GUJARAT TECHNOLOGICAL UNIVERSITY

Program Name: Bachelor of Engineering
Level: UG
Branch: ALL (Except Chemical Engineering and Allied Branches)
Subject Code: BE05000561
Subject Name: Sustainable Energy Technology

w. e. f. Academic Year:	2024-25
Semester:	5
Category of the Course:	MOPEC-Mandatory Open Elective Courses

Prerequisite:	Basic knowledge of physics, mathematics and thermodynamics
Rationale:	Rapid depletion of fossil fuels and climate change concerns necessitate sustainable energy solutions. This course introduces energy sustainability concepts, SDGs, conventional and renewable energy sources, emerging technologies, energy management, and modern trends aligned with the latest technology.

Course Outcome:

After completion of the course, student will able to:

No	Course Outcomes
01	Explain sustainability concepts, role of energy and energy-related SDGs.
02	Understand conventional energy sources and their applications.
03	Understand non-conventional/renewable energy sources and their applications.
04	Evaluate emerging technologies for energy generation.
05	Apply energy management and conservation techniques.

Teaching and Examination Scheme:

Teaching/Learning Scheme in hrs/semester					Total Credits	Assessment Pattern and Marks					Total Marks
						Theory		Practical			
L	T	P	PBL*	TH	TH/30	ESE (E)	PA (M)	PA (I)	PBL(I)	ESE (V)	
45	0	00	15	60	2	70	30	0	30	0	130

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

*** Problem Based Learning (PBL) aims to accommodate learning beyond syllabus as per clause 9.4 of NBA manual.**

Course Content:

Unit No.	Content	No. of Hours	% of Weightage
1.	**Introduction:** Global energy scenario and sustainability challenges, limitations of conventional energy sources, need for clean and renewable energy technologies, emerging energy generation technologies, role of energy storage and conversion systems, energy transition, decarbonization, and net-zero targets, importance of sustainable energy in economic development, United Nations Sustainable Development Goals (SDGs), Affordable and Clean Energy (SDG 7), energy policies supporting SDG.	**7**	**15**

2.	**Energy generation sources:** **Conventional energy sources:** Fossil fuels: properties, extraction, utilization, and environmental impacts; Thermal power plants – working principle, efficiency, environment impact; Nuclear energy: basic principle, types of reactors, advantages and limitations. **Non-Conventional / Renewable energy sources:** Solar energy: solar radiation, solar thermal systems, photovoltaic systems, applications; Wind energy: wind energy conversion systems, wind turbines, onshore and offshore wind farms; Biomass energy: biogas plants, biofuels, waste-to-energy concept; Other renewable sources: hydropower, geothermal and ocean energy; Advantages and limitations of renewable energy sources.	**10**	**25**
3.	**Emerging Technologies for energy generation:** **Hydrogen energy**: fundamentals, hydrogen as an energy carrier, advantages and limitations of hydrogen energy, safety, storage, and transportation of hydrogen; Green hydrogen – concept, significance, grey, blue, and green hydrogen; Hydrogen production methods – Conventional techniques: Steam Methane Reforming, coal gasification, partial oxidation and autothermal reforming, Renewable and low-carbon hydrogen production: water electrolysis, biomass gasification, photo electrochemical water splitting, biological methods; **Electrolyzer Technologies**: Introduction, working principle, types of eletrolyzers, advantages and limitations. **Fuel cell technology**: Concept of fuel cell, working principle, component of fuel cell, comparison of fuel cells with batteries and IC engines, different types of fuel cell, fuel-cell electric vehicle, advantages and limitations.	**10**	**25**
4.	**Energy generation from waste:** Concept and importance of energy recovery from waste, sources of waste, environmental aspects; Thermal Conversion Technologies-incineration, pyrolysis, gasification, comparison of the thermal conversion technologies; Biological Conversion Technologies- Anaerobic digestion, biogas generation, Landfill gas recovery, fermentation processes for bioenergy; Refuse-Derived Fuel (RDF) and Co-processing – RDF preparation and quality parameters, co-processing of waste in cement kilns and boilers; Waste heat recovery, waste heat recovery methods and devices, economic benefits.	**10**	**20**
5.	**Energy management and conservation:** Introduction, energy management systems (EMS), Energy regulations and standards, ISO 50001, 50002, energy conservation techniques in industry, economic analysis of conservation measures; Energy audit - introduction, role of energy audit in sustainable development, Types of energy audit, steps involved in energy audit, instruments used, report preparation, case study.	**8**	**15**
	Total	**45**	**100**

Overall Course SDG Mapping:

The course as a whole primarily addresses **SDG 7: Affordable and Clean Energy**, **SDG 9: Industry, Innovation and Infrastructure**, **SDG 11: Sustainable Cities and Communities, SDG 12: Responsible Consumption and Production**, and **SDG 13: Climate Action** through comprehensive coverage of emerging clean energy technologies and climate mitigation strategies.

Suggested Specification Table with Marks (Theory):

Distribution of Theory Marks					
R Level	**U Level**	**A Level**	**N Level**	**E Level**	**C Level**
10	**25**	**15**	**10**	**10**	**---**

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.

References/Suggested Learning Resources:

(a) Books:

1. B. H. Khan, Non-Conventional Energy Resources, McGraw Hill Education.
2. S. Rao and B. B. Parulekar, Energy Technology, Khanna Publishers.
3. G. D. Rai, Non-Conventional Energy Sources, Khanna Publishers
4. General aspects of energy management and energy audit, Bureau of Energy Efficiency, 4th ed. 2015.
5. D.P.Kothari, K.C.Singal, R. Ranjan, Renewable Energy Sources and Emerging Technologies, PHI Pub.

(b) Open source software and website:

1. Students can refer to video lectures available on the websites including NPTEL.
2. Students can refer to the website (www.beeindia.gov.in) for energy management and audit.

List of suggested activities for Problem based Learning:

Sl. No.	Activity	No. of hours	Total hours claimed	Evaluation criteria
1	Assignments on topics based on sustainable energy technology	Five assignments (2h each)	**10**	Quality of submitted assignment.
2	Literature Review: Review 3–5 research papers on non-renewable energy, energy management, emerging technologies and other related topics and prepare a report.	Literature review: 5h Report preparation: 5h	**10**	Relevance of papers, depth of research papers reviewed, technical analysis, Quality of report.
3	Developing posters, charts or PowerPoint presentations on topics related to emerging sustainable technologies.	Study and in-depth analysis of content: 4h Preparation and presentation of visual content: 1h	**5**	Quality of topic researched and presentation.
4	Technical video based learning related to subject and report preparation.	Duration of video: 4h, report preparation: 1h.	**5**	Quality of technical video based learning and report prepared.

5	Energy audit of an industry.	Energy audit report	**10**	Quality of the energy audit work and report submitted.
6	Self-learning on-line course.	Min. Duration of the course should be 10h	**10**	On submission of certificate of completion.
7	Development of physical model	Model development: working 10h, non-working 5h	**5/10**	Quality of model developed and explanation.
8	Industry visit	Industry visit: 5h, Report preparation: 5h	**10**	Quality of observations made and detail report submitted.
9	Case study	Data collection, case analysis: 5h Report preparation: 5h	**10**	Understanding and analysis of the selected case and report submitted.

- Above activities are suggestive, faculty can choose any of these activities.
- The number of hour is suggestive. Faculty can sub-divide the number of hours based on the activity. However, the total number of hours is fixed.
- 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 problem based learning.

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