Energy Storage Technologies- An Overview

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Abstract-Rapidlyrising demand of energy**,** fast depleting and limited stock of fossil fuels, their serious environmental issues compel to shift towards to more use of renewable energy sources.There are some critical issues while using renewable energy sources like reliability, quality, etc. Energy storage systems have the capability to solve the problems up to some extent towards smooth and continuous energy supply. Paper presents brief overview of various energy storage systems.

Keywords-Energy storage; Renewable energy.

I. **INTRODUCTION**

Due to rapid growth in 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 the sustainable development, have many advantagesover conventional energy sources like availability, environment friendly, etc. But the most important difficultyis theunevengeneration 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 systemholdsthe generated energyfor 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. 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 researches come on the conclusion that renewable energy sources are the only option for sustainable development and appropriate energy storage systems are the prerequisite. 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.

A. *Flywheel energy storage system*

Flywheel energy storage systems store energy mechanically in the flywheel rotor by rotating the rotor. Afterward generator is employed to convert mechanical energy to electrical, 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.

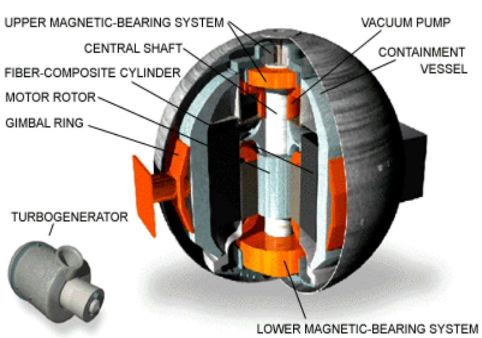


Fig. 1.Flywheel energy storage system

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. Conceptual diagram is shown as Fig. 2. It is getting popularity due to quick start-up, able to integrate with other energy sources but requires geological structure reliance [5].

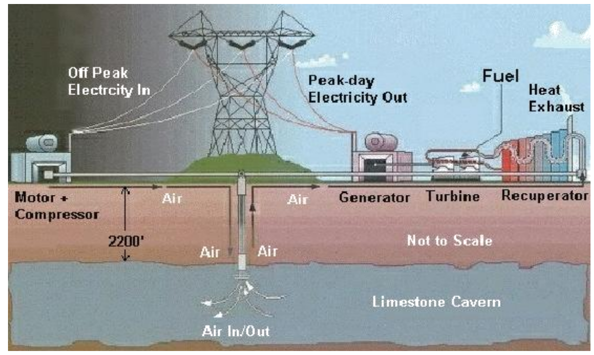


Fig. 2. Compressed air energy storage

C. *Pumped storage*

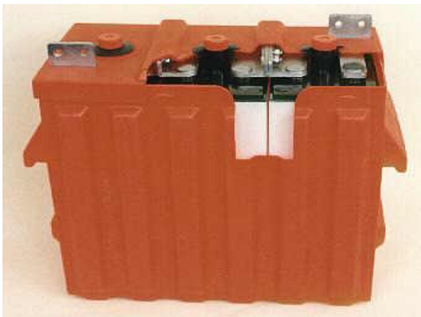
In pumped storage system, water is pumped and stored at height during off-peak periodsthen utilized to generate electricity to meet the peak demand, as shown in Fig. 3. Hydro power plants store electricity in Megawatts (MW) or Gigawatts(GW). It has many advantages i.e. fast start-up, reliable but requires large area and cost.

Fig. 3. Pumped storage

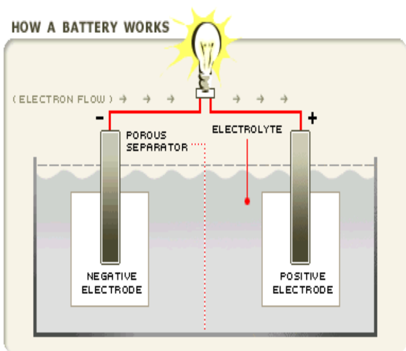
D. *Battery*

Basic construction, working principle, functions of battery is very familiar, as shown in Fig. 4 (a) and (b).Portable batteries are well accepted in many small storage applications like transport sector, utilities, etc.

But it has some drawbacks like high cost, short life and regular maintenance.



(a)



(b)

Fig. 4. Battery

E. *Regenerative fuel cell storage*

It is electrochemical cell, converts source fuel (i.e. hydrogen, methane, propane, methanol, etc.) into electricity. 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 like hydrogen cell produces by product water. It has many advantages like no green house gases, more operating time [6]. But has some disadvantages like facing difficulty in storing of hydrogen due to highly inflammable nature of H_2 and requirement of high capital cost due to platinum catalyst.

