# Energy Storage Technologies- An Overview

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**Abstract-** The trend in the increase of energy demands and creating new platform for electrical automobile, with concern of exhausting of the natural resource and vast serious impact on our environmental problems. This encourages us to establish positive shift toward renewable energy with reliability, quality and economic feasibility. The renewable sector has a concern of storage as renewable sector is depending on nature for production of power or thermal application like solar cooking. Such problems could be solved by energy storage in different form only and this paper presents an overview of various storage systems.

**Keywords-** Energy storage; Renewable energy, Thermal energy

## I. INTRODUCTION

Due to rapid growth in the infrastructure sector (i.e. communication, transport, road and rail networks, etc.), demand of energy is rising enormously and more than 20-30% demand is satisfied by non-conventional energy sources [1]. Renewable or non-conventional energy sources are essential for sustainable development, have many advantages over conventional energy sources like availability, environment-friendly, etc. But the most important difficulty is the uneven generation of energy. Therefore, trustworthy and affordable energy storage system becomes a prerequisite for using renewable energy [2] [3]. Energy storage systems play pivotal role towards smooth and continuous energy supply. Energy storage system holds the generated energy for a short time and supplied it according to need. Therefore, energy storage system is the most capable technology to meet the rising demand of energy [4]. A device that accumulates energy is sometimes termed as an accumulator. There are various energy storage systems. Paper presents brief overview of various energy storage systems.

## II. ENERGY STORAGE SYSTEMS (ESSs)

Many types of research come on the conclusion that renewable energy sources are the only option for sustainable development and appropriate energy storage systems are the prerequisite [5]. They have feature to store the energy and then release as and when required. Some ESSs are flywheel energy storage, compressed air energy storage, pumped storage, batteries, regenerative fuel cell storage, superconducting magnet energy storage, etc [6].

### A. Flywheel energy storage system

Flywheel energy storage systems store energy mechanically in the flywheel rotor by rotating the rotor. Afterward, the generator is employed to convert mechanical energy to electrical [7], as shown in Fig. 1. It is efficient and used for various applications. It is preferred due to compactness, light in weight and high energy capacity. But due to limited amount of charge/discharge cycle characteristic, it is not cost-effective.

Another assortment of flywheel energy storage system utilizes an attractive suspension where the hub burden is given exclusively by permanent magnets, while the dynamic attractive course is utilized for outspread adjustment. This implies the permanent magnet bearing must give all the hub damping. Moreover, it must have as low a negative outspread firmness as conceivable to decrease the remaining task at hand on the spiral dynamic attractive direction [7]. A wide range of scientific models for deciding power, firmness, and damping of permanent magnet heading. This work will further build up the most pertinent explanatory and numerical techniques so as to make them straightforwardly implementable for structuring permanent magnet push course for flywheel energy storage systems. The result is a quick and proficient technique for deciding the power, firmness, and damping when the bearing arrangement contains attractive materials with relative porousness higher than one just as when it doesn't.

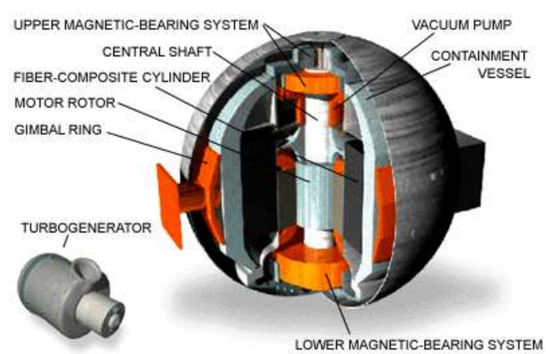



Fig. 1: Flywheel energy storage system (www.greenoptimistic.com/mechanical-battery-flywheel)

### B. Compressed air energy storage

It is also known as stone storage system. Air is compressed to absorb and store heat energy after that released to utilized to generate steam and electricity [8]

[9]. The conceptual diagram is shown in Fig. 2. It is getting popularity due to quick start-up, able to integrate with other energy sources but requires geological structure reliance [10].

