Lahore University of Management Sciences

EE555 – Renewable Energy Systems

Fall 2023-2024

Instructor	Hassan Abbas Khan and Syed Muhammad Ahsan
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Secretary/TA	TBD
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Course URL (if any)	

Course Teaching Methodology (Please mention following details in plain text)
• In person (90+ %) with some online/recorded sessions

Course Basics				
Credit Hours	3			
Lecture(s)	Nbr of Lec(s) Per Week	2	Duration	75 minutes
Recitation/Lab (per week)	Nbr of Lec(s) Per Week	-	Duration	-
Tutorial (per week)	Nbr of Lec(s) Per Week	-	Duration	-

Course Distribution	
Core	-
Elective	yes
Open for Student Category	Electrical Engineering, Computer Science, Physics
Close for Student Category	None

COURSE DESCRIPTION

This course would review the renewable sources and their need in world energy scenario. Starting with an overview of renewable energy technologies, energy harvesting through wind and PV would be focused in detail for this course. Firstly, the course will encapsulate PV systems in detail from analysis of the basic unit i.e., a solar cell to module and to a complete standalone system with storage. Grid tied PV systems will also be analyzed in detail with focus on optimized system design and maximizing the return-on-investment on these initiatives. Secondly, wind energy conversion system will be discussed including the extraction limitation, associated components, basic operation and modern systems will be discussed in detail. The course also includes a research project in which students would be required to do a detailed evaluation (and possibly design) of an aspect/technology studied in the course. It may include (but not limited to) Profiling of PV cells/modules, modeling of renewable systems, evaluation of a potential wind/PV/other application or detailed review of some applications in Pakistan scenario. Original research is encouraged with hands on simulation analysis of modern systems.

COURSE PREREQUISITE(S)

•	Devices and Electronics (EE-340)

COURSE OBJECTIVES

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• • • • •	The objectives of this course will be to introduce students to Why is there a need of renewables worldwide and in Pakistan scenario Basic understanding of wind power system Detailed understanding of PV cells, panels and technologies In depth analysis on PV systems and applications Costing of renewable energy systems

Learning Outcomes	
CLO1:	Understanding of technologies available in renewables with parametric analysis of Wind Energy Conversion systems
CLO2:	Understand and analyze fundamentals of energy generation through PV cells
CLO3:	Analyze PV generation , Balance of System including modules, inverters, storage in various applications
CLO4:	Apply principles of economics of renewable and hybrid systems for optimized system design

Grading Breakup and Policy

Assignments (4-5): 5%
Quizzes (6-7): 15 % (N-1 if 6 quizzes and N-2 if 7 quizzes are taken)
Midterm Examination: 30 %
Project: 10 %
Final Examination: 40%

Relation to EE Program Outcomes

EE-555 CLOs	Related PLOs	Levels of Learning	Teaching Methods	CLO Attainment checked in
CLO1	PLO1	Cog-3	Instruction, Tutorial, Assignments	Quiz, Midterm, Final
CLO2	PLO2	Cog-4	Instruction, Tutorial, Assignments	Quiz, Midterm, Final
CLO3	PLO3	Cog-4	Instruction, Tutorial, Assignments	Quiz, Final
CLO4	PLO4	Cog-4	Instruction, Tutorial, Assignments	Quiz, Final, project

Examination Detail	
Midterm Exam	Yes Duration: 75-90 mins Preferred Date: Midterm week Exam Specifications: close book/close notes
Final Exam	Yes Duration: 3 hrs Exam Specifications: close book/close notes

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COURSE OVERVIEW			
Module	Topics	Recommended Readings	Related CLOs
1 (1 week)	World energy scenario and place of renewable for energy generation, review of renewable energy technologies and place of PV in context of Pakistan and its importance. Overview of technologies • Wind Energy • Hydroelectric Energy • Solar Energy • Tidal Energy • Geothermal Energy • Biomass	**Ch 1 (Solanki), Lec slides**	CLO1
2 (2 weeks)	Wind Energy • Classification of wind turbines • Types of rotors • Energy extraction from wind • Wind Speed, Power and Energy Distribution • Wind power systems	**CH 4, 5, 6 (Makund)**	CLO1
3 (2 weeks)	Fundamentals of semiconductors • Semiconductors as materials for solar cells • Carrier concentration and distribution • generation-recombination processes • Continuity Equations • PN diodes: introduction to solar cells	**Ch 2, 3, 4 (Solanki)**	CLO2
4 (3 weeks)	Design of solar cells • Photovoltaic Effect • Solar Cell equivalent modelling • Upper limits of cell parameters • Losses in solar cells • Design of parameters for a high efficiency solar cell	**Ch 5 (Solanki)**	CLO2
5 (1 weeks)	Heterojunction, thin films and other promising solar cells • GaAs-based tandem cells • Amorphous Si based thin films • CIGS and CdTe based cells • Emerging cells	**Ch 8 (Solanki), research papers**	CLO2
6 (3 weeks)	PV modules, systems and applications • PV Modules • PV arrays • Stand-alone system • Mppt, batteries, inversion	**Ch 12-1 4 (Solanki)**	CLO3

7 **(1 weeks)**	Grid Connected PV systems Operation Sizing of hybrid systems	**Ch 13 (Makund)**	CLO4
8 **(1 week)**	Costing: payback period, life cycle cost, Case study of LUMS Solar PV installation with performance evaluation	**Handouts**	CLO4

Textbooks:

1. Solar Photovoltaics: Fundamental, technologies and applications
   SOLANKI, CHETAN SINGH: 2nd ed. 2009 (Prentice Hall)
2. Wind and Solar Power Systems.
   R.P Makund, 1999 (CRC press)

Reference books:
'Renewable and Efficient Electric Power Systems' by **Gilbert M. Masters (Wiley)**