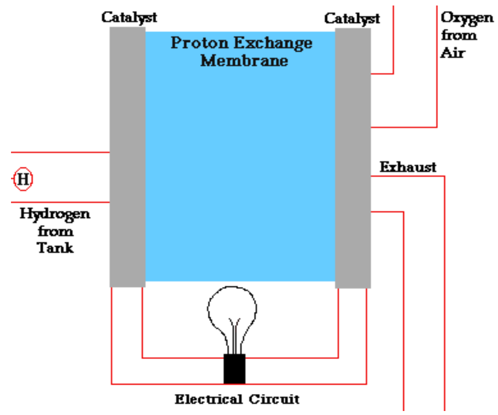


Fig. 5.Hydrogen fuel cell

F. *Under-ground thermal energy storage*

Temperature of underground (i.e. below 2-3m) remains constant round the year [7,8]. Using methods of ground coupled heat exchange systems(i.e. Earth Air Heat Exchange (EAHE), as shown in Fig. 6, ground source heat pumps), natural heating/cooling air/liquid could be done.

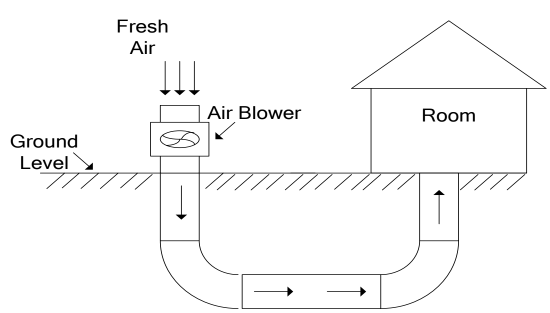


Fig. 6.Earth air heat exchanger

G. Superconducting magnet energy storage

This is an advanced energy storage system. It stores energy in the magnetic field within magnets that is developed by flow of direct current in a superconducting coil, and then releases it within fraction of cycle, as shown in Fig.7.

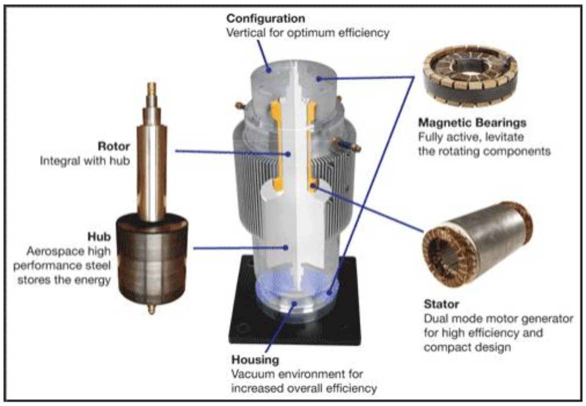
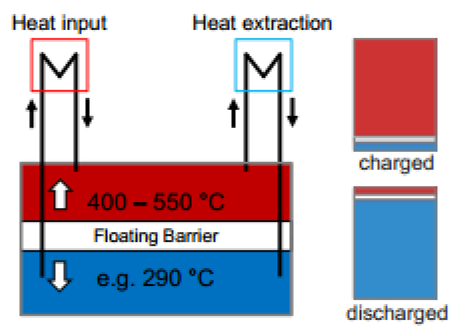


Fig. 7.Superconducting magnet energy storage

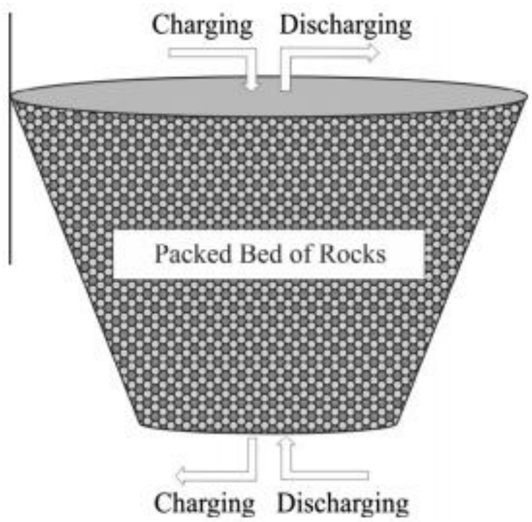
H. Molten salt

Molten salt storage systems are the established commercially available concept for solar thermal power plants. Due to their low vapor pressure and comparatively high thermal stability, molten salts are preferred as the heat transfer fluid and storage medium. However, due to pricing pressure, the development of alternative, more cost-effective concepts is an important step in making thermal energy storage more competitive for industrial processes and solar thermal applications [9,10]. A closer look at the capital cost distribution of two-tank storage systems, reveals that indirect systems with a maximum operating temperature of 400 °C have differing heattransfer fluids (HTF) and storage media. 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 directsystems 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 [11]



I. Stone Storage

In this type of energy storage medium is pebbles that has significantly higher thermal conductivity than normal concrete. 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[12,13]



Stone storage may be a good technology for CL-CSP system.

III. CONCLUSION

It can be concluded from comparative study of various energy storage systems that for the need of large scale energy storage underground thermal, pumped hydro and compressed air energy storagesystems 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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