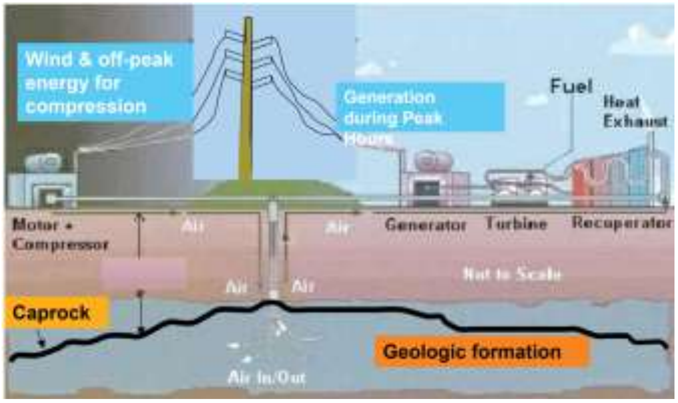



Fig 2: Compressed air energy storage (energynews.us/2012/01/19/midwest/scrapped-iowa-project-leaves-energy-storage-lessons)

The wind has been perceived as one of the major sensible clean energy hotspots for power age to meet the persistently expanded energy request and to accomplish the carbon discharge decrease targets. Be that as it may, the use of wind energy experiences an unavoidable test coming about because of the idea of wind discontinuity. To address this, the paper shows the ongoing exploration work at Warwick on the attainability investigation of another cross breed framework by coordinating a breeze turbine with compressed air energy storage. A mechanical transmission component is structured and actualized for power combination inside the half and half framework [7]. A parchment expander is adjusted to fill in as an "air-apparatus energy converter", which can transmit extra driving force summed up from the put away compressed air to the turbine shaft for smoothing the breeze control variance. A numerical model for the total half and the half procedure is created and the control methodology is examined for comparing helpful activities. A model test rig for actualizing the proposed instrument is worked for proof of the idea.

### C. Pumped storages

In a pumped storage system, water is pumped and stored at height during off-peak periods then utilized to generate electricity to meet the peak demand [8] [11], as shown in Fig. 3. Hydropower plants store electricity in Megawatts (MW) or Giga-watts (GW). It has many advantages i.e. fast start-up, reliable but requires large area and cost [12].

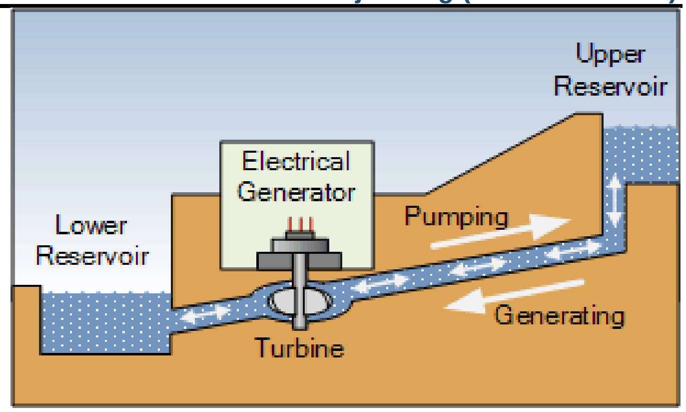



Fig 3: Pumped storage (www.alternative-energy-tutorials.com/energy-articles/pumped-hydro-storage.html)

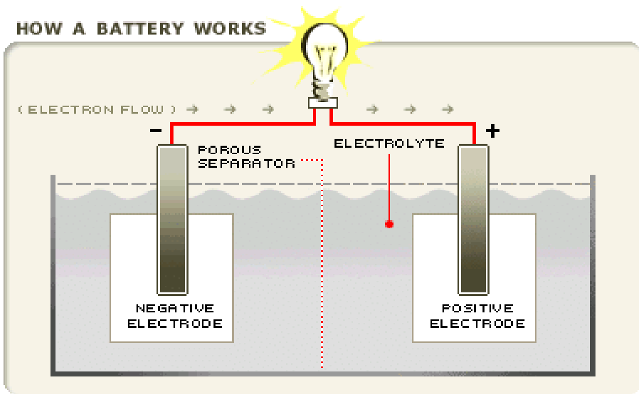
The pumped hydro energy storage (PHES) is an entrenched and financially adequate innovation for utility-scale power storage and has been utilized since as ahead of schedule as the 1890s. Hydropower isn't just an inexhaustible and feasible energy source, yet its adaptability and storage limit likewise makes it conceivable to improve framework soundness and to help the sending of other irregular sustainable power sources, for example, wind and sun based [13]. Therefore, are another enthusiasm for PHES and interest in the restoration of old little hydropower plants are developing all-inclusive? Concerning PHES, advance turbine configuration is required to upgrade plant execution and adaptability and new methodologies for streamlining storage limit and for boosting plant gainfulness in the deregulated energy advertise.

