UNIT V

ALTERNATE ENERGY STORAGE TECHNOLOGIES

Hybrid Energy Storage System (HESS)

A Hybrid Energy Storage System (HESS) is **a combination of two or more energy storage technologies** used together **to improve performance, efficiency, and reliability**. It overcomes the limitations of a single storage system by integrating complementary technologies.

Need for Hybrid Storage:

- Address limitations of single storage types
- Meet dynamic energy demands (power and energy)
- Improve system efficiency, life and safety

Components of HESS:

1. Battery (e.g., Lithium-ion battery)

- Stores large amount of energy
- Suitable for long-duration supply

2. Supercapacitor

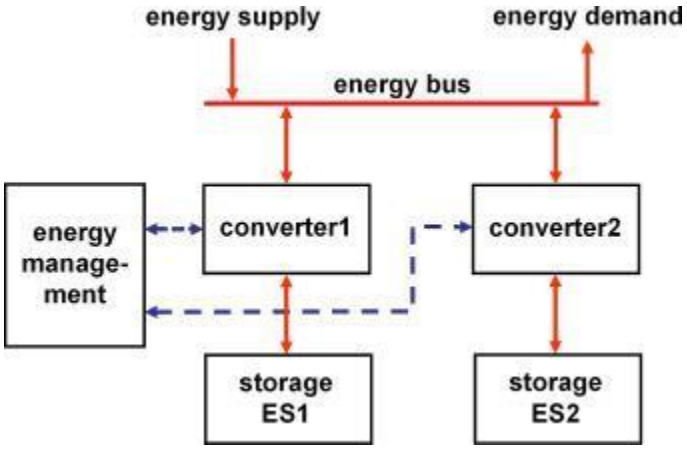
- Provides quick charge and discharge
- Handles peak power demand

3. Power Electronics Converter

- Controls energy flow between sources and load.

4. Energy Management System (EMS)

- Optimizes operation
- Decides when to use battery or super capacitor.



Working Principle

During **low power** demand: Battery supplies energy

During **high power** demand: Super capacitor provides additional power

During **regenerative mode**: Super capacitor stores sudden energy bursts.EMS ensures efficient energy sharing between devices.

Types of Hybrid Storage Systems

1. Battery + Supercapacitor

2. Battery + Flywheel

3. Fuel Cell + Battery

4. Battery + Compressed Air Energy Storage

Advantages

- High energy density
- High power density
- Longer life cycle
- Better efficiency
- Fast response to load changes
- Reduced energy losses
- Enhanced reliability and stability

Disadvantages

- High initial cost
- Complex control system
- Requires sophisticated energy management

Applications

Used in

- Electric vehicles (EVs)
- Renewable energy systems (solar, wind)
- Smart grids
- Uninterruptible Power Supply (UPS)
- Portable electronic devices