



GUJARAT TECHNOLOGICAL UNIVERSITY

Program Name: Engineering Level: Masters

Branch: Electrical Engineering

Course / Subject Code: ME01000151

Course / Subject Name: Renewable Energy

w. e. f. Academic Year:	2024-25
Semester:	1 st Semester
Category of the Course:	PEC

Prerequisite:	Basic knowledge of power electronics and conventional methods of electrical power generation
Rationale:	The objective of this course is to provide the knowledge of the upcoming technology related to renewable power generation, their advantages over the conventional sources and relevant techno-economic aspects.

Course Outcome:

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

No	Course Outcomes	RBT Level
01	Infer the techno-economic aspects of renewable energy	U
02	Analyze the performance characteristics of solar and wind energy systems	N
03	Justify the applications of renewable energy sources	A
04	Understand the techniques and issues of renewable power generation	U
05	Analyze the performance of hybrid energy systems	N

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

Teaching and Examination Scheme:

Teaching Scheme (in Hours per week)			Total Credits L+T+ (PR/2)	Assessment Pattern and Marks				Total Marks
L	T	PR		C	Theory		Tutorial / Practical	
			ESE (E)		PA (M)	PA (I)	ESE (V)	
3	0	2	4	70	30	20	30	150



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Course Content:

Unit No.	Content	No. of Hours	% of Weightage
1.	Introduction: Conventional, non-conventional, renewable and non-renewable sources, Statistics of renewable energy availability in the world and in India, Significance of renewable sources, Techno-commercial aspects of various renewable technologies, Energy Efficiency and Conservation, Basic knowledge of Indian Electricity Grid Code, Electricity Act2003, MNRE and National Smart Grid Mission	5	10
2.	Solar Energy: Basic definitions and technical terms related with solar energy, Applications of solar energy like water heating, Passive and Active solar cooling, Crop drying, Cooking etc.. Solar thermal generation, Solar Photovoltaic System (SPV): Solar collectors, Operating principle and construction of PV Cell, Technologies-Amorphous, Monocrystalline, Polycrystalline, Equivalent circuit of cell, Cells to modules to arrays, Standard Test Conditions (STC) of photovoltaics, I-V & P-V Characteristics, Impacts of temperature and insolation, Shading effect, Bypass and blocking diode, SPV Balance of System (BOS), Sizing and Designing a SPV System, Power electronic converters for SPV Systems, Maximum Power Point Tracking (MPPT) algorithms, Battery Energy Storage System (BESS)	10	25
3.	Wind Energy: History, Classification, Components, operating characteristics and schematic diagram of wind energy conversion system. Types of wind power generators, Limitations of constant speed wind generators, Variable speed wind energy generators, Control of isolated and grid-connected wind energy generators, Onshore and Offshore wind farms, Power system stability issues related to wind farms. Wind Energy Physics: Components of Wind Turbine Generating System and its function, Betz Limit, Tip Speed Ratio, Active and Passive Stall and Pitch Control, Yaw control, Performance Coefficient, Wind Power, Power-Speed & Power-Torque Characteristics Wind Speed Statistics- Wind Energy Estimation, Discrete Wind Histogram, Wind Power Probability Density Functions, Weibull and Rayleigh Statistics.	10	25
4.	Hydrogen Energy and Fuel Cells: Introduction, Types, Characteristics and Applications of Hydrogen energy-based generation. Introduction to fuel cells and characteristics. Generation and storage of Hydrogen.	5	10



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5.	Small Hydro Electric power plant Introduction, operating principle and site selection of mini and micro hydropower plants, case study of micro hydel plant.	5	10
6.	Other sources of Renewable Energy: Biomass characteristics and their availability, bioenergy extraction methods: anaerobic digestion, gasification, liquefaction, biomethane, biohydrogen, biodiesel. Tidal generation, Energy calculation in the tide, Ocean Thermal Energy Conversion, Estimation of power associated with waves, Challenges with wave energy, Wave energy collecting devices, Geothermal resources, exploration of geothermal energy, Geothermal systems, Concepts of hybrid system: PV-wind system, PV-hydro system, Biomass-PV-Diesel system, PV-solar thermal-grid connected system.	10	20
Total		45	100

Suggested Specification Table with Marks (Theory):

Distribution of Theory Marks (in %)					
R Level	U Level	A Level	N Level	E Level	C Level
20	25	25	25	5	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) Reference Books:

1. J. Twidell, T Weir, Renewable Energy Sources, Taylor and Francis, 2015
2. Chetansingh Solanki, Solar Photo Voltaics: Fundamentals, Technologies and Applications, PHI learning 2015
3. D. P. Kothari, K. C. Singhal, and Rakesh Ranjan, "Renewable Energy Sources and Emerging Technologies", PHI Learning Pvt. Ltd. 2021
4. S. P. Sukhatme, "Solar Energy - Principles of thermal collection and storage", TMH, 2008
5. Thomas Ackermann, "Wind Power in Power System", John Willey & Sons, 2005
6. Daniel, Hunt V, "Wind Power - A Handbook of WECS", Van Nostrend Co., New York, 1981
7. Gary L. Johnson, "Wind Energy Systems", Prentice Hall Inc., 1985
8. Masters G., "Renewable and Efficient Electric Power Systems", John Wiley & Sons, Inc., Publication, 2004



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9. Lara O, Jenkins N, Ekanayake J, “Wind Energy Generation Modelling and Control”, John Wiley & Sons, Ltd., 2009
10. Mathew S., Wind Energy-Fundamentals, Resource Analysis and Economics, Springer, 2006
11. S. N. Bhadra, D. Kasta, S. Banerjee, Wind Electrical Systems, Oxford publications , 2013
12. G. D. Rai, Non-conventional energy sources, Khanna Publishers, 2009
13. B. H. Khan, Non-Conventional Energy Resources, Tata McGraw Hill, 2006
14. G. S. Sawhney, Non-Conventional Energy Resources, PHI learning, 2012

(b) Open source software and website:

E-materials available at the website of NPTEL-

<https://archive.nptel.ac.in/courses/108/106/108106182>

<http://nptel.ac.in/courses/112104117/18>

<http://nptel.ac.in/courses/112104117/4>

<http://nptel.ac.in/courses/112104117/17>

Suggested Course Practical List:

1. Observe the I-V and P-V characteristics of a solar cell using solar simulator
2. Obtain I-V and P-V characteristics of PV modules: single module, series connection of PV modules and parallel connection of PV modules.
3. Observe the I-V and P-V curve of a silicon solar cell with varying solar irradiation and operating temperatures
4. Develop a simulation/program of Perturb & Observe MPPT algorithm for a PV panel connected with DC-DC Boost converter through a resistive load.
5. Develop a simulation/program of Incremental conductance MPPT algorithm for a PV panel connected with DC-DC Boost converter through a resistive load.
6. Prepare a simulation of PV system integrated to grid through voltage source inverter.
7. To work out the Payback period of a Solar PV module of appropriate rating for a residential load of 5 kW.
8. Develop a simulation of a wind turbine system
9. To carry out the wind speed forecast and to evaluate the wind energy potential
10. Learn and compute the characteristics and performance of the wind turbine system on the wind emulator.
11. Design of biomass plants
12. Design of tidal energy plants
13. Study on Fuel cell characteristics and efficiency
14. To develop and simulate an integrated hybrid model having different renewable energy sources and energy storage.



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List of Laboratory/Learning Resources Required

1. Softwares like MATLAB, PSPICE, PSCAD useful for simulation and analysis of electrical systems
2. Working models and prototypes of various renewable energy generation like solar, wind etc..

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