### D. Battery

Basic construction, working principle, functions of battery is very familiar, as shown in Fig. 4 (a) and (b). Portable batteries are well accepted small storage applications like transport sector, utilities, etc [14]. But it has some drawbacks like cost, short life and regular maintenance [15].

Chemical batteries have assumed significant jobs in energy storage and change. Among as of now accessible battery advancements, lithium-based batteries, for example, Li-particle batteries (LIBs), are viewed as the most encouraging ones because of their moderately higher energy thickness. Typically, the ordinary Li batteries utilize natural liquid electrolytes, which have generally low ionic obstruction, prompting a few downsides, for example, security issue, deficient lifetime, staggering expense, and low control thickness. Be that as it may, all-solid-state Li batteries with nonflammable solid electrolytes can keep away from a portion of the issues, specifically, the security one. Generally, when contrasted with liquid-electrolyte Li batteries, all-solid-state ones are believed to be more secure and to have longer cycle life, higher energy thickness, fewer necessities on bundling and condition of-charge observing circuits [16]. Concerning this, there is a developing enthusiasm for all-solid-state batteries. Nonetheless, mediocre cycle execution initiated by the constant advancement of interfacial obstruction layer among cathode and electrolyte materials is one of the real downsides that should be defeated for the fruitful commercialization of auxiliary Li batteries. It is normal that all-solid-state batteries ought to be utilized broadly in enormous electrical power storage frameworks, for example, electrical vehicles just as electronic gadgets because of their high energy thickness and wellbeing. Hence, there are serious inquires about on Li-particle leading inorganic materials utilized as a solid-state electrolyte for all-solid-state Li batteries as of late.

(a)




(b)

Fig 4: Battery [17]

### E. Regenerative fuel cell storage

It is an electrochemical cell, converts source fuel (i.e. hydrogen, methane, propane, methanol, etc.) into electricity [18]. A hydrogen fuel cell is the one type of electrochemical cell, where hydrogen is used the primary fuel and oxygen is also required, as shown in Fig. 5. They produce electricity with very little pollution as hydrogen cell produces by-product water [19]. It has many advantages like no greenhouse gases; more operating time has some disadvantages like facing difficulty in storing of hydrogen due to highly inflammable nature of H2 and requirement of high capital cost due to platinum catalyst [20].

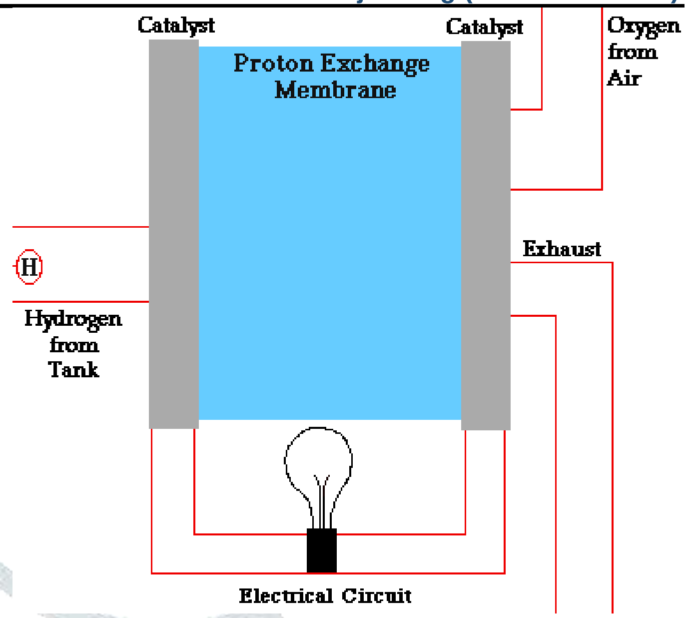



Fig 5: Hydrogen cell (americanhistory.si.edu/fuelcells/basics.htm)

### F. Under-ground thermal energy storage

Temperature of underground (i.e. remains constant round the year methods of ground-coupled heat exchange systems (i.e. Earth-Air Heat Exchanger (EAHE has shown in Fig. 6, ground source heat pumps) natural heating/cooling air/liquid [21]. But fuel cell below 2-3m) [22] [23] Using EAHE), as pumps), could be done.

