GUJARAT TECHNOLOGICAL UNIVERSITY

Program Name: Master of Engineering

Level: PG

Subject Code: ME02000681

Subject Name: Power Electronics for Sustainable Energy

w. e. f. Academic Year:	2024-25
Semester:	2
Category of the Course:	Professional Elective Course

Prerequisite:	Fundamentals of Power Electronics
Rationale:	Sustainable energy is crucial for reducing environmental impact and ensuring long-term energy security. Power electronics are important in efficient energy conversion and management, enhancing the performance and integration of renewable energy sources like solar and wind into the power grid, thus promoting a greener future.

Course Outcome:

After Completion of the Course, the student will be able to:

No	Course Outcomes
01	Comprehensive Understanding of Sustainable Energy
02	Design and Optimization of Renewable Energy Systems
03	Knowledge of Energy Storage Technologies
04	Expertise in Solar and Wind Energy Systems
05	Awareness of Emerging Trends and Technologies

Teaching and Examination Scheme:

Teaching Scheme (in			Total Credits (L+T+	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	2	4	70	30	20	30	150

Course Content:

Unit No.	Content	No. of Hours	% of Weightage
1.	**Introduction to Sustainable Energy:** Overview of sustainable energy sources (solar, wind, hydro, geothermal), Importance and benefits of sustainable energy, Current trends and future prospects in sustainable energy, Environmental impact and sustainability considerations	6	15
2.	**Solar Energy Systems and Power Electronics:** Design and operation of solar photovoltaic (PV) systems, Maximum power point tracking (MPPT) techniques, Grid-connected and off-grid solar PV systems, Power conditioning and energy storage for solar applications, Performance analysis and optimization of solar PV systems	6	10

3.	**Wind Energy Systems and Power Electronics:** Basics of wind energy conversion systems, Power electronics interfaces for wind turbines, Control and optimization of wind energy systems, Integration of wind energy systems with the grid, Performance analysis and optimization of wind energy systems	10	25
4.	**Energy Storage Technologies and Power Electronics:** Importance of energy storage in sustainable energy systems, Types of energy storage technologies (batteries, supercapacitors, flywheels, etc.), Power electronics for energy storage systems, Energy management strategies and techniques, Integration of energy storage with renewable energy sources	11	20
5.	**Challenges and Opportunities in Sustainable Energy Systems:** Technical and economic challenges in sustainable energy adoption, Policy and regulatory considerations, Case studies of successful sustainable energy projects, Innovation and research opportunities in power electronics for sustainable energy, Future trends and developments	9	20
6.	**Practical Applications and Real-World Implementation:** Hands-on projects and simulations, Design and analysis of renewable energy power plants, Real-world applications and industry practices, Performance evaluation and troubleshooting, Capstone project: Design and implementation of a sustainable energy system	3	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**
30	20	20	20	10	0

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:

1. J. Twidell, T. Weir, Renewable Energy Resources, Taylor and Francis, 4th Edition, 2021.
2. G. Boyle (Editor), Renewable Energy: Power for a Sustainable Future, Oxford University press, 3rd Edition, 2012.
3. G. N. Tiwari, Solar Energy, Fundamentals, Design, Modeling and Applications, Narosa, 2002.
4. J. A. Duffie and W. A. Beckman, Solar Engineering of Thermal Processes, John Wiley, 4th

Edition, 2013.

5. R. Gasch, J. Twele, Wind Power Plants: Fundamentals, Design, Construction and Operation, Springer, 2nd Edition, 2012.

Open-source software and website:

1. https://nptel.ac.in/

Suggested Course Practical List:

This is a suggestive list only. The subject teacher can change the list according to availability of resources.

1. Simulation of solar photovoltaic (PV) system design, including panel layout, sizing, and performance analysis.
2. Implementation and comparison of various Maximum Power Point Tracking (MPPT) algorithms in a simulated solar PV system.
3. Simulation and analysis of a grid-connected solar inverter, focusing on power quality and efficiency.
4. Modeling and simulation of a wind turbine, including aerodynamic analysis and power curve generation.
5. Design and simulation of a power electronics interface for a wind energy conversion system.
6. Simulation of integrating different energy storage technologies (batteries, supercapacitors) with renewable energy sources.
7. Design and analysis of power electronics converters for energy storage applications.
8. Implementation of various control strategies for inverters in renewable energy systems.
9. Simulation of renewable energy sources integrated into a smart grid, including load management and grid stability analysis.
10. Analysis and mitigation of harmonics in power electronic systems used in renewable energy applications.
11. To study optimization techniques for efficiency evaluation of power electronic converters.
12. Real-world case study simulation of a renewable energy power plant, analyzing its performance, efficiency, and sustainability.

Major Equipment:

1. Solar Photovoltaic (PV) Panels, Wind Turbine Models, Energy Storage Devices like Batteries, supercapacitors, and flywheels for energy storage experiments, Power Electronics Converters and Inverters, Electronic Loads, Data Acquisition Systems, Laboratory Power Supplies, Oscilloscopes, Signal Generators etc.
2. Simulation software like MATLAB along with necessary toolbox, PSIM, PSCAD , Ansys etc.

List of Laboratory/Learning Resources Required:

1. Sustainable Power Generation Systems by Dr. Pankaj Kalita, IIT Guwahati
   Sustainable Power Generation Systems - Course

2. Sustainable Energy Technology by Prof. Sayak Banerjee, IIT Hyderabad
Sustainable Energy Technology - Course

3. Advanced Power Electronics and Control by Prof. Avik Bhattacharya, IIT Roorkee
Advance power electronics and Control - Course

- E-materials available at the website of NPTEL- http://nptel.ac.in/

* * * * * * *