Course title: Renewable energy resource characteristics

Course code: ENR 146	**No. of credits:** 3	**L-T-P:** 34-11-0	**Learning hours:** 45
Pre-requisite course code and title (if any): Not required			
Department: Sustainable Engineering			
Course coordinator: Dr Ramkishore Singh		**Course instructor(s):** Prof. Naqui Anwer/ Dr Ramkishore Singh/ Dr Aditi Agarwal	
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Course type: Programme Core		**Course offered in:** Semester 1	

Course description

The course is designed to familiarize and train the students with the tools and techniques used to assess the various renewable energy resources and their potential at any location, so that they are able analyse a case quantitatively at the end of the term.

Course objectives

The objective of the courses is to develop in-depth knowledge in the following:

- Various renewable energy resources available at a location and the assessment of their potential
- Solar energy radiation, its interactions, measurement and estimation
- Site selection for wind turbines, measurements and instruments
- Bioenergy resource assessment, pathway selection, biomass supply

Course contents

Module	Topic	L	T	P
	SOLAR			
1	**Introduction** Introduction to renewable energy sources **Solar Energy Resources** Solar radiation: Spectrum of EM radiation, sun structure and characteristics, extra-terrestrial radiation, solar constant, air mass,beam, diffused and total solar radiation, spectral distribution Sun-earth movement in different seasons, solar geometry, solar radiation on tilted surface, local apparent time, irradiance, insolation Attenuation of solar radiation by the atmosphere, albedo, beam and diffuse components of hourly and daily radiation, GHI and DNI, clearnessindex, Radiation augmentation Different climatic zones and their impact on site selection	1 1 1 2 1	1	0
2	**Measurement of solar radiation** Instruments: sunshine recorder, Pyranometer, Pyrheliometer, Albedometer. Radiation measurement stations in India (NIWE, IMD etc.), Solar radiation data, graphs, Meteonorm, NASA-SSE and other databases, Daily, monthly and annul average radiation data analysis using annual and TMY data	2	2	0

3	**Prediction of available solar radiation** Solar mapping using satellite data, Typical Meteorological Year	2	2	0
	Models and methods for estimating solar radiation, estimation of global radiation, estimation of diffused components			
	WIND			
4	**Introduction** Introduction to Atmospheric Boundary Layer Theory, Wind gradient and geographical importance, Wind energy database-Wind atlas	3	0	0
5	**Physics of Wind** Wind Systems in India as Case, Potential sites, diurnal and seasonal variations	5	0	0
6	**Basic Introduction to Wind Energy** Introduction to wind power, Worldwide Developments	2	1	0
7	Instruments used and measurement process wind data	2	2	0
	BIOMASS			
8	**Basics** Biomass resources: plant derived, residues, aquatic and marine biomass, various wastes, photosynthesis. **Biomass resource assessment** Estimation of woody biomass, non woody biomass and wastes, ASTM standards.	2 2	0	0
9	**Bulk chemical properties** Moisture content, proximate and ultimate analyses, calorific value, waste water analysis for solids.	2	1	0
10	**Chemical composition of biomass** Cellulose, hemicelluloses and lignin content in common agricultural residues and their estimation, protein content in biomass, extractable,COD.	2	1	0
11	**Structural properties** Physical structure, particle size and size distribution, permeability. Physical properties: Bulk density, angle of repose, thermal analysis (thermogravimetric, differential thermal and differential scanning calorimetry). Properties of microbial biomass: Protein estimation, flocculating ability, relative hydrophobicity of sludge, sludge volume index.	4	1	0
		34	**11**	**0**

Evaluation criteria:

- Quizzes/Assignments: 30% (During module 1-11)
- Minor test 1: 15% (after Module 1, 4, 8 and 9)
- Minor test 2: 15% (after Module 2,3, 5, 6,10)
- Major test: 40%

Learning outcomes:

At the end of the course the student will be able to:

- Identify a Renewable Energy Resource at a given location [Minor test 1 and assignments]
- Assess/quantify the potential of the renewable-energy resources at a given location [Minor test 2, Major test 3]
- Develop understanding for case studies [assignments and Major test 3]

Pedagogical approach:

A combination of class-room interactions, group discussion and presentations, tutorials and assignments

Material

Text Books:

Renewable Energy Engineering and Technology – A Knowledge Compendium, ed. VVN Kishore (TERI Press, 2008).

Reference Books:

Donald Klass, "Biomass for Renewable Energy, Fuels, and Chemicals", Entech International Inc., USA
JA Duffie and WA Beckman, "Solar Engineering of Thermal Processes", Third Edition (John Wiley & Sons)
S Sukhatme and J Nayak, "Solar Energy: Principles of Thermal Collection and Storage", Third Edition (Tata McGraw Hill, 2008)TERI Energy Data Directory (TEDDY) 2020-21 (TERI Press, 2021)

Websites:

Ministry of new and renewable energy
NITI Aayog

Additional information (if any):

Student responsibilities:

Attendance, timely feedback, discipline: as per university rules, adopt peer learning and knowledge sharing within the class

Course reviewers:

- Dr. Anish Modi, Assistant Professor, IIT Bombay
- Dr. Birinchi Bora, Deputy Director (Technical), National Institute of Solar Energy (NISE)