



GUJARAT TECHNOLOGICAL UNIVERSITY

Program Name: Bachelor of Engineering

Level: UG

Branch: Electrical Engineering

Subject Code: BE05009051

Subject Name: Renewable Energy Technology

w.e.f. Academic Year:	2024-25
Semester:	5
Category of the Course:	Professional Elective Course - 1

Prerequisite:	Not Applicable
Rationale:	Growing energy demand, depletion of fossil fuels, and environmental concerns have accelerated the adoption of renewable energy technologies. Electrical engineers must understand the principles, operation, and integration of renewable energy systems into modern power networks. This course provides fundamental knowledge of solar, wind, biomass, geothermal, tidal, hydrogen energy, and energy storage systems. It enables students to analyze and apply renewable energy technologies for sustainable power generation and distributed energy applications.

Course Outcome:

After Completion of the Course, Student will able to:

No	Course Outcomes
01	Explain principles of renewable energy sources, their availability in India, and impacts compared to conventional energy.
02	Analyze solar energy systems, including thermal/electrical generation, radiation measurement, and PV applications like MPPT.
03	Evaluate wind energy conversion systems (WECS), including turbine components, generators, and site-specific power estimation
04	Compare tidal, ocean thermal, hydrogen energy, and fuel cell technologies with respect to operating principles, advantages, limitations, and practical applications.
05	Design and justify suitable renewable energy and energy storage solutions for distributed generation and bulk power applications.

Teaching and Examination Scheme:

Teaching / Learning Scheme (in Hours per semester)					Total Credits	Assessment Pattern and Marks					Total Marks
L	T	P	PBL	Total no of hours per semester		Theory		Tutorial / Practical			
						ESE (E)	PA / CA (M)	PA/ CA (I)	PBL (I)	ESE (V)	
45	0	30	15	90	3	70	30	20	30	50	200

Where L = Lecture, T= Tutorial, P= Practical, TW/SL = Term-Work / Self-Learning, TH = Total Hours, ESE = End-Semester Examination, PA = Progressive Assessment

Course Content:

w.e.f. 2026-27

<https://syllabus.gtu.ac.in/>

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Unit No.	Content	No. of Hours	% of Weightage
1.	Renewable Energy: Conventional energy Sources and its Impacts, Non-conventional energy–Sources, Seasonal variations and availability, Principles of renewable energy; energy and sustainable development, worldwide renewable energy scenario, renewable energy availability in India, Distributed energy systems and dispersed generation (DG).	04	10
2.	Solar Energy: Fundamentals; Solar Radiation; Estimation of solar radiation on horizontal and inclined surfaces; Solar radiation Measurements- Pyrheliometers, Pyrometer, Sunshine Recorder. Solar Thermal systems: Flat plate collector; Solar distillation; Solar pond electric power plant. Solar electric power generation- Principle of Solar cell, Photovoltaic system for electric power generation, advantages, Disadvantages and applications of solar photovoltaic system, Effects of Shadowing-Partial and Complete Shadowing, Series and parallel connections, Cell mismatching, Maximum power point tracking.	08	20
3.	Wind Energy: Properties of wind, availability of wind energy in India, wind velocity and power from wind; major problems associated with wind power, Basic components of wind energy conversion system (WECS); Classification of WECS. wind turbine control systems; conversion to electrical power: Generators used in WECS.	08	15
4.	Biomass Energy: Introduction; Photosynthesis Process; Biofuels; Biomass Resources; Biomass conversion technologies-fixed dome; Urban waste to energy conversion; Biomass gasification (Downdraft). Geothermal energy: Introduction, Nature of geothermal fields, Geothermal resources, Hydrothermal (convective) Resources, Geo pressured resources, Hot dry rock resources of petro-thermal systems, Magma resources-Interconnection of geothermal fossil systems, Advantages and disadvantages of geothermal energy over other energy forms	07	15
5.	Tidal Power: Tides and waves as energy suppliers and their mechanics; fundamental characteristics of tidal power, harnessing tidal energy, advantages and limitations. Ocean Thermal Energy Conversion: Principle of working, OTEC power stations in the world, problems associated with OTEC.	07	15



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6.	Green Energy: Introduction, Fuel cells: Classification of fuel cells; Operating principles of fuel cells. Benefits of hydrogen energy, hydrogen production technologies (electrolysis method only), hydrogen energy storage, applications of hydrogen energy, problem associated with hydrogen energy.	06	15
7.	Energy Storage System: Basic Battery Theory, Battery Fundamental Characteristics, Different Types of Battery Arrangement, Classification of Batteries, Advantages of Batteries for Bulk Energy Storage	05	10
Total		45	100

Suggested Specification Table with Marks (Theory):

Distribution of Theory Marks					
R Level	U Level	A Level	N Level	E Level	C Level
20	30	20	20	10	0

Where, R: Remember; U: Understanding; A: Application, N: Analyze and E: Evaluate C: Create (as per 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.

