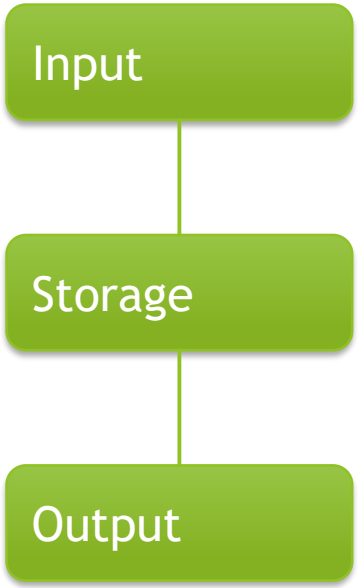
UNIT-II

Types of Electrical Energy Storage Systems

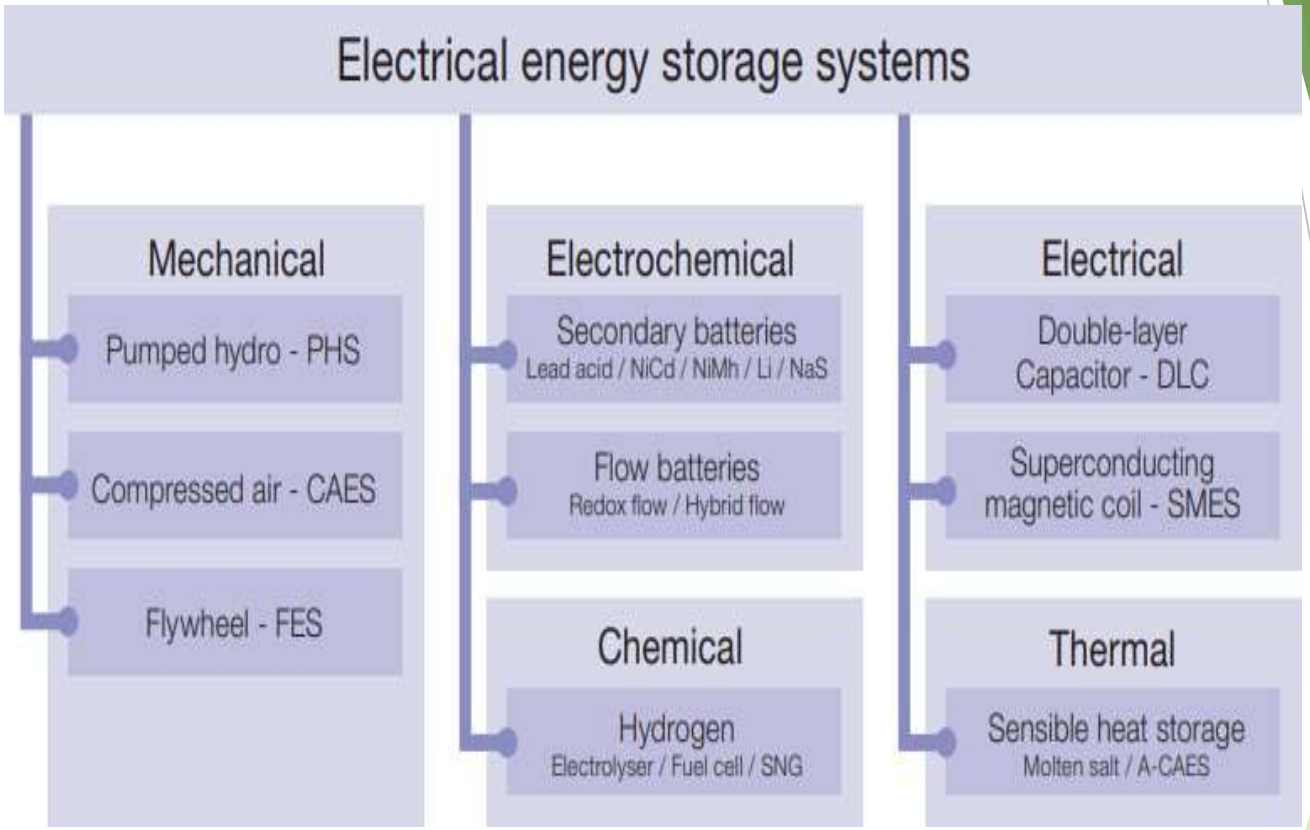
Types of Electrical Energy Storage Systems

