret scenario of non-renewable energy in India **CO2.** Interpret principle of solar energy systems
CO3. Describe the wind energy conversion system.
CO4. Compare biomass, Ocean and Geothermal energy conversion. **CO5.** Promote the use of renewable energy sources

4. TEACHING AND EXAMINATION SCHEME

Teaching Scheme (In Hours)			Total Credits (L+T+P)	Examination Scheme				
				Theory Marks		Practical Marks		Total Marks
L	T	P	C	ESE	CA	ESE	CA	150
3	0	2	5	70	30	25	25	

Legends: L -Lecture; **T -**Tutorial/Teacher Guided Student Activity; **P -**Practical; **C -** Credit; **ESE**-End Semester Examination; **PA** -Progressive Assessment

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	Measure instantaneous solar irradiation and estimate the solar insolation (kWh/m2) during a day.	I	4
2	Measure electrical parameters with respect to orientation of solar panel and compare the same.	I	2
3	Figure out the variation of electricity consumption of your campus with season and reason behind it and Make summary of observations.	I	4
3	Plot P-V and I-V characteristics of solar cell and fill factor.	I	4
4	Plot P-V characteristics of solar cell and obtain effect of ambient temperature. *	I	4
6	Measure the wind speed and calculate the intensity of Wind Power can be generated.	II	4

7	Prepare report on important terms regarding wind generation.	II	2
8	Prepare technical report of visit to a nearby Solar power plant.	III	2
9	Prepare technical report of visit to a nearby Wind farm.	III	2
10	Prepare technical report on energy generation from biomass*	IV	2
11	Prepare technical report on tidal energy generation.		
Total			28

Sr. No. 6 is recommended to perform the same on simulator.

6 EQUIPMENT REQUIREMENT

- Pyranometer, Electromagnetic Radiation EMF Tester
- Solar panel with angle change arrangement
- Energy meter and multi-meters
- Solar panels (Polycrystalline and Monocrystalline) with different type of connector
- Anemometer
- Solar simulator

5 SUGGESTED STUDENT ACTIVITIES/ MICRO-PROJECTS

Other than the classroom and laboratory learning, following are the suggested studentrelated activities/ MICRO-PROJECTS 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:

1. Estimate the monthly energy consumption of your own family, include energy consumption from electricity, petrol, diesel, LPG, public transportation, etc. Make a brief report on it.
2. Visit near by PV cell manufacturing unit.
3. Debate on which energy sources to be promoted, students are to be divided in 4 or 5 groups, each group representing different source, each group presents their idea why that particular source should be promoted, the task of the whole class is to come to a conclusion on use of a particular source.
4. Debate on international agreements, protocol with respect to climate change.

6 UNDERPINNING THEORY

Unit	Major Learning Outcomes	Topics and Sub-topics	Hours
Unit I Need of Renewable Energy	1a. Classify different energy resources	1.1 Sources or Energy: classification of energy sources 1.2 Energy source usage sustainability issues ~~of energy use~~ 1.3 Economical aspects of renewable energy source.	4
	1b.	1.4 International convention on climate and role of non-renewable energy: • Kyoto protocol • Paris agreement, 1.5 The pledges of COP26:Sustainable development Goals (SDG)-2030 and India 1.6 Overview of India's energy scenario. 1.6.1 Non-Renewable energy Potential, Generation and Policy of India 1.6.2 Non-Renewable energy Potential, Generation and Policy of Gujarat	

Unit II Solar energy	2a. Solar PV technologies 2b. Solar irradiation measurement 2c. PV cell characteristics	2.1 Sun as a source of energy, units of solar energy 2.2 Solar spectrum- Photons of different energy. 2.3 Solar radiation: classification. 2.4.1 Radiation/insolation 2.4.2 Hourly, daily, monthly and yearly solar radiation. 2.4 Radiation measurement principles and forecasting 2.5 Radiation measuring instruments 2.6 Factor affecting on solar radiation. 2.7 Optimal collection of solar radiation: 2.8.1 Effect of motion of sun and earth 2.8.2 Maximum solar radiation collection by optimal angle of solar collectors 2.8.3 optimum angle for summer and winter 2.8 Solar radiation maps of India 2.9 Solar PV cell 2.10.1 Types of solar cell 2.10.2 Construction and working of solar cell 2.10.3 Important terms regarding solar cell 2.10.4 Measurement of misc. parameters. 2.11 Solar Cell, Module, Array and its rating 2.12 Solar cell characteristics, fill factor 2.13 Effect of Radiation , Temperature and angle on PV generation.	14
Unit III Wind energy		3.1 History of wind energy, Potential of Wind Energy in India. 3.2 Environmental merits and demerits of wind energy 3.3 Measurement of wind: 3.4.1 Ecological indicator 3.4.2 Anemometers and wind directions. 3.5 Wind speed statistics: Time and Frequency distribution,	8
		Mean wind speed and distribution of wind velocity. 3.4 Wind energy estimation, capacity factor 3.5 Power conversation in WPP, Wind Turbine power and torque characteristics, 3.6.1 Horizontal axis wind turbine 3.6.2 Vertical axis wind turbine. 3.6 Guidelines for Wind power plant site selection.	

