Course Title: Clean Energy Generation, Integration and Storage **(Elective Course)**

Course Code: EPE-801

Objectives: This course is designed for electrical engineers to provide a primer on the generation, grid integration and storage of renewable energy system. It covers a wide span starting from fundamental principles of renewable energy generation and the mathematical modeling for computer simulation. Then it provides technical insight into energy conversion systems essential for the reliable integration with the load. Then it provides a sufficient introduction to the various forms of energy storage that are electrical, chemical and mechanical storage. Although the primary focus of this course is on the two most naturally occurring renewable energy sources – solar and wind, however this course also provides basic introduction to Solar Thermal, Fuel Cells, Biomass, Geothermal, Microhydro, Tidal and Wave Energy Systems. The course concludes by discussing issues in the grid integration of large-scale renewable energy systems as well as the enabling technologies for grid integration which are essential for reliability and power quality.

The core objective of this course is to familiarize the students with different means of harnessing clean energy, how this energy can be integrated with the existing grid and what challenges it poses to the security of the grid and how these challenges can be overcome with storage devices.

Learning Outcomes: On successful completion of the module the student will have:

- Sound understanding of energy production method from different renewable energy sources.
- Appropriate knowledge of integration issues of renewable energy sources with the power grid
- Abilities to cope with the intermittent issues of renewables by deploying different energy storage devices.

Contents:

Need of Renewable Energy System: Conversion Efficiency and Environmental Cost of Conventional Energy Systems.

Solar Energy Conversion: Mathematical & Simulation Modeling, Characteristic Curves & Dark I-V testing, Bypass & Blocking Diodes for Partial Shading and Sizing a PV array for certain load.

Efficiency Maximization of PV Energy Conversion Systems: Principle & Significance Sun Tracking, Partial Shading and Local Maxima and Critical Analysis of the existing MPPT techniques.

Wind Energy Conversion: Mathematical & Simulation Modeling, Conversion Efficiency and Betz Limits, Effects of Turbine Design on Efficiency and Generator types.

Efficiency Maximization of Wind Energy Conversion Systems: Pitch and Yaw Control Maximum Power Point Tracking and Generator Loss Minimization.

Alternate Renewable Energy Sources: Solar Thermal, Fuel Cells, Biomass, Geothermal, Tidal, Wave and Micro-hydro.

Energy Storage: Super Capacitors, Batteries, Flywheel, Pumped storage, Compressed Gases and Thermal storage, Electric Vehicle.

Grid Integration: Issues in Large Scale Renewable Energy Systems and Enabling Technologies for Grid Integration

Recommended Book:

- Renewable and Efficient Electric Power Systems Gilbert Masters
- Wind & Solar Power Systems Mukund R. Patel
- Renewable Energy Integration: Challenges and Solutions Jahangir Hussain
- Energy Storage for Smart Grids: Planning and Operation for Renewable and Variable Energy Resources Pengwei Du

Large Scale Wind Power Grid Integration: Technological and Regulatory Issues Ningbo Wang