- Mechanical Storage
- Electrochemical Storage
- Chemical Storage
- Electrical Storage
- Thermal Storage



Classification of EES Systems

- Mechanical: PHS, CAES, Flywheel
- Electrochemical: Batteries, Flow Batteries
- Chemical: Hydrogen, SNG
- Electrical: DLC, SMES
- Thermal: Sensible and Latent Heat Storage


Electrical energy storage systems
Mechanical
Pumped hydro - PHS
Compressed air - CAES
Flywheel - FES
Electrochemical
Secondary batteries
Lead acid / NiCd / NiMh / Li / NaS
Flow batteries
Redox flow / Hybrid flow
Chemical
Hydrogen
Electrolyser / Fuel cell / SNG
Electrical
Double-layer
Capacitor - DLC
Superconducting
magnetic coil - SMES
Thermal
Sensible heat storage
Molten salt / A-CAES

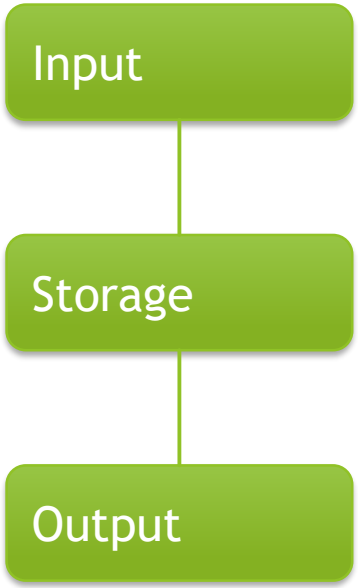
Pumped Hydro Storage (PHS)

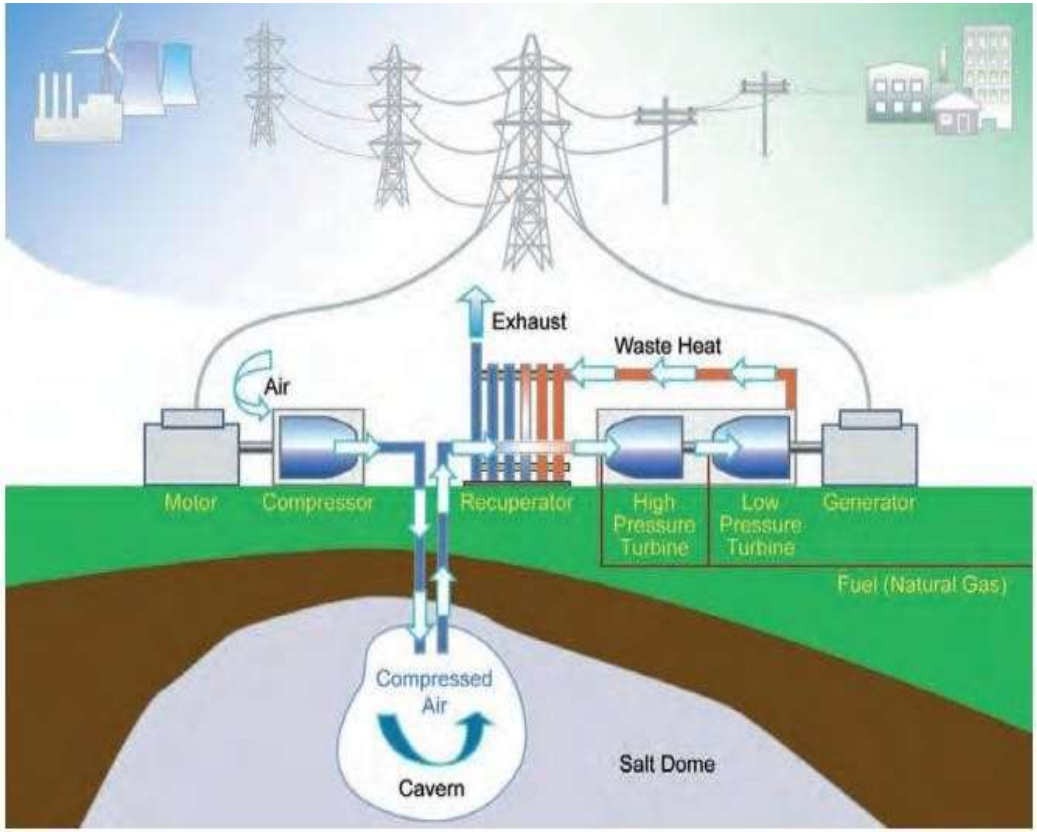
- Stores water at different heights
- Used for large-scale energy storage
- Efficiency: 70% - 85%
- Advantages: Long life, high capacity
- Disadvantages: Needs special topography

