GUJARAT TECHNOLOGICAL UNIVERSITY

Program Name: Engineering

Level: PG

Branch: Energy Engineering

Course / Subject Code : ME01075031

Course / Subject Name : Wind and Small Hydro Energy System

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

Prerequisite:	Fundamentals of fluid mechanics and hydraulic machines
Rationale:	The course provides basic understanding of wind and small hydro energy systems along with economics of wind energy.

Course Outcome:

After Completion of the Course, Student will able to:

No	Course Outcomes	RBT level
1	Explain the basic principles of wind energy and wind conversion systems.	Understand
2	Compute statistical analysis of wind data to estimate average wind speed for a given location.	Apply
3	Appraise concept of aerodynamics design and performance of airfoil-based rotor blade.	Evaluate
4	Analyze economics of wind energy system for selecting the optimum system for a given location.	Analyze
5	Design small hydro system components and controls.	Create

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	2	4	70	30	20	30	150

Course Content:

Unit No.	Content	No. of Hours	% of Weightage
1.	**Fundamentals of Wind Energy Systems:** Definition of Wind energy; Wind generation - Uneven solar heating, Coriolis force, Local geography; History of wind energy applications; Benefits and challenges of Wind Energy; Power available in the wind; Wind turbine power and torque; Classification, construction and working of wind turbines - Horizontal axis wind turbines (HAWT), Vertical axis wind turbines (VAWT).	**06**	13
2.	**Wind Measurements, Characteristics and Estimation:** Wind measurement basics; Characterization of Measurements and Instrument Characteristics; Wind Speed Measurement - Anemometers, Lidar, Sodar; Temporal and Spatial Characteristics of Wind - Variations in Time, Variations due to Location and Wind Direction; Wind Mast; Statistical Analysis of Wind Data - Weibull distribution.	**08**	18
3.	**Aerodynamics of HAWT:** Airfoil Terminology; Airfoil Behavior – characteristics of lift, drag and angle of attack, Relative Velocity of Wind; One-dimensional Momentum Theory and the Betz Limit; BEM theory; Blade Shape for Ideal Rotor without Wake Rotation; Rotor Performance using wind tunnel.	**15**	33
4.	**Economics of Wind Energy:** Factors influencing the wind energy economics - Site specific factors, Machine parameters, Energy market, Incentives and exemptions; The 'present worth' approach; Cost of wind energy - Initial investment, Operation and maintenance costs, Present value of annual costs; Yardsticks of economic merit - Net present value, Benefit cost ratio, Payback period, Internal rate of return.	**06**	13
5.	**Small Hydro Energy system:** Overview and Analysis of Small, mini and micro hydro turbines; Site selection and civil works; Penstocks and turbines; Economical and Electrical Aspects of Small, mini and micro hydro turbines; potential developments; Design and reliability of Small, mini and micro hydro turbines – Case Study.	**10**	23

	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**
10	**20**	**20**	**20**	**20**	**10**

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. Wind Energy Explained – Theory, Design and Application, J. F. Manwell, J. G. McGowan and A. L. Rogers, John Wiley and Sons Ltd., 2010.
2. Wind Energy Conversion Systems, L. L. Freris, Prentice Hall, 1990.
3. Wind Energy Technology, J. F. Walker, John Wiley, 1997.
4. Aerodynamics of Wind turbines, Martin O. L. Hansen, Earthscan, 2008.
5. Micro-Hydro Design Manual: A Guide to Small-Scale Water Power Schemes, Adam Harvey, Intermediate Technology Publications, 1993.
6. Good and Bad of Mini Hydro Power, Roman Ritter, 2009.
7. Wind Energy Systems, G. L. Johnson, Prentice Hall, 1985.
8. Renewable Energy Resources, John Twidell and Tony Weir, Taylor & Francis, 2006.

(b) Open-source software and website:

1. https://web.mit.edu/drela/Public/web/xfoil/
2. https://www.nrel.gov/research/software.html
3. https://www.openfoam.com/

Suggested Course Practical List:

1. Wind measurement for a month and Statistical Analysis of Wind data.
2. To study the construction and working of various type of HAWT and VAWT.
3. NACA Airfoil aerodynamic analysis using open/close wind tunnel.
4. 2D CFD analysis of cambered NACA airfoil using Ansys/OpenFOAM.
5. 3D CFD analysis of symmetrical NACA airfoil using Ansys/OpenFOAM.
6. To study the wind farm planning and development.
7. Programming for HAWT rotor design using Python.
8. Case study on wind energy economics.

9. To study and design of small hydro turbine.
10. To study and design of mini and micro hydro turbines.

List of Laboratory/Learning Resources Required:

1. Design and fabricate HAWT /VAWT turbine.
2. Design and 3D print micro hydro turbine.

Suggested Project List:

1. Design and fabricate HAWT /VAWT turbine.
2. Design and 3D print micro hydro turbine.

Suggested Activities for Students:

1. Field testing of HAWT /VAWT turbine.
2. Testing of 3D printed micro hydro turbines.

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