GUJARAT TECHNOLOGICAL UNIVERSITY

Program Name: Master of Engineering

Level: PG

Subject Code: ME03072031

Subject Name : Alternative Energy Utilization for Sustainable Process

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

Prerequisite:	Basic knowledge of energy sources
Rationale:	This course standardizes information on non-traditional energy sources such as solar, wind, and biomass, highlighting their significance in clean energy systems. It centers on the technical aspects of engineering and design, showcasing breakthroughs in these areas. In this course, students will study the various types of biomass, their classifications, and how to use them selectively. Design of various energy systems is also incorporated.

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. Analyze the performance and design parameters of solar collectors, to assess their efficiency and the impact of various factors on their functionality.
02	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.
03	Explore biomass energy conversion technologies, including biochemical and thermochemical methods, with emphasis on process mechanisms, parameters, and product properties for sustainable energy solutions.
04	Analyze the performance and design parameters of fuel cells
05	Apply various alternative green energy sources in process systems

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:** Solar radiation, flat plate collectors, solar concentration, thermal applications of solar energy, photovoltaic technology and applications, energy storage.	5	10
2.	**Solar collector:** Solar cell and its function, solar technologies, solar cell parameters, efficiency of solar cell, solar PV module, rating of solar PV module, PV module parameters, efficiency of PV module, measuring module parameters, connection of PV module in series and parallel, estimation and measurement of PV module power, selection of PV module. Types of solar PV system, design methodology for SPV system, design of off grid solar power plant, design and development of solar street light and solar lantern.	5	10
3.	**Wind power:** Introduction, Factors Affecting the Distribution of Wind Energy on the Surface of Earth, Estimation of Wind Energy at a Site, Application of wind power. Types of wind mills and their characteristics. Mechanics of wind mills. Design of wind mills.	5	10
5.	**Other Alternate Sources**: Geothermal, ocean thermal energy conversion, Tidal, Wave energy, MHD, environmental issues of energy services.	3	10
5.	**Biogas:** Conversion mechanism of biomass to biogas and its properties, Classification of biogas plants, Utilisation of biomass through biochemical and thermo-chemical routes, Design of biogas systems, Economics of biogas utilization. Biofuels.	5	10
6.	**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	10
7.	**Gasification:** Theory, process steps and types, gasification process in reactor, kinetics of gasification. Models of gasification, design aspects	5	10
8.	**Green techniques for energy conservation:** Introduction, ultrasound, microwave, cavitation, plasma technology, other non-conventional energy sources and their applications.	5	10
10.	**Hydrogen and Fuel Cell Technology:** Introduction to hydrogen energy, various hydrogen production methods, types of electrolyzer: proton-exchange membrane, alkaline, solid oxide, alkaline, microbial, efficiency, open circuit voltage, and losses, type of fuel cells: proton-exchange membrane, alkaline, anion exchange membrane, solid oxide,	7	20

	microbial, storage, fueling fuel cell, component of fuel cells, fuel cell calculations, design of integrated hydrogen energy systems, fuel-cell electric vehicle and applications		
	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. 20010.
- Prabir Basu, Biomass Gasification, Pyrolysis and Torrefaction, Academic Press, Elsevier, 2013.
- B Sorensen, G Spazzafumo, Hydrogen and Fuel Cells: Emerging Technologies and Applications, 3 rd Edition, Academic Press, 2018.

(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_ch50/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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