Pumped Hydro Storage

Compressed Air Energy Storage (CAES)

- Air compressed and stored underground
- Uses gas turbine during discharge
- Large capacity storage
- Lower efficiency (<50%)

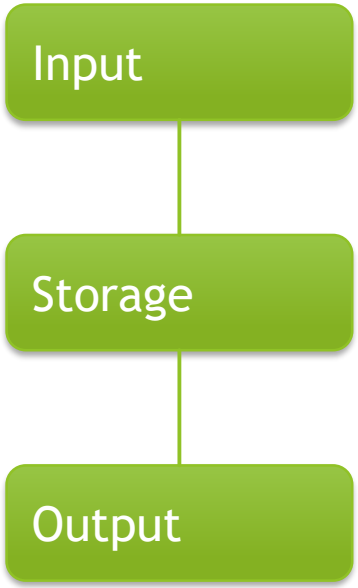


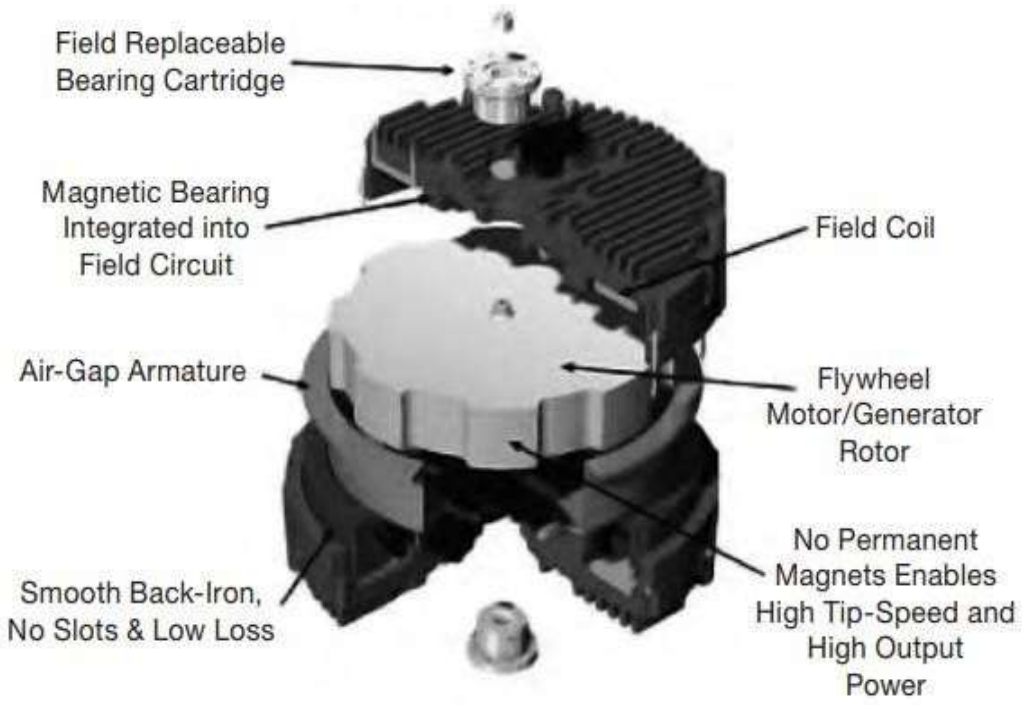


Underground CAES

Flywheel Energy Storage (FES)

- Stores rotational kinetic energy
- High power density
- Fast response
- Excellent cycle stability





