GUJARAT TECHNOLOGICAL UNIVERSITY

Program Name: Master of Engineering

Level: PG

Branch: Chemical Engineering

Course / Subject Code: ME03030021

Subject Name: Renewable Energy Engineering: Solar, Wind And Biomass Energy Systems

w. e. f. Academic Year:	2024-25
Semester:	3
Category of the Course:	MOPEC

Prerequisite:	Students should have a basic knowledge of renewable energy systems.
Rationale:	This course standardises material on non-conventional energy sources like solar, wind, and biomass, emphasising their importance in clean energy. It focuses on engineering and design aspects, highlighting advancements in these technologies. Students will learn about biomass types, classifications, selective utilization, bio-digester, wind machine, and thermo-digester design.

Course Outcome:

After Completion of the Course, Student will able to:

No	Course Outcomes
01	Understand the fundamental principles of solar energy, including solar radiation components, Earth-Sun geometry, and methods for solar radiation measurement and estimation.
02	Analyze the performance and design parameters of solar collectors, including flat plate and parabolic collectors, to assess their efficiency and the impact of various factors on their functionality.
03	Demonstrate knowledge of wind energy systems, including wind power estimation, turbine dynamics, energy storage, and environmental impact, with a focus on system integration and hybrid setups.
04	Explore biomass energy conversion technologies, including biochemical and thermochemical methods, with emphasis on process mechanisms, parameters, and product properties for sustainable energy solutions.

Teaching and Examination Scheme:

Teaching Scheme(in Hours)			Total Credits L+T+ (PR/2)	Assessment Pattern and Marks				Total Marks
				Theory		Tutorial / Practical		
L	T	PR	C	ESE (E)	PA / CA (M)	PA/CA (I)	ESE (V)	
3	0	0	3	70	30	0	0	100

Course Content:

Unit No.	Content	No. of Hours	% of Weightage
1.	**Solar Energy:** An overview of thermal applications. **Solar radiation**: Extraterrestrial solar radiation, Components of radiation, Geometry of the Earth and Sun, Geometry of collector and the solar beam, Effects of the Earth's atmosphere, Measurements and estimation of solar radiation, Practice problems of solar energy.	4	9
2.	**Solar collector:** classification of solar collector, Performance Indices, **Non-concentrating solar collectors:** Liquid flat plate collector, Material Selection, Flat plate air heating collector, Evacuated Tube Collector, performance analysis, transmissivity of the cover system, overall loss coefficient and heat transfer correlation. Collector efficiency factor, collector heat removal factor, Effect of Various Parameters on Performance.	4	9
3.	**Parabolic solar collectors:** Modified Flat Plate Collector, Compound Parabolic Concentrator, Cylindrical Parabolic Concentrator, Fixed Mirror Solar Concentrator, Linear Fresnel Lens Collector, Paraboloidal Dish Collector, Hemispherical Bowl Mirror Concentrator, Circular Fresnel Lens Concentrator, Central Tower Receiver, geometry, performance analysis, and loss calculation.	4	9
4.	**Thermal energy storage systems:** Introduction, sensible heat storage, latent heat storage, Thermochemical storage, Photovoltaic generation, Solar energy utilization methods, problem-based on thermal energy storage.	4	9
5.	**Wind power:** Introduction, Factors Affecting the Distribution of Wind Energy on the Surface of Earth, Estimation of Wind Energy at a Site, Turbine types and terms, Linear momentum and basic theory, Dynamic matching, Blade element theory, Characteristics of the wind, Power	4	9

	extraction by a turbine, Electricity generation, Mechanical power, Application of wind power, Examples based on wind power.		
6.	**Wind energy conversion**: Wind energy conversion system, Wind diesel hybrid system, system integration, wind energy storage, Environmental impact, Characteristics and Power Generation from Wind Energy, Practice problems	4	9
7.	**Biomass Energy**: Classification of energy resources, Photosynthesis process, Usable forms of biomass, their composition and fuel properties, Broad classification and compositional analysis, Characteristics of biomass, Physical and thermodynamic properties of biomass, Properties and structural components of biomass, biomass composition expression.	4	9
8.	**Biomass conversion:** Biomass residues and energy conversion routes: Utilisation of biomass through biochemical and thermo-chemical routes, Motivation for biomass conversion	4	9
9.	**Biogas:** Conversion mechanism of biomass to biogas and its properties, Classification of biogas plants, Practice problems **Bioconversion:** Bioconversion of substrates into alcohol	4	9
10.	**Thermo-chemical conversion:** Thermo-chemical methods such as torrefaction, combustion and pyrolysis, process stages, mechanism, process parameter impact and properties of product and technology involved. Design consideration of torrefaction, combustion and pyrolysis.	5	9
11.	**Gasification:** Theory, process steps and types, gasification process in reactor, kinetics of gasification. Models of gasification, practice problems.	4	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**
5	25	15	10	10	5

Where R: Remember; U: Understanding; A: Application, N: Analyze and E: Evaluate C: Create (as per Revised Bloom's Taxonomy)

References/Suggested Learning Resources:

(a) Books:

- Sukhatme S. P., Nayak J. K., Solar Energy: Principles of thermal Collection and Storage, 3 rd Ed., Tata McGraw-Hill Education Pvt. Ltd 2008.
- Twidell, J. and Tony W., Renewable Energy Resources, 2 nd Edition, Taylor & Francis 2006.
- Khan B. H., Non-Conventional Energy Resources, 2 nd Edition, Tata McGraw-Hill Education Pvt. Ltd. 2009.
- Prabir Basu, Biomass Gasification, Pyrolysis and Torrefaction, Academic Press, Elsevier, 2013.

(b) Open-source software and website:

To enhance learning, students can use the following open-source software tools and websites for modelling and simulation in renewable energy system.

- Open-Source Software
- OpenFOAM: For chemical kinetics, thermodynamics, and transport processes.
- Reaction Mechanism Generator: Generates detailed kinetic mechanisms for thermochemical processes.
- BioRT: Biomass reaction modelling tool that supports pyrolysis kinetics.
- PVWatts: Tool for estimating the energy production of grid-connected solar PV.
- OpenModelica: Modeling and simulation environment for renewable energy.
- PVLib: A Python library for modeling solar photovoltaic systems.

Websites and Resources

- NPTEL MOOC course: https://onlinecourses.nptel.ac.in/noc25_ch40/preview

Suggested Activities for Students:

- Energy Storage Solutions for Solar Power
- Building Integrated Photovoltaics (BIPV)
- Solar-Powered Desalination Plant
- Solar Thermal Energy for Industrial Applications
- Advanced Solar Panel Design
- Solar-Powered Microgrid
- Floating Wind Turbines
- Grid Integration of Wind Energy
- Vertical Axis Wind Turbine (VAWT) Development
- Wind Energy Forecasting Using Machine Learning
- Advanced Wind Turbine Materials

- Optimization of Wind Turbine Blade Design
- Kinetic Modeling of Biomass Combustion
- Design of a Small-Scale Biomass Gasifier
- Comparative Study of Biomass Feedstocks for Thermochemical Conversion
- Development of Biochar-Based Catalysts
- Torrefaction of Biomass for Improved Gasification
- Techno-Economic Analysis of Biomass-to-Fuel Pathways
- Modeling and Simulation of Biomass Conversion Systems
- Bio-Synthetic Natural Gas (Bio-SNG) Production
- Catalytic Upgrading of Pyrolysis Bio-Oil

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