Approval: 9th Senate Meeting

Course Number: EN 503

Course Name: Energy Storage Technologies

Credits: 3-0-0-3

Prerequisites: None

Intended for: UG/PG

Distribution: Foundation/core course for M.Tech. (Energy Engineering) students, Elective for MS, PhD, Final year UG students

Semester: odd/even

Preamble: The emerging energy generation sources such as solar and wind generates energy in variable patterns. Hence, energy storage is becoming of major importance to store and supply energy without any interruption. The energy storage can be in mechanical, electrochemical, or chemical forms.

Course Outline: This course intends to provide an understanding of working mechanisms of different energy storage technologies, comparison of different energy storage technologies, and an overview of energy storage opportunities and challenges. This course will also emphasize on emission, economics of different storage technologies and comparison of time scale of storage technologies and their applications.

Course modules:

Module 1: Energy storage systems overview - Scope of energy storage, needs and opportunities in energy storage, Technology overview and key disciplines, comparison of time scale of storages and applications. (3 Contact hours)

Module 2: Mechanical and thermal storage system -Introduction to major forms of mechanical storages such as flywheels, pumped hydro storage, compressed air, hydraulic accumulator, heat pumps, heat engine flywheel, hot water storage tank, vacuum solar thermal collector, steam accumulator, application of phase change materials for heat storage, characteristics of mechanical systems, efficiencies and economic evaluation of mechanical energy storage systems. (8 Contact hours)

Module 3: Electrochemical storage system- Introduction to the fundamental aspects of electrochemistry, Battery working principle, primary and secondary (flow) batteries, battery performance evaluation methods, major battery chemistries and their voltages; supercapacitors working principle, types of supercapcitors, cycling and performance characteristics, difference

between battery and supercapacitors, Introduction to Hybrid electrochemical supercapacitors; Stand alone and grid tied energy storage systems. (11 Contact hours)

Module 4: Chemical storage system- hydrogen, synthetic natural gas, biofuels and biomass, liquid nitrogen, concept of chemical storage of solar energy, application of chemical energy storage system, advantages and limitations of chemical energy storage, challenges and future prospects of chemical storage systems. (10 Contact hours)

Module 5: Electromagnetic storage systems - double layer capacitors with electrostatically charge storage, superconducting magnetic energy storage (SMES), concepts, advantages and limitations of electromagnetic energy storage systems, and future prospects of electrochemical storage systems. (10 Contact hours)

Reference Books:

1.Frank S. Barnes and Jonah G. Levine, Large Energy Storage Systems Handbook (Mechanical and Aerospace Engineering Series), CRC press (2011)

2. Robert A. Huggins, Energy storage, Springer Science & Business Media (2010)

3. Ralph Zito, Energy storage: A new approach, Wiley (2010)