A further expansion of surface pumped storage power plants is limited by their topographic requirements (available elevation difference between both reservoirs) and by their public acceptance in relation to the land use and the associated environmental impact. In that sense, these systems can be designed so that the lower reservoir (and even the upper reservoir) is underground (UPHES). This concept was firstly proposed by Fessenden in 1910 [24]. The advantage is not economic but the installations are not visible and there is no need to construct dams occupying scenic mountain areas. In addition, the lower reservoir can be placed directly under the upper one, so the horizontal distance between the reservoirs the length of the water conduits are minimized. The head difference is usually higher than in PHES systems, so smaller reservoirs can generate the same amount of energy. Interesting discussions about UPHES can be found at. Although the lower reservoir can be drilled, underground or open-pit mines can be used for that purpose, being proposed by Harza in 1960 for the first time

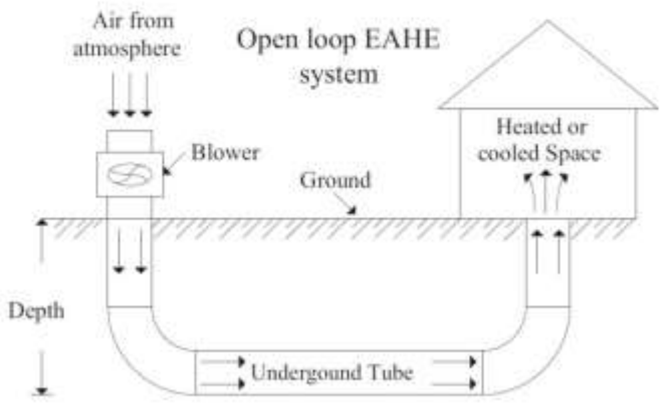



Fig 6: Earth air heat exchanger [20]

### G. Superconducting magnet energy storage

This is advanced energy storage stores energy in the magnetic field within magnets that are developed by flow of direct current in a superconducting coil, and then releases fraction of cycle [25] [26], as shown in Fig.7.

This study examines the use of superconducting magnetic and battery hybrid energy storage to compensate grid voltage fluctuations. The superconducting magnetic energy storage system (SMES) has been emulated by a high current inductor to investigate a system employing both SMES and battery energy storage experimentally. The design of the laboratory prototype is described in detail, which consists of a series-connected three-phase voltage source inverter used to regulate AC voltage, and two bidirectional DC/DC converters used to control energy storage system charge and discharge [27]. 'DC bus level signalling' and 'voltage droop control' have been used to automatically control power from the magnetic energy storage system during short-duration, high power voltage sags, while the battery is used to provide power during longer-term, low power under-voltages.

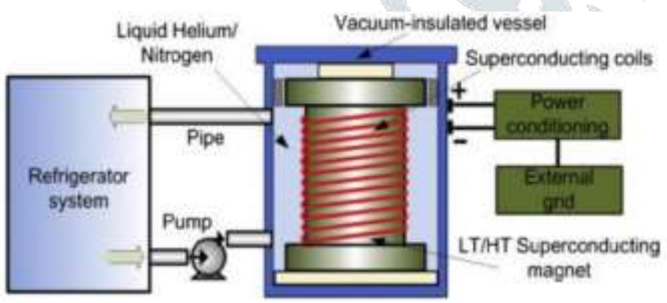



Fig 7: Superconducting magnet energy storage [28]

### H. Molten salt

Molten salt storage systems are the established commercially available concept for the solar system. It is within thermal power plants [29]. Due to their low vapour pressure and comparatively high thermal stability, molten salts are preferred as the heat transfer fluid and storage medium [30]. However, due to pressure, the development of alternative more cost-effective concepts is a step in making thermal energy storage more competitive for industrial processes and solar thermal applications [31]. A closer look at the capital cost distribution of two storage systems reveals that indirect systems with a maximum operating temperature of 400 °C have differing heat transfer fluids (HTF) and storage media [32]. For those systems, the molten salt storage media (about 35 % of the direct capital costs) and the storage tanks (about 24% of the direct capital costs) are the main bearers of cost. For direct systems with operating temperatures up to 560 °C, using molten salt as the HTF and the storage media, the capital cost ratios are 34 % for the storage media and 31 % for the storage tank, respectively [33].

