

COURSE TITLE	DISTRIBUTED ENERGY RESOURCES AND ENERGY STORAGE SYSTEMS
COURSE CODE	01EE1606
COURSE CREDITS	3

Objective:

- 1 To provide knowledge on the various aspects of distributed energy resources and various energy storage system.

Course Outcomes: After completion of this course, student will be able to:

- 1 Explain the underlying principles and definitions of distributed energy resources.
- 2 Differentiate the performance and control requirements between the standalone and grid-integrated operational modes of wind and solar systems.
- 3 Illustrate the operation of power system with wind and solar system.
- 4 Assess the impact of generation/load on the system voltage profile and power quality upon grid integration.
- 5 Evaluate different technologies used for energy storage system.

Pre-requisite of course: Basic Electronics, Power Electronics

Teaching and Examination Scheme

Theory Hours	Tutorial Hours	Practical Hours	ESE	IA	CSE	Viva	Term Work
3	0	0	50	30	20	0	0

Contents : Unit	Topics	Contact Hours
1	Distributed Energy Resources (DERs) Definition of DERs, characteristics of DERs, DER technologies, Operation of DERs, advantages and disadvantages of DERs, comparisons of various DERs, Need of grid integration of DERs, IEEE 1547 Standard for Interconnection of DERs	8
2	Solar and Wind system Solar: Operating Principle Solar Cell, Equivalent Circuit of Cell, Solar array system analysis for performance prediction, I-V & P-V Characteristics, Impacts of Temperature and Insolation on performance of PV module, Maximum Power Point tracking methods: Perturbation and observation technique, Incremental conductance, Wind: Wind system components,, Size of wind turbines, wind turbine generators,, wind power calculation, wind turbine power characteristics curve, pitch control, SCIG in WEGS, DFIG in WEGS, grid code requirements	10

Contents : Unit	Topics	Contact Hours
3	Operation of Power System with Wind and Solar Interface requirement, synchronizing with grid, load scheduling, calculation of voltage, current and power efficiency, component design for maximum efficiency, static bus impedance and voltage regulation, quality of power, renewable capacity limit	8
4	Impact of Grid Integration Requirements for grid integration of DERs, Limits on operational parameters: voltage, frequency, THD, response to grid abnormal operating conditions, islanding issues, Impact of grid integration with NCE sources on existing power system: reliability, stability and power quality issues	8
5	Energy Storage System Introduction, different types of energy storage devices, Battery – fundamentals, types, characteristics, equivalent circuit and performance comparison, emerging trends in batteries, solar PV and battery based hybrid energy system, Fuel cell – fuel cell principles, types, characteristics of fuel cell, fuel cell based hybrid energy system	8
Total Hours		42

Textbook :

- 1 Principles of Solar Engineering, Goswami, D.Y., Kreith, F. and Kreider, J.F. , CRC Press, 1999
- 2 Solar Photovoltaics. Fundamental Technologies and Application, Chetan Singh Solanki, PHI Learning, 2015
- 3 Wind Electrical Systems, S.N.Bhadra, D. Kastha, & S. Banerjee, Oxford University Press, 2009
- 4 Fundamentals of Energy Storage, J. Jensen and B. Sorenson, Wiley-Interscience, NewYork, 1984

References:

- 1 Energy Technology, Energy Technology, Rao & Parulaker, Khanna Publications, NewDelhi, 2009
- 2 Energy Storage -Technologies and Applications, Energy Storage -Technologies and Applications, Ahmed Faheem Zobaa, InTech, 2013
- 3 Wind Energy Explained: Theory, Design and Application, Wind Energy Explained: Theory, Design and Application, J. F. Manwell, J. G. McGowan, A. L. Rogers, John Wiley & Sons, 2009
- 4 Chemical and Electrochemical Energy Systems, Chemical and Electrochemical Energy Systems, R. Narayan, B. Viswanathan, Universities Press, 1998

Suggested Theory Distribution:

The suggested theory distribution as per Bloom's taxonomy is as follows. This distribution serves as guidelines for teachers and students to achieve effective teaching-learning process

Distribution of Theory for course delivery					
Remember / Knowledge	Understand	Apply	Analyze	Evaluate	Higher order Thinking / Creative
20.00	30.00	25.00	15.00	10.00	0.00

Supplementary Resources:

- 1 https://onlinecourses.nptel.ac.in/noc21_ee62/preview
- 2 https://onlinecourses.nptel.ac.in/noc21_ee103/preview