L	T	P	Credit	Area		CWS	PRS	MTE	ETE	PRE
3	0/1	2/0	4	DEC/GEC		15/25	25	20/25	40/50	-

Objective: To enable the students to understand the fundamental of clean energy, sustainability. To impart in-depth knowledge of solar energy, wind energy, biomass energy and energy storage systems.

Syllabus		Contact Hours
Unit-1	**Introduction to Clean Energy and Sustainability.** Overview of global energy demand and its environmental impacts; Concept of sustainability and carbon neutrality; Classification of energy resources: Conventional vs Non-conventional; Importance of clean energy in mitigating climate change; Policies, international agreements, and regulatory frameworks promoting clean energy (e.g., Paris Agreement, SDGs)	**8**
Unit-2	**Solar Energy Technologies.** Solar radiation fundamentals and measurement; Photovoltaic (PV) technology: Types of solar cells, working principle, and advancements; Concentrated Solar Power (CSP): Parabolic troughs, solar towers, Fresnel reflectors; Solar thermal applications: Water heating, space heating, and solar drying systems; Case studies on solar power plants and solar microgrids	**8**
Unit-3	**Wind Energy Systems.** Wind Energy: Basics of wind power, aerodynamics of wind turbines, types of turbines, and wind resource assessment; Wind farm layout and integration into the grid	**6**
Unit-4	**Biomass Energy Systems.** Biomass Energy: Biomass conversion technologies (combustion, gasification, pyrolysis, and fermentation); Biogas production, biodiesel synthesis, and their applications Environmental benefits and challenges of wind and biomass energy	**8**
Unit-5	**Energy Storage and Hybrid Systems.** Overview of energy storage technologies: Mechanical, chemical, electrochemical, and thermal. Battery technologies: Li-ion, flow batteries, and emerging advancements. Role of hydrogen in clean energy: Hydrogen production, storage, and fuel cells. Design and operation of hybrid renewable energy systems (HRES) Case studies of hybrid systems integrating solar, wind, and storage	**6**
Unit-6	**Future Trends and Emerging Technologies.** Smart grids and digitalization in energy systems. Artificial intelligence and machine learning in clean energy optimization. Advances in wave, tidal, and geothermal energy technologies. Circular economy approaches in clean energy production. Socio-economic and environmental impacts of clean energy deployment	**6**
	Total	**42**

Reference Book:	
1	"Renewable Energy Resources" by John Twidell and Tony Weir, Publisher: Routledge
2	"Solar Engineering of Thermal Processes" by John A. Duffie and William A. Beckman, Wiley.
3	"Solar Energy: Principles of Thermal Collection and Storage" by S.P. Sukhatme and J.K. Nayak, Publisher: Tata McGraw-Hill
4	"Non-Conventional Energy Sources" by G.D. Rai, Publisher: Khanna Publishers
5	"Fundamentals of Renewable Energy Systems" by D. Mukherjee and S. Chakrabarti, Publisher: New Age International
6	"Solar Engineering of Thermal Processes" by John A. Duffie and William A. Beckman, Publisher: Wiley
7	"Wind Energy Explained: Theory, Design, and Application" by James F. Manwell et al., Publisher: Wiley
8	"Biomass for Renewable Energy, Fuels, and Chemicals" by Donald L. Klass, Academic Press.
9	"Energy Storage for Renewable Energy Systems" by Augustus W. Clarke, CRC Press.
10	"Hydrogen and Fuel Cells: Emerging Technologies and Applications" by Bent Sørensen, Academic Press.
11	"Solar Engineering of Thermal Processes" by John A. Duffie and William A. Beckman, Publisher: Wiley

Course Outcomes

CO1	Understand the fundamental principles of clean energy technologies and their importance in sustainable development
CO2	Analyze renewable energy sources and assess their technical, economic, and environmental feasibility.
CO3	Design systems using solar, wind, and biomass energy for real-world applications.
CO4	Evaluate the role of energy storage and hybrid systems in enhancing clean energy utilization.

CO5	Develop strategies for integrating clean energy systems into existing energy infrastructure to mitigate environmental impacts.
CO6	Applications of clean energy

CO-PO/PSO Matrix

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
CO1	3	3	3	2	2	0	0	0	0	0	0	2	2	1	1
CO2	3	3	2	3	1	0	0	0	0	0	0	1	2	1	1
CO3	3	3	3	3	1	0	0	0	0	0	0	2	3	3	2
CO4	3	3	3	3	1	0	0	0	0	0	0	1	3	3	2
CO5	2	2	2	2	2	0	0	0	0	0	0	1	2	2	2