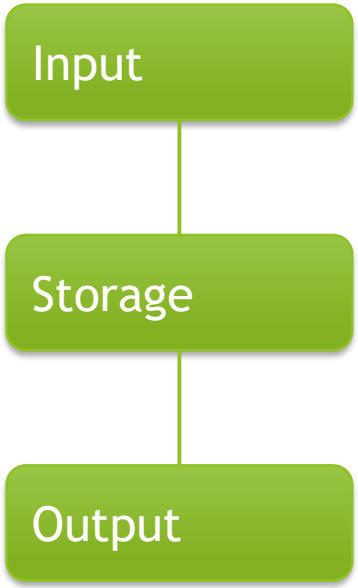
Flywheel energy storage

Electrochemical storage systems

- secondary batteries
- Flow batteries

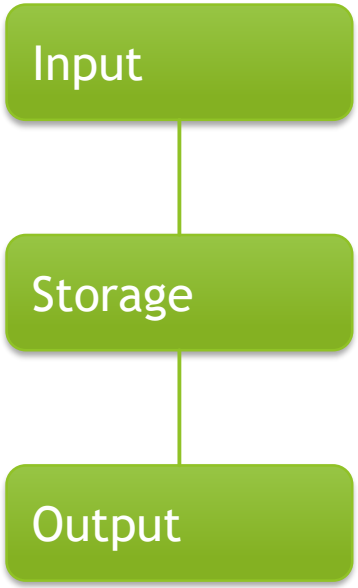
Lead Acid Batteries

- Most widely used battery
- Low cost and recyclable
- Efficiency: 80% - 90%
- Used in UPS and renewable systems



Lithium Ion Batteries

- High energy density
- Efficiency: 95% - 98%
- Used in EVs and electronics
- Needs safety monitoring



Li-ion prismatic cell design and battery modules

Nickel cadmium and nickel metal hydride battery (NiCd, NiMH)

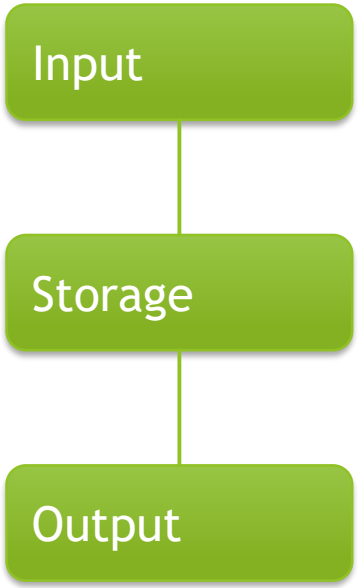
- High power density
- Temperature low (-20 °C to -40 °C) also
- Portable and mobile applications
- Cost same as Li-ion battery

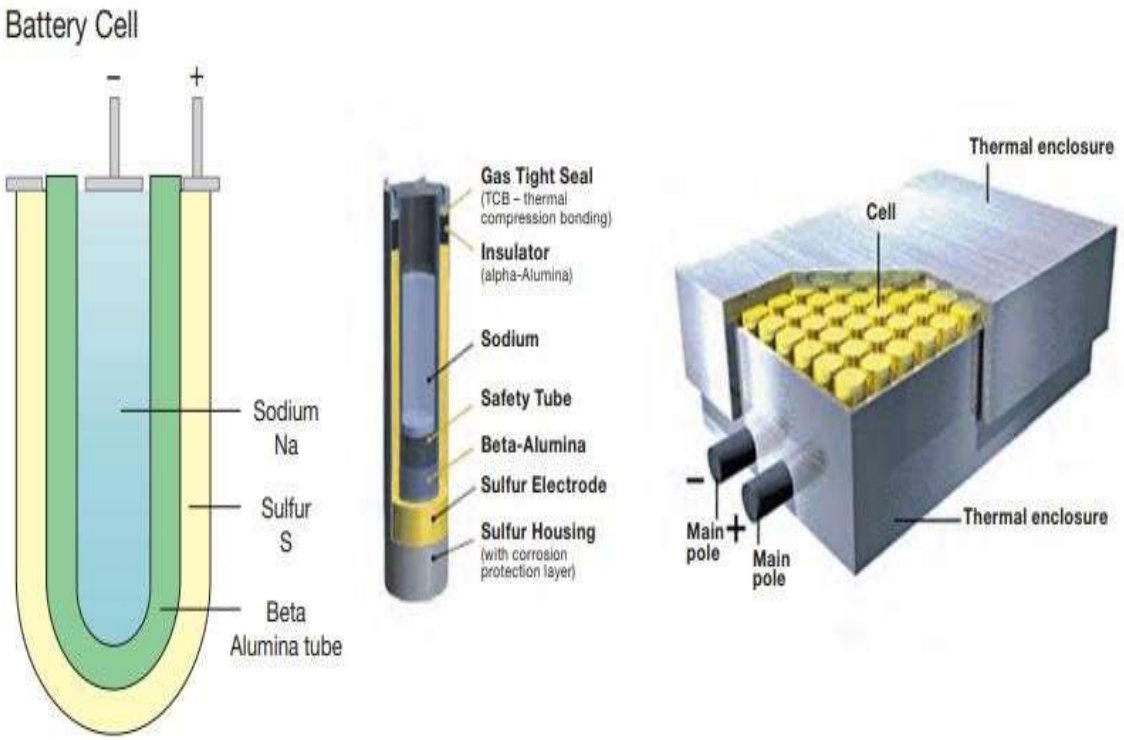
Metal air battery (Me-air)