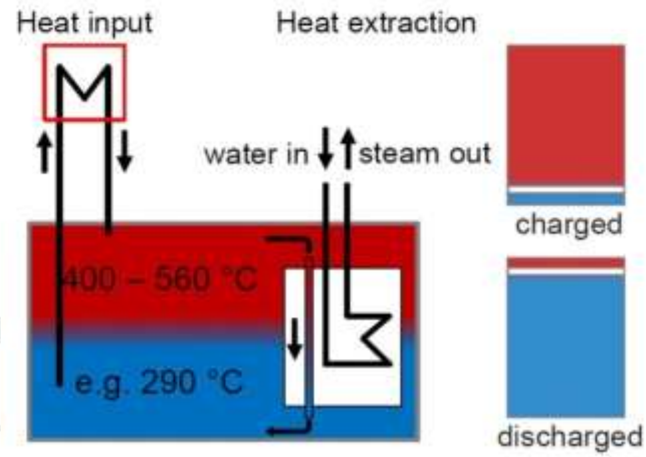



Fig 8: Molten Thermal Energy Storage Device [25]

It ought to be noticed that the examinations of the molten salt chiefly centred around the thermo-physical properties and warmth move execution of unadulterated molten salt in the warm energy stockpiling unit. There was only occasionally report about the LHTES system with molten salt, not to mention the investigation about the warm energy stockpiling and recovery attributes. Furthermore, the operational qualities of the LHTES system with composite PCM framed by molten salt and permeable medium were infrequently announced. Such certainties demonstrate that serious examinations are as yet expected to advance the utilization of molten salt in the LHTES system [34]. In the present examination, a shell and-cylinder LHTES system utilizing molten salt as the PCM and oil as the HTF is worked to tentatively explore the exhibition for medium-temperature warm energy stockpiling application. The impact of the mass stream pace of the HTF on the warm energy stockpiling and recovery procedures is examined. Since the little warm conductivity of the unadulterated molten salt prompts horrible showing, nickel froth which is erosion resistive is installed in molten salt to frame composite PCM with high viable warm conductivity so as to improve the warmth move execution. The exhibition of the LHTES system with unadulterated molten salt is contrasted and that of the system with composite PCM. The mean power and energy effectiveness are evaluated and utilized as warm presentation pointers to survey the LHTES system in the present examination.

### I. Stone Storage

In this type of energy storage medium is a pebble that has significantly higher thermal conductivity than normal concrete [35]. Although the recipe of this material is quite complex the main component is quartzite, a natural geo-material readily available in many parts of the world. Further, heat is transported in and out of the storage by way of a heat transfer fluid (HTF) which flows through steel pipe heat exchangers that are cast into concrete storage elements. These elements are specially designed to deal with thermal deformations and stressing [36] [37] Stone storage may be a good technology for CL-CSP system.

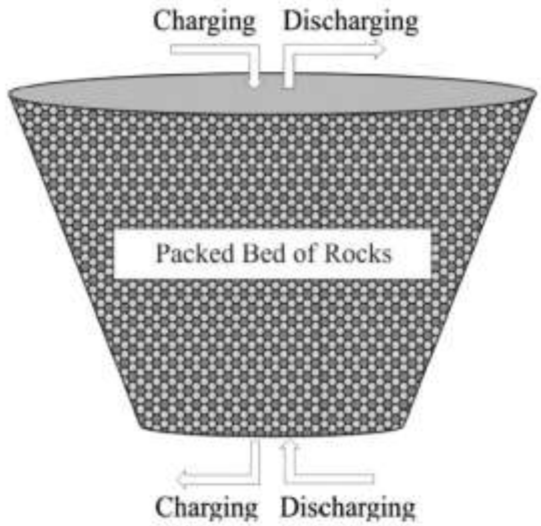



Fig 9: Pebble Energy Storage [30]

## III. CONCLUSION

It can be concluded from a comparative study of various energy storage systems that for the need of large scale energy storage underground thermal, pumped hydro and compressed air energy storage systems are suitable. Superconductors are able to store energy with negligible losses. Fuel cells are a viable alternative to petrol engines due to their high efficiency. Flywheels have a narrow range and suitable for small scale operations.

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