Course title : Renewable Energy Resources
Course credits : 2
No. of modules : 2
Module 1: Solar Resources
Module 2: Wind & Biomass Resources

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

Detailed syllabus:

Module 1: Solar Resources

I. Introduction
Introduction to renewable energy sources.

II. 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.

III. Measurement of solar radiation
Instruments: sunshine recorder, Pyranometer, Pyrheliometer,Albedometer.
Radiation measurement stations in India (NIWE, IMD etc.),
Solar radiation data, graphs, Metronome, NASA-SSE and other databases, Daily, monthly and annul average radiation data analysis using annual and TMY data.

IV. Prediction of available solar radiation
Solar mapping using satellite data, Typical Meteorological Year Models and methods for estimating solar radiation, estimation of globalradiation, estimation of diffused components.

Module 2: Wind & Biomass Resources

I. Introduction
Introduction to Atmospheric Boundary Layer Theory, Wind gradient and geographical importance, Wind energy database-Wind atlas.

II. Wind Resource Assessment
Wind Systems in India as Case, Potential sites, diurnal and seasonal variations. Instruments used and measurement process wind data.

III. Biomass Resources & Resource Assessment
Biomass resources: plant derived, residues, aquatic and marine biomass, various wastes, photosynthesis. Estimation of woody biomass, non-woody biomass and wastes, ASTM standards.

IV. Chemical composition of biomass
Moisture content, proximate and ultimate analyses, calorific value, waste-water analysis for solids.
Cellulose, hemicelluloses and lignin content in common agriculturalresidues and their estimation, protein content in biomass, extractable,COD.

V. 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 ofsludge, sludge volume index.

Evaluation/Assessment scheme:

1. Quizzes – 40% (one at the end of each module)
2. End semester exam – 60% (at the end of course)

Learning outcomes:

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

- Identify a Renewable Energy Resource at a given location
- Assess/quantify the potential of the renewable-energy resources at a given location
- Develop understanding for case studies