- Anode is pure metal catode is air
- Lithium air batteries
- Zink air batteries
- low materials cost and high specific energy
- Not reached marketability

Sodium Sulphur Batteries (NaS)

- Operates at high temperature
- Efficient for grid applications
- Fast response and long cycle life




Battery Cell
–
+
Sodium
Na
Sulfur
S
Beta
Alumina tube
Gas Tight Seal
(TCB – thermal compression bonding)
Insulator
(alpha-Alumina)
Sodium
Safety Tube
Beta-Alumina
Sulfur Electrode
Sulfur Housing
(with corrosion protection layer)
Thermal enclosure
Cell
–
Main pole
+
Main pole
Thermal enclosure

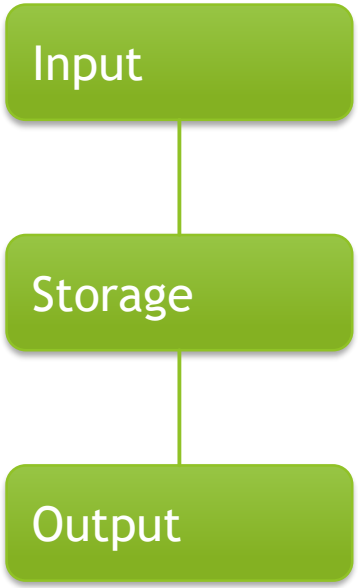
NaS Battery

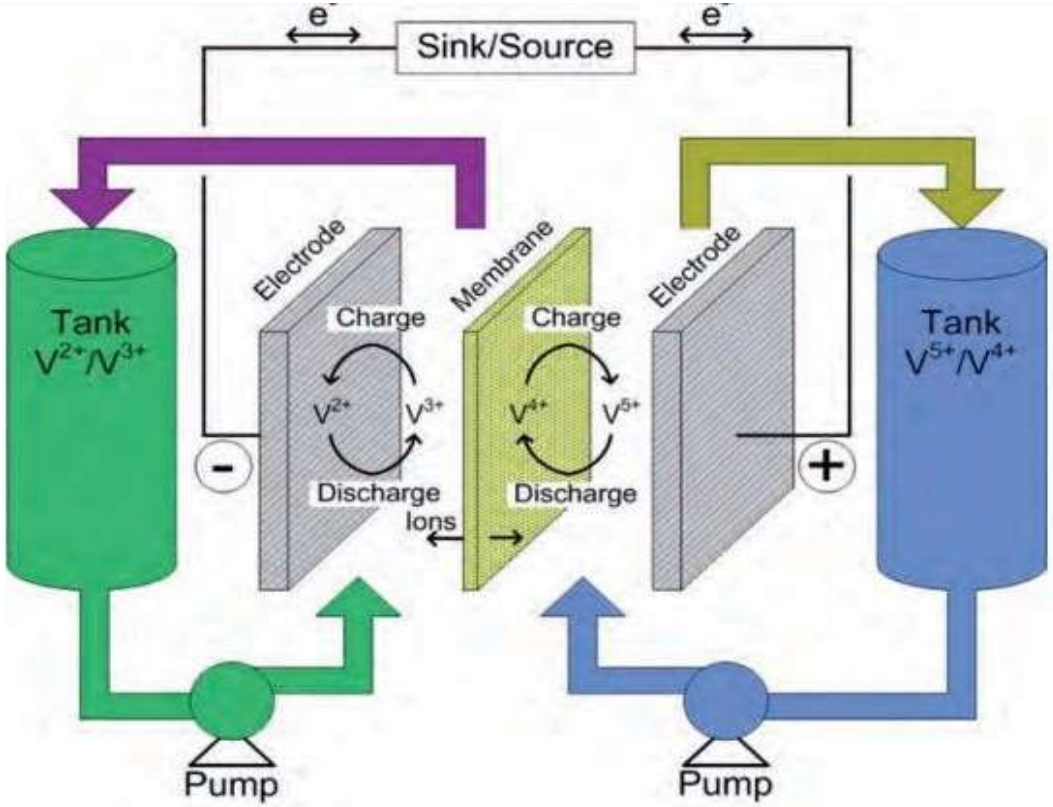
Sodium nickel chloride battery (NaNiCl)

