Course-Plan

School: **Engineering**
Department: **Energy**
Course Code: **EN 527 (3-0-0)**
Course Name: **Renewable Energy Grid Integration**

Instructor: P. K. Choudhury

1. Abstract

This course deals with the integration of renewable energy systems with the grid. Due to inherent temporal and spatial variations of renewable energy sources, integration of various renewable energy based systems is essential in order to exploit the available resources in best possible way. Consequently, conservation of fossil fuel is also assured along with flexible utilization of electric power generated from renewable energy sources through the grid. Various modes of grid integration along with the need and application of power electronics components/systems is discussed. An overview of simulation and modelling tools is also briefly presented.

2. Objectives

The primary objectives of this course are outlined as below.

a) To understand the basics of power system operation including power transmission and distribution.
b) To understand the power generations from renewable energy sources (SPV/Wind) and issues and challenges in grid integration.
c) To understand the role of power electronics in grid integration and addressing issues on power quality and stability.

3. Course Outcomes

CO1: Explain power system structure in single line and per unit system
CO2: Assess power generation from renewable energy sources
CO3: Analyze grid integrated power quality and stability

4. Prerequisites of the course

This course is an elective course and second semester students of MTech. in Energy Technology programme can opt to register for this course.

5. Course outline

Unit	Topic	Learning Objectives
Unit 1:	Introduction	To understand the basics of power system operation, power quality and stability, introduction to electric grid and load scheduling
Unit 2:	Power electronics systems	To understand the basic power electronics systems, operation of power converters, power conversion schemes between electric machines and the grid
Unit3:	Power control and management	To understand the power control and management systems in grid integration, synchronizing with the grid, wind and photovoltaic power applications
Unit4:	Issues in integration	To understand the issues related to integration of generator and converter based sources, management of network voltage, power quality and frequency
Unit 5:	Electric Systems Modelling	To understand modelling and simulation of electric systems, simulation tools, simulation of grid connected/off grid renewable energy system (PV/WECS)

6. (a)Time-Plan

Tentative Lectures	Topic to be covered	No. of classes
1-7	**Introduction** 1. Course overview 2. basics of power system operation 3. power quality and stability 4. introduction to electric grid and load scheduling	**7**
8-15	**Power electronics systems** 1. basic power electronics systems 2. Electronic conversion systems 3. Functional analysis of power converters 4. Power conversion schemes between electric machines and the grid	**8**
16-22	**Power control and management** 1. Power control and management systems in grid integration 2. Synchronizing with the grid 3. Wind and photovoltaic power applications	**7**
23-29	**Issues in integration** 1. Issues related to integration of generator and converter based Sources 2. Network voltage management, 3. Power quality and frequency management	**7**
30-36	**Electric Systems Modelling** 1. Modelling and simulation of electric systems 2. Simulation tools 3. Simulation of grid connected/off grid renewable energy system (PV/WECS) 4. Optimization and grid planning	**7**
Total		**36**

(b) Evaluation plan

Tests	Type	Date*	Marks*	Time*
Sessional Test I	Objective/ Quiz	7^{th} – 16^{th} February	25	45 min
Mid-Semester Examination	Descriptive/ Objective	15^{th} – 23^{rd} March	40	2 hour
Sessional Test II	Assignment/Seminar/Case study/ Objective/ Quiz	17^{th} – 26^{th} April	25	45 min
End-Semester Examination	Descriptive/ Objective	20^{th} May – 1^{st} June	60	3 hour
Total Marks			**150**	

***Exact Dates/Marks/Time will be as per Tezpur University academic calendar**

7. Pedagogy

Apart from the theory classes students will also be given some practical oriented assignments. The objective of such assignments is to make the students familiar with the instrumentations/ control/ power electronics components related to integration of renewable energy systems.

Teaching-learning methods to be used are

- Lecture and Discussion
- Assignment and Presentations
- Case studies
- Problem Solving

8. Expected outcome

Towards the end of the course the student would be able to know the issues related to renewable energy grid integration and related power electronics components/systems. Students are expected to comprehend the issues and essential design considerations required for maintaining a stable grid integrated renewable energy systems

9. Text Book

1. Kersting W. H. (2004); *Distribution System Modeling and Analysis*, Second Edition, CRC Press
2. Vittal V. and Ayyanar R. (2012); *Grid Integration and Dynamic Impact of Wind Energy*, Springer

References

1. Bollen M. H. and Hassan F. (2011); Integration of Distributed Generation in the Power System, Wiley-IEEE Press
2. Keyhani A. (2011); Design of Smart Power Grid Renewable Energy Systems, Wiley–IEEE Press
3. Muhannad H. R. (2004); Power Electronics: Circuits, Devices and Applications, Pearson Prentice Hall Publisher
4. Gellings C. W. (2009); The Smart Grid: Enabling Energy Efficiency and Demand Response, First Edition, CRC Press
5. Teodorescu R. Liserre M. Rodriguez P. (2011); Grid Converters for Photovoltaic and Wind Power Systems, First Edition, Wiley-IEEE Press

Program Outcomes, Course Outcomes and Assessment Criteria

EN 527 Renewable Energy Grid Integration

CO1	Explain power system structure in single line and per unit system
CO2	Assess power generation from renewable energy sources
CO3	Analyze grid integrated power quality and stability

Mapping	**PO1**	**CO1**		
	PO2		**CO2**	
	PO3			**CO3**

Course Outcomes	**Weightage (%)**	**Test I (25)**	**Mid Term Test (40)**	**Test II (25)**	**Sem End Exam (60)**	**Total (150)**
CO1	30	6	20		19	45
CO2	40	15	10		35	60
CO3	30	4	10	25	6	45
TOTAL	100	25	40	25	60	150

Assessment Criteria		**Marks distribution**					
Bloom Taxonomy	**Level**	**Marks Weightage (%)**	**Test I (25)**	**Mid Term Test (40)**	**Test II (25)**	**Semester End (60)**	**Total (150)**
Knowledge	Easy	10.67	6	5		5	15
Understanding	Easy	24	15	5		6	25
Application	Average	20.67		10		21	30
Analysis	Above average	13.33		10		10	28
Synthesis	Difficult	28.67		10	25	8	42
Evaluation	Difficult	2.67	4				10
TOTAL		**100**	**25**	**40**	**25**	**60**	**150**

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