The syllabus of Renewable Energy Technologies directly contributes to following SDG's

SDG 1&2	No Poverty & Zero Hunger: These goals focus on basic needs and rural development. Rural Electrification: Designing standalone solar systems for rural housing. Biomass Energy: Using agricultural waste for power through biomass gasification. Impact: Providing energy to remote areas supports local economies and food processing.
SDG 3	Good Health and Well-being: This goal relates to reducing pollution-related illnesses. Conventional Energy Impacts: Studying the environmental harm of fossil fuels. Clean Power: Using Solar and Wind to reduce air pollution. Impact: Lower carbon emissions lead to cleaner air and better respiratory health.
SDG 4	Quality Education: This focuses on technical skills and specialized training. Entire Syllabus: Training Electrical Engineers in future-proof technologies. Practical Skills: Learning to measure solar radiation and simulate hybrid systems.



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	Self-Learning: Using NPTEL and IEEE resources for technical depth.
SDG 7	Affordable and Clean Energy : This is the core focus of the entire course. Unit 2 & 3: Solar and Wind energy conversion systems. Unit 5: Tidal and Ocean Thermal Energy (OTEC). Distributed Generation: Making energy available locally without large grid reliance.
SDG 9	Industry, Innovation, and Infrastructure: This focuses on upgrading technology and industrial processes. Green Energy: Hydrogen production, storage, and fuel cell technologies. Grid Integration: Synchronization of renewables with modern power networks. Energy Storage: Advanced battery systems (Lead-Acid vs. Li-ion).
SDG 11	Sustainable Cities and Communities: This relates to urban management and resilience. Waste to Energy: Converting urban waste into usable biomass energy. Microgrids: Designing resilient energy storage for local communities. Sustainable Development: Principles of renewable energy for city planning.
SDG 12	Responsible Consumption and Production: Focuses on resource efficiency and lifecycle. Energy Storage Systems: Comparing battery life cycles and standards (BIS Standards). System Justification: Designing solutions that balance load and peak management. Solar Distillation: Efficiently using solar energy for clean water production.
SDG 13	Climate Action: Focuses on urgent action to combat climate change. DE carbonization: Moving from fossil fuels to hydrogen and green energy. Environmental Concerns: The rationale for accelerating renewable adoption. Policy Research: Studying national renewable energy policies in India.

References / Suggested Learning Resources:

Books:

1. Solar Energy Principles, Thermal Collection & Storage, S.P.Sukhatme: Tata McGraw Hill Pub., New Delhi.
2. Renewable Energy- Power for a Sustainable Future, Godfrey Boyle, Oxford University Press.
3. Non-Conventional Energy Resources, B. H. Khan, Tata McGrawHill.
4. Non-Conventional Energy Sources, G.D.Rai, Khanna Publishers, New Delhi.
5. Wind Electrical Systems, S. N. Bhadra, D. Kastha, S. Banerjee, Oxford University Press.
6. Renewable Energy Sources and Their Environmental Impact, S. A. Abbasi, N. Abbasi, Prentice Hall of India, New Delhi.
7. Non-Conventional Energy Resources by Shobh Nath Singh, Pearson India.

Suggested Course Practical List:

1. To study and measure solar radiation using a pyranometer/sunshine recorder and compare with theoretical



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- estimation methods.
2. To calculate solar radiation on horizontal and inclined surfaces for a given location using standard solar angles and radiation models.
 3. To study the I–V and P–V characteristics of a solar photovoltaic (PV) module under varying irradiation and temperature conditions.
 4. To analyze the effect of partial and complete shading on the performance of a solar PV system.
 5. To implement and study Maximum Power Point Tracking (MPPT) techniques for a photovoltaic system (simulation or hardware-based).
 6. To study the basic components and working of a Wind Energy Conversion System (WECS) and determine power output for given wind speeds.
 7. To study biomass energy conversion systems, including downdraft gasifier models (demonstration/simulation-based).
 8. To study the working and performance characteristics of a fuel cell and analyze its V–I characteristics.
 9. To study hydrogen production by electrolysis method and analyze efficiency considerations (demonstration/simulation-based).
 10. To study battery characteristics including charging, discharging curves, and different battery configurations for energy storage applications.
 11. To simulate a hybrid renewable energy system (e.g., Solar–Wind–Battery system) using MATLAB/Simulink/Scilab or equivalent open-source software.
 12. To compare tidal and OTEC power generation systems through case study analysis and performance evaluation.
 13. To study and understand the variability nature of renewables and its effect on power system operation.
 14. To study the challenges of synchronization of renewable generation sources with grid and its Impact on operation of power systems

Design based Problems (DP)/Open Ended Problem:

1. Design a standalone solar photovoltaic system to supply power to a rural house
2. Design a PV-Wind based hybrid renewable energy system
3. Design a small-scale biomass gasifier-based power plant
4. Design a hydrogen-based energy storage system integrated with a solar plant for peak load management.
5. Design an energy storage system for a renewable-based microgrid

These problems may be done on paper by hand and/or using some simulation software.