- ZEBRA (Zero Emission Battery Research) battery,
- operating temperature is around 270 °C
- uses nickel chloride instead of sulphur
- Smart EV applications

Flow Batteries

- Energy stored in liquid electrolytes
- Suitable for large-scale storage
- Types: Redox and Hybrid Flow Batteries





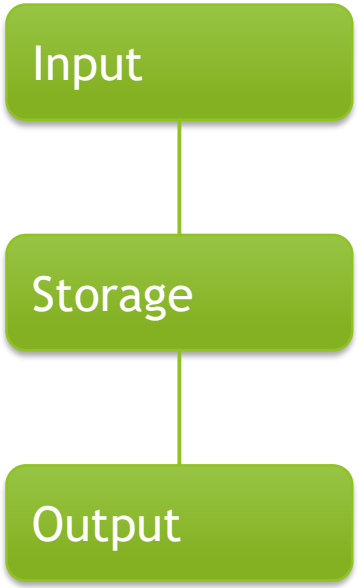
Redox flow battery (RFB)

Hybrid flow battery (HFB)

- combine features of conventional secondary batteries and redox flow batteries
- capacity of the battery depends on the size
- examples of a HFB are the Zn-Ce and the Zn-Br systems

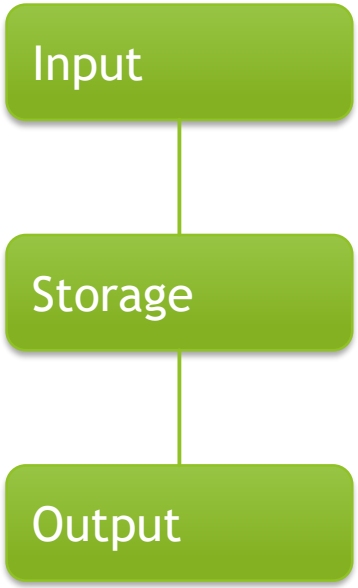
Hydrogen and SNG Storage

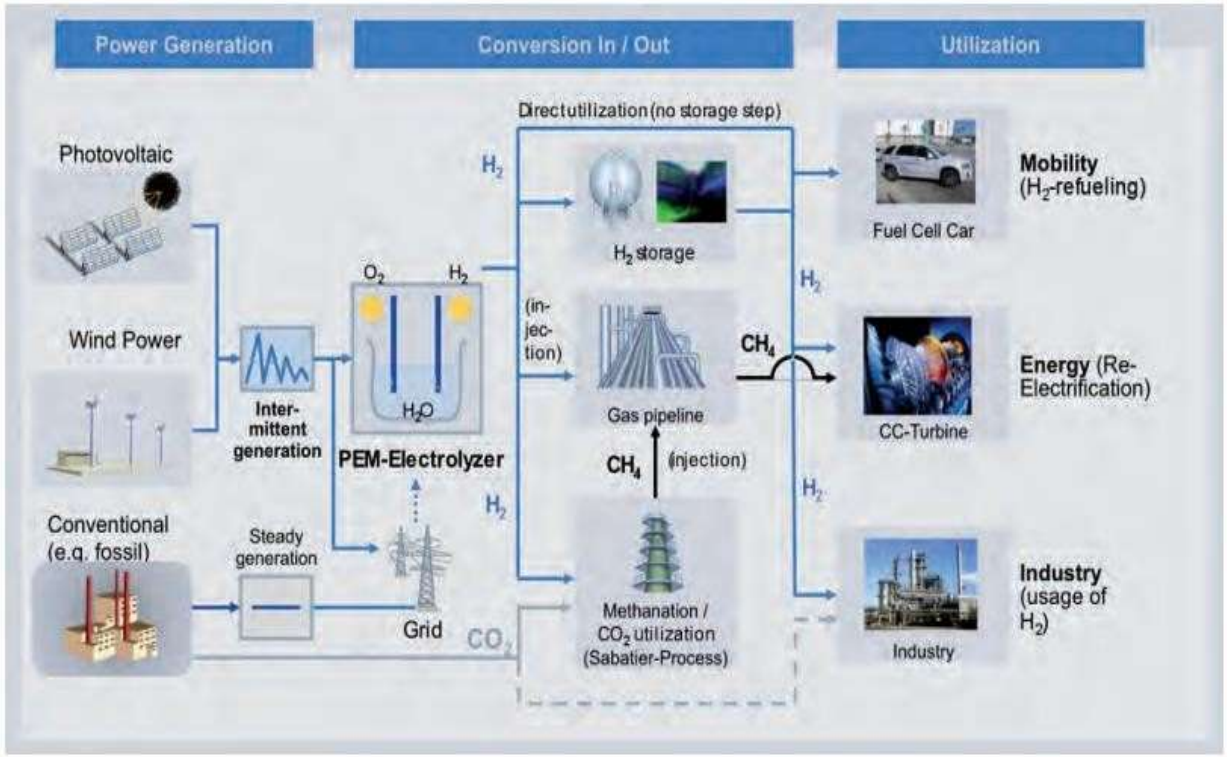
- Hydrogen produced by electrolysis
- Can be stored for long durations
- Useful for renewable integration
- Lower overall efficiency



