22EEHO310	ENERGY STORAGE SYSTEMS AND APPLICATIONS	SEMESTER			
PREREQUISITES	CATEGORY	PEC	Credit		3
Electrical Engineering	Hours/Week	L	T	P	TH
		3	0	0	3

Course Objectives:

1. To understand the various types of energy storage technologies.
2. To analyze thermal storage system.
3. To analyze different battery storage technologies.
4. To model the Lithium-ion batteries.
5. To study the various applications of energy storage systems.

UNIT I	INTRODUCTION	9	0	0	9

Necessity of energy storage – Types of energy storage – Comparison of energy storage technologies – Demand functions of energy storage technology in power system, application outlook and challenges of energy storage technology in power system.

UNIT II	THERMAL STORAGE SYSTEM	9	0	0	9

Thermal storage – Types – Modeling of thermal storage units – Simple water and rock bed storage system – Pressurized water storage system – Modeling of phase change storage system – Simple units, packed bed storag units –
Modeling using porous medium approach – Use of TRNSYS.

UNIT III	ELECTRICAL ENERGY STORAGE	9	0	0	9

Fundamental concept of batteries – Measuring battery performance, charging and discharging, power density, energy density, and safety issues. Types of batteries – Lead Acid, Nickel – Cadmium, Zinc Manganese dioxide, Li-ion batteries – Mathematical modeling of Lead Acid batteries – Flow batteries.

UNIT IV	LITHIUM-ION BATTERY MODELING	9	0	0	9

Analysis on charge and discharge temperature characteristics of Lithium-ion batteries – Electrothermal coupling Modeling - Modeling and Optimization of Air Cooling Heat Dissipation of Lithium-ion Battery Packs.

UNIT V	ALTERNATE ENERGY STORAGE TECHNOLOGIES	9	0	0	9

Flywheel, Supercapacitors, Principles and methods – Applications, Compressed air energy storage, Concept of Hybrid storage – Applications, Pumped hydro storage – Applications.

Total (45L+0T)= 45 Periods

Text Books:

1. Ibrahim Dincer and Mark A. Rosen, 'Thermal Energy Storage Systems and Applications', John Wiley & Sons, 3rd Edition, 2021.
2. Ru-shi Liu, Lei Zhang and Xueliang sun, 'Electrochemical technologies for energy storage and conversion', Wiley publications, 2nd Volume set, 2012.
3. Junqiu Li, "Modeling and simulation of Lithium-ion power battery thermal management", Springer, 2020.

Reference Books:

1. Lunardini.V.J, 'Heat Transfer in Cold Climates', John Wiley and Sons 1981, 1st Edition
2. Schmidt. F.W. and Willmott. A.J., 'Thermal Energy Storage and Regeneration', Hemisphere Publishing Corporation, 1981, 1st Edition

E-References:

1. Prof. Subhasish Basu Majumder, "Electrochemical Energy Storage", NPTEL Course, https://nptel.ac.in/courses/113105102
2. Prof. PK Das, "Energy conservation and waste heat recovery", NPTEL Course, https://nptel.ac.in/courses/112105221.

Course Outcomes: Upon completion of this course, the students will be able to:			**Bloom's Taxonomy Mapped**
CO1	:	Understand different types of storage technologies.	L2: Understanding
CO2	:	Model a thermal battery energy storage system	L1: Remembering
CO3	:	Analyze the modeling of Lithium-ion batteries.	L4: Analyzing
CO4	:	Analyze the appropriate storage technologies for different applications.	L3: Applying
CO5	:	Explore the alternate energy storage technologies.	L2: Understanding

COURSE ARTICULATION MATRIX

COs/ POs	**PO1**	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PO8**	**PO9**	**PO 10**	**PO 11**	**PO 12**	**PS O1**	**PS O2**	**PS O3**
CO1	3	1											2		3
CO2	3		2										2		3
CO3	3		2										2		3
CO4	3		2										2		3
CO5		3				2		1					2		3
Avg	3	2	2	0	0	2	0	1	0	0	0	0	2	0	3
3/2/1-indicates strength of correlation (3- High, 2-Medium, 1- Low)															