Major Equipment:

1. Solar Photovoltaic (PV) Training Kit (with panel, charge controller, inverter, and load setup)
2. Solar Radiation Measuring Instruments
Pyranometer
Pyrheliometer
Sunshine Recorder
3. Solar Thermal Demonstration Setup
Flat Plate Collector Model
Solar Water Heating System



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- Solar Distillation Unit (Model)
- Maximum Power Point Tracking (MPPT) Trainer Kit
 - Wind Energy Conversion System (WECS) Trainer Kit
Wind Turbine Model with Generator
Wind Speed Indicator / Anemometer
 - Biomass Energy Demonstration Setup
Biomass Gasifier Model (Downdraft Type)
Biogas Plant Model (Fixed Dome Type)
 - Fuel Cell Trainer Kit
 - Hydrogen Production by Electrolysis Demonstration Kit
 - Battery Energy Storage System (BESS) Setup
Different types of batteries (Lead-Acid / Li-ion)
Charge–Discharge Test Bench
 - Hybrid Renewable Energy System Trainer
(Solar–Wind–Battery Integrated System)
 - Computer Systems with Simulation Software like MATLAB/Simulink / Scilab / Open-source renewable energy

List of Open-Source Software/learning website:

Learning website

- <https://nptel.ac.in/courses/103103206> - Renewable Energy Engineering: Solar, Wind And Biomass Energy Systems, IIT Guwahati
- <https://nptel.ac.in/courses/103101215> - Hydrogen Energy: Production, Storage, Transportation and Safety, IIT Bombay

Activities Suggested for Self-Learning:

Sr. No		Activity	Suggested Hours	Evaluation Criteria
1	Industry Visit	Industry Visit to Solar Plant / Wind Farm / Biomass Power Plant	Visit: 5h Report: 5h Total: 10h	Quality of report, understanding of plant components, system operation analysis, and observations
2	Video Based Learning	Technical Video-Based Learning (NPTEL/IEEE) on Solar PV, MPPT, Fuel Cells, or Energy Storage	Video: 5h Report/Presentation: 5h Total: 10h	Conceptual clarity, summary quality, technical depth, presentation skills



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		Online Certification Course (Minimum 10h) in Renewable Energy Domain	10h	Course completion certificate and performance in quiz/assessment
3	Complex Problem-Solving / Mini Project	Solar Radiation Data Collection & Analysis for a Selected Location	Data Collection & Calculation: 10h	Accuracy of calculations, use of proper methodology, interpretation of results
4	Mini Project / Simulation	Simulation of Renewable Energy System (PV/Wind/Hybrid) using MATLAB/Scilab	Simulation: 10h	Correct system modeling, simulation outputs, documentation, result interpretation
5	Case Study Analysis / Seminar	Case Study on National Renewable Energy Policies (India)	Research: 6h Report: 4h Total: 10h	Depth of analysis, comparison of policies, technical relevance, clarity
6	Design Assignment	Design Assignment: Standalone Solar System or Hybrid System	Design & Calculation: 10h	Proper sizing methodology, justification of assumptions, technical correctness
7	Research Paper Review / Analysis	Comparative Study of Energy Storage Technologies and its standards (Lead-Acid vs Li-ion vs Hydrogen)	Research: 6h Presentation: 4h Total: 10h	Technical comparison, lifecycle analysis, feasibility discussion, BIS Standards of battery
8	Research Paper Review / Analysis	Patent Search on Renewable Energy Technologies	Research & Analysis: 10h	Number of patents reviewed, identification of innovation trends, originality
9	Research Paper Review / Analysis	Technical Article / Blog Writing on Emerging Renewable Technology	Research: 6h Writing: 4h Total: 10h	Technical accuracy, originality, clarity of explanation
10	Micro Project	Mini Working/Non-Working Model (Solar Tracker / Mini Wind Turbine Model)	Working: 12h Non-working: 8h	Innovation, design approach, functionality (if working), demonstration & explanation
11	Group Discussion	Group Discussion on Emerging Trends (Green Hydrogen, Smart	1h per session	Depth of knowledge, participation, technical



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	/ Quiz	Grids, Microgrids)		terminology usage
12	Research Paper Review / Analysis	Grid codes and government policies for the integration of renewables to Grid	06 Hrs	Students /group of students should learn the latest govt. policies and grid codes and give presentation and submit report
13	Research Paper Review / Analysis	BIS standards of Solar PV and its accessories	10 Hrs	Based on BIS standards of PV Solar and its accessories like converter, inverter, transformer, its Earthing etc...for various applications.

Note:

- All the suggested activities should be related to the course contents/ Topics.
- The number of hours is suggestive. Faculty can sub-divide the number of hours based on the activity. However, total number of hours is fixed.
- Rubrics for the evaluation can be prepared by the faculty and disclose to the students well in advance.
- All records pertaining to the evaluation and assessment of self-learning activities must be properly maintained and preserved at the institute level. These records should be made available to the university upon request.
- Institutes are encouraged to utilize digital platforms, such as Microsoft Teams, for effective record-keeping and to ensure transparency in the evaluation and assessment of self-learning activities.