Double Layer Capacitors (DLC)

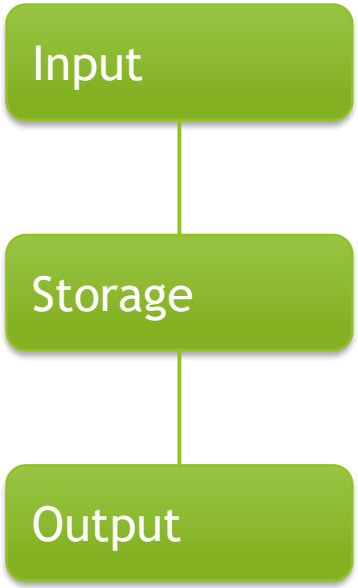
- Very high power capability
- Extremely fast charging/discharging
- Long life and high cycle stability




Power Generation
Conversion In / Out
Utilization
Direct utilization (no storage step)
Photovoltaic
Wind Power
Conventional (e.g. fossil)
Inter-mittent generation
Steady generation
PEM-Electrolyzer
Grid
H_2 storage
Gas pipeline
(in-jec-tion)
CH_4
CH_4 (injection)
Methanation / CO_2 utilization (Sabatier-Process)
Fuel Cell Car
CC-Turbine
Industry
Mobility (H_2-refueling)
Energy (Re-Electrification)
Industry (usage of H_2)

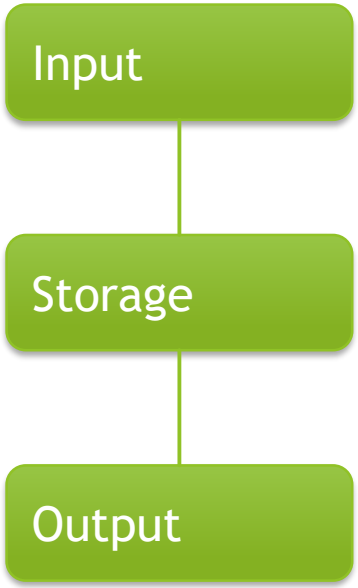
Superconducting Magnetic Energy Storage (SMES)

- Stores energy in magnetic field
- Very fast response time
- High efficiency: 85% - 90%