Unit IV Ocean and Geothermal energy	4a. Classify Ocean energy 4b. Explain Ocean thermal energy 4c. Describe harvesting of geothermal energy	4.1 Introduction 4.2 Classification of ocean energy 4.3 Ocean Thermal Electric power generation 4.3.1 Types of Ocean Thermal Energy Conversion Systems 4.3.2 Open cycle OTEC 4.3.3 Close cycle OTEC 4.3.4 Hybrid cycle 4.3.5 Utilization of ocean energy 4.4 Tidal Energy 4.4.1 Characteristics of Tidal Energy 4.4.2 Utilization of Tidal Energy 4.4.3 Site selection 4.4.4 Tidal Energy Advantages and Disadvantages 4.5 Harvesting geothermal energy 4.5.1 Geothermal resources 4.5.2 Prime movers for Geothermal energy conversion 4.5.3 Geothermal Advantages and Disadvantages 4.5.4 Application of Geothermal energy	8
Unit VI Biomass energy	5a. Classify biomass for generation of biogas 5b. Describe the process of Gasification and biogas generation	5.1 Introduction 5.2 Classification of biomass 5.3 Thermal gasification of Biomass 5.3.1 Chemistry of gasification process 5.3.2 Classification of biomass gasifiers 5.3.3 Application of Gasifiers 5.4 Biogas generation 5.4.1 Formation of biogas 5.4.2 Different types of Biogas plants 5.4.3 Building a biogas plant 5.4.4 Utilization of biogas for the generation of electric power and heat 5.4.5 Biogas combustion and emissions 5.4.6 Advantages of a biogas plant	8

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*

7 SUGGESTED SPECIFICATION TABLE FOR QUESTIONPAPER DESIGN

Unit	Unit Title	Teaching Hours	Distribution of Theory Marks			
			R Level	U Level	A Level	Total Marks
I	**Need of Renewable Energy**	4	4	4	0	8
II	**Solar energy**	14	6	6	8	20
III	**Wind energy**	8	8	6	4	18
IV	**Ocean and Geothermal energy**	8	6	6	2	14
V	**Biomass energy**	8	4	4	2	10
Total		**42**	28	26	16	**70**

8 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.
c) Show animation/ video related to course content.
d) Co-relating the importance of content of this course with other courses/ practical applications. (e.g. importance of a content in course or whole course related to A.C. Machines, Transmission and Distribution of Electrical Power, Energy Conservation Switchgear and Protection etc. and in practical industrial &/ domestic applications.
e) Guide students on how to address issues on environment and sustainability

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 **1214**

(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 showing working principle of renewable energy generation
b) Prepare mini working model of solar panel with small load.
c) Prepare mini working model of wind plant with small load.
d) Prepare technical data sheet of 1 KW solar power panel.

13. SUGGESTED LEARNING RESOURCES

1) Non-Conventional Energy Sources, Khanna Publishers, by G. D. Rai ISBN: 9788174090737, 9788174090737
2) Solar Photovoltaics: Fundamentals, Technologies and Applications, by Chetan Singh Solanki ISBN 8120351118, 9788120351110
3) Solar Energy : - Principles of thermal collection and storage - by S.P. Sukhatame, Tata McGrow Hills, ISBN, 0070142963, 978007014296
4) Fundamentals Of Wind Energy Utilization by Dr. A G Powar and Er. A G Mohod, Jain Brothers-new Delhi, ISBN: 9788183601337

14. SOFTWARE/LEARNING WEBSITES

1. https://impactful.ninja/renewable-vs-alternative-energydifferences/#:~:text=Renewable%20energy%20generation%20comes%20from,to%20figh t%20global%20climate%20change.
2. https://byjus.com/physics/non-conventional-sources-of-energy-ocean-thermalenergy/#:~:text=Ocean%20thermal%20energy%20conversion%20is%20an%20electricity %20generation,run%20a%20heat%20engine%20and%20produce%20useful%20work.
3. https://www.vedantu.com/physics/tidal-energy
4. http://www.ener-supply.eu/downloads/ENER_handbook_en.pdf
5. https://www.energy.gov/eere/forge/geothermal-basics
6. https://www.researchgate.net/figure/Classification-of-biomass_fig1_330484204
7. https://www.agrifarming.in/biogas-production-process-working-principles-plantcost
8. https://www.researchgate.net/publication/242363939_Thermochemical_conversion_of_biomass

9. https://www.nrel.gov/docs/fy01osti/27955.pdf
10. https://interactives.ck12.org/simulations/physics/wind-turbine/app/index.html
11. http://www.greenrhinoenergy.com/renewable/wind/wind_environment.php

15. PO-COMPETENCY-CO MAPPING:

Semester I	**Basics of Renewable Energy (Course Code: 1316402)**						
	POs						
Competency & Course Outcomes	PO 1 Basic & Discipline specific knowledge	PO 2 Problem Analysis	PO 3 Design / development of solution	PO4 Engineering Tools, Experimentation & Testing	PO 5 Engineering practices for society, sustainability & environment	PO 6 Project Management	PO 7 Life-long learning
Competency	**Apply basic concepts, laws and principles about the renewable energy sources for sustainable development**						
Course Outcomes CO1. Interpret scenario of non-renewable energy in India	3	-	-	-	3	-	2
CO2. Interpret principle of solar energy systems	2	2	-	3	3	-	2
CO3. Describe the wind energy conversion system.	2	-	2	-	3	-	2
CO4. Compare biomass, Ocean and Geothermal energy conversion.	2	2	2	-	2	-	2
CO5. Promote the use of renewable energy sources	2	2	-	-	-	-	2

16. COURSE CURRICULUM DEVELOPMENT COMMITTEE

GTU Resource Persons

Sr. No.	Name and Designation	Institute	Contact No.	Email
1.	Dr. V S Tejwani Lecturer-Electrical Engg.	Government Polytechnic, Jamnagar	9428569904	vstejwani@gmail.com
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