Course: **Battery Energy Storage Systems 101: A Practical Introduction to Battery Technology, Chemistry and Applications**

Contact Hours: **30**

Pre-requisite: **None**

Abstract

With the increasing awareness of renewable energy systems, electric vehicles (EVs) and hybrid technologies, the use of battery storage systems is becoming increasingly important. As such, this short course will be exploring the electrical principles of various types of batteries, battery chemistry and construction, life cycle of various battery chemistries, battery charging circuits and operation, safety and applications of battery storage systems as well as possible future trajectory of battery technology.

At the end of this course, you will have a comprehensive understanding of the battery technology involved in your battery storage system as well as understand the principles and theories associated with the choice of battery technology, maintenance, operation and comparisons to other types of battery technologies/chemistries.

Target Audience

This short course will be beneficial to Solar Photovoltaic (PV) technicians, Hybrid Electric Vehicles (HEVs) technicians, Auto-Electrical Technicians, Electrical and Maintenance Engineers, Renewable Energy Engineers, Plant Managers, Power System Maintenance Personnel, Health and Safety Personnel and Procurement Personnel.

Learning Outcomes

On completion of this course, learners will be able to:

1. Explain the rationale for selecting various battery technologies/chemistries:
    a. Discuss the theory of electrochemical energy storage systems.
    b. Compare the suitability of selected battery technologies based on applications.
    c. Discuss the charging/discharging requirements of various battery technologies/chemistries.
    d. Understand the advantages and disadvantages of various battery chemistries.
    e. Determine the best suited battery chemistry based on the conditions that the battery storage system will be exposed to.
    f. Perform a lifecycle analysis of the battery storage system.

2. Distinguish battery technologies and storage systems based on categories:
    a. Selection of battery technologies and storage systems for residential applications
    b. Selection of battery technologies and storage systems for stand-alone renewable energy applications.
    c. Selection of battery technologies and storage systems for automotive applications.
    d. Selection of battery technologies and storage systems for commercial grid-tied applications.

3. Determine the storage requirements based on calculations and usage:
    a. Specify performance and energy density required for specific applications.
    b. Select battery technologies based on designed charging/discharging circuits.
    c. Analyze the lifecycle of the battery storage system and estimate the economic feasibility of their design.

4. Discuss the safety and hazards associated with electrochemical energy storage:
    a. Identify the hazards associated with various battery chemistries.
    b. Identify methods of reducing health and safety risks associated with electrochemical energy storage.
    c. Understand the safety standards with respect to electrochemical energy storage.

5. Understand the balance of designing an electrochemical energy storage system to meet maximum performance, financial feasibility and safety requirements.

Course Content

1. Introduction to Electrochemical Energy Storage

- Principle of Electrochemical Energy Storage Systems
- Overview of Current Status of Electrochemical Energy Storage Systems
- Overview of Applications of Electrochemical Energy Storage – Global Perspective

2. Definitions, Measures and Units

- Terminologies in Electrochemistry – Current, Voltage, Oxidation – Reduction, Cell Potential, Electrochemical Couples, Electrode, Electrolytes and Collectors, Galvanic Cell, Electrochemical Cell and Battery
- Units of Electrochemical Parameters and Their Conversions
- Measure of Basic Electrochemical Parameters

3. Theory of Batteries – Construction and Chemistry

- Performance Comparison of Batteries, Power and Energy
- Densities, Specific Power and Specific Energy of Different Batteries
- Charging and Discharging of Different Batteries
- Comparison of Energy Storage Technologies Based on Battery Chemistry

4. Lead Acid Batteries

- Construction and Electrochemistry of Lead Acid Batteries
- Battery Characteristics, Charging and Discharging of Lead Acid Batteries
- Advantages and Disadvantages
- Applications of Lead Acid Batteries

5. Nickel-Metal Hydride Batteries

- Construction and Electrochemistry of NiMH Batteries
- Battery Characteristics, Charging and Discharging of NiMH Batteries
- Advantages and Disadvantages
- Applications of NiMH Batteries

6. Li-Ion Batteries

- Electrochemistry and Construction of Li-Ion Batteries
- Battery Characteristics, Charging and Discharging of Li-Ion Batteries
- Advantages and Disadvantages
- Battery Manufacturing and Supply Chain of Lithium-Ion Batteries
- Applications of Li-Ion Batteries

7. Other Lithium-Based Batteries

- Li–Air Batteries – Construction, Chemistry and Characteristics
- Li–Sulphur Batteries – Construction, Chemistry and Characteristics
- Other Types of Batteries
- Battery State Estimation – State of Charge (SOC), State of Health (SOH), State of Function (SOF)

8. Recycling and Disposal of Batteries

- Need and Importance of Recycling
- Lithium Reserves – Resource Extraction
- Scope for Recycling of Batteries
- Challenges in Disposal of Batteries
- Environmental Health and Safety of Battery Recycling and Disposal

9. Battery Chargers

- Charger Configurations and Features – An Introduction
- Performance Characteristics of Chargers
- Electronics, Automotive and Industrial Applications

10. Safety in Commercial Battery Storage Systems

- Common Hazards and Safety Considerations, Fundamental Failure Modes
- Compliance to Safety Aspects in Commercial Battery Installations
- Mandated Fire Safety Compliance in Battery Installations – Effectiveness of Strategies
- Various Standards/Codes and Regulations

11. Application of Battery Energy Storage Systems

- Residential Applications – Self-consumption, Off-Grid Homes, and Emergency Backup.
- Commercial Applications of Batteries – Peak Shaving, Load Shifting, Emergency Backup, Microgrids, Renewable Integration and Various Grid Services
- Energy Storage in Transportation Sector – Electric Vehicles, Degrees of Vehicle Electrification, Current and Future Electric Vehicle Market
- Grid-Tied Energy Storage System Applications

12. Future of Battery Energy Storage System

- Innovations in Battery Electrochemistry, Advanced Materials and Battery Systems
- Scope for Advancements in Existing Battery Technology
- Batteries Beyond Lithium Ion
- Supercapacitors as Energy Storage Systems

Essential Learning Resources

Learners will have access to various types of batteries to investigate its construction in detail. It should be noted that some of these batteries will be deconstructed and as such, persons may be exposed to corrosive chemicals. The following dress code will be in effect for all practical work.