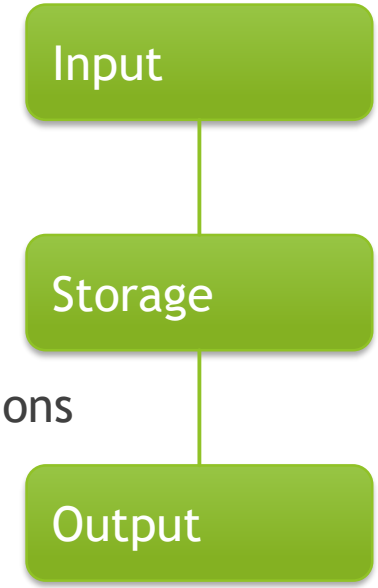
Thermal Storage Systems

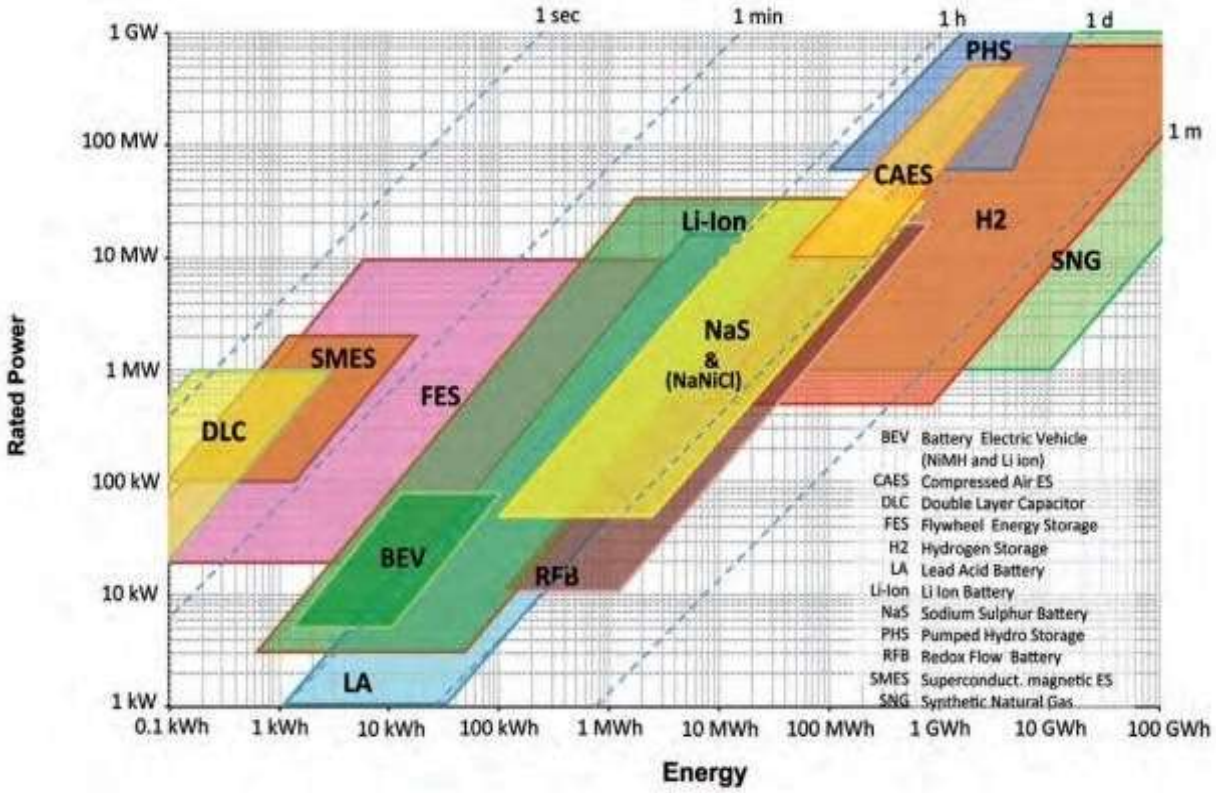
- Stores heat energy
- Types: Sensible, Latent, Thermochemical
- Used in CSP plants and heating systems



Technical Comparison of EES

- Short Duration: DLC, SMES, Flywheel
- Medium Duration: Batteries
- Long Duration: Hydrogen, SNG
- Each technology suits different applications

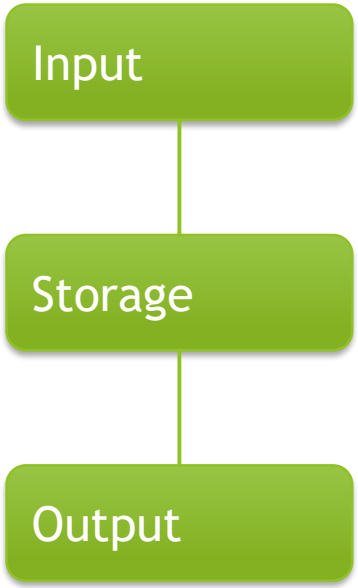




Comparison of rated power, energy content and discharge time of different EES technologies

Advantages of EES Technologies

- Supports renewable energy
- Improves power quality
- Provides backup power
- Helps Smart Grid applications



Thank You

Questions & Discussion