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India Energy Storage Alliance

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Emerging Technology Review: Stationary Storage Part III

Pumped Storage Hydro, Thermal Storage, Mechanical Storage

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About IESA (India Energy Storage Alliance)

- India Energy Storage Alliance (IESA) is the premier alliance focusing on the advancement of energy storage and e-mobility technologies in India. The alliance was founded in 2012 by Customized Energy Solutions (CES). We are working towards making India a global hub for R&D, manufacturing and adoption of advanced energy storage and e-mobility technologies.

- We have been at the forefront to contribute to the development of enabling policy frameworks for the adoption of Energy Storage and e-mobility technologies in India. We provide an eco-system to our members to network and grow their business in India and around the world through in-depth analysis and active dialogue among the various stakeholders. Our initiative 'IESA Academy' addresses the much-required skill development area through capacity building programs and customized training with collaboration of Industry and academia.

- Our members encompass all the vertices of the Industry covering energy storage manufacturers, research institutes, renewable energy, power electronics, EV manufacturing companies.

Founded in 2012

Located In Pune, MH

90+ Members

20 Global alliance

Motivation and Objectives of this Review

The world is undergoing an immense transition in one of the most key aspects governing our lives. It is in the generation, availability and use of energy which supports all dimensions of our existence. Food production, processing and delivery, infrastructure development, clothing industry, transportation, healthcare and any other activity crucial for our sustenance depends on energy. Over time we have become used to depending on fossil fuels for providing us this key supporting ingredient. It is this core enabler, which is undergoing transition.

This transition has been made possible, in part due to the development of advanced technologies for energy storage and conversion. In this series of 3 reports, we attempt to cover all the major technologies which are either currently commercially available or those which are in the late development stages and will be commercially manufactured at scale in the next 3-5 years. All technologies for energy storage and conversion are constantly evolving and improving in performance owing to the ongoing efforts of the global academic and industrial community.

In this report ,which is third in this series of reports, we cover all the technologies which are of interest for stationary storage applications. These applications can range from domestic energy backup systems to large grid scale energy storage.

We wish that through this report we are able to provide specific and to-the-point information to a wide range of audience who are interested in learning about these new technologies. The review is prepared keeping in mind that the readers may be from very different backgrounds and we hope that the concepts and information presented will help all decisions makers from industry as well as from the government.

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Executive Summary

Grid scale energy storage is rapidly gaining importance as the renewable penetration continues to increase. As the fraction of power supplied by solar and wind plants increases, long duration energy storage becomes an indispensable arm of this ecosystem to fulfill our power reliability needs. In parallel, there are ongoing policy changes on a global level which are encouraging and pushing for greenhouse gas (GHG) emissions reduction. This is gradually pushing companies to reduce their dependence on fossil fuels via electrification, hybridization, energy recovery and other ways of improved energy utilization.

Based on this changing scenario there is a strong focus on the development, manufacturing and cost reduction of various types of technologies which can help in realizing the goals. In this report, we look at the important performance metrics, core technology design/operation, current status of prototype development and manufacturing. The performance characteristics of the technology are used to predict a future scenario of expected applications.

- **Pumped Storage Hydro (PSH):** This is a well established technology and over a hundred years old. PSH is ideally suited for very large scale (GWh) and long duration storage and is capable of supporting deep renewable penetration in the grid. Development of adjustable speed motor/generators have ensured a higher roundtrip efficiency and the possibility of offering frequency regulation services thus increasing the utility of this technology. These systems have a 50+ year operational lifetime. One major challenge that remains is the need for specific geographical features and the long time required for environmental permits and construction of the systems.
- **Gravity based storage:** These are a group of new technologies under development and early stage of deployment which can be considered as the distributed form of PSH. Gravity based storage systems do not require specific geological features and their modular units are smaller as compared to PSH allowing them to be located as per requirement. The storage medium used has a much higher density compared to water allowing the systems to be relatively more compact. Currently, the initial deployment and demonstration of these technologies is under way. Gravity based storage are expected to have a long operational lifetime of 30+ years and will be more economical for long duration storage applications.
- **Li-ion:** Li-ion batteries are experiencing tremendous growth in the manufacturing scale currently driven by the demand for electric vehicles. For stationary storage also, globally this technology is being deployed for both short duration and long duration storage applications. In addition to deployment on the grid scale, smaller systems for rooftop solar connected domestic energy backup have also gained traction. The compactness or this technology is a major benefit which allows it to be located inside buildings and offices where space is at a premium. The manufacturing scale increase is expected to further lower costs ($/kWh) in the coming 3-5 years posing a challenge for competing technologies. However, the calendar life of these systems is currently not expected to exceed 15 years.

Executive Summary (continued)

- **Thermal storage:** This is well established and represents a rather large family of technologies. Broadly it can be classified based on the application requirement, which is either for heating or for cooling applications. Space conditioning of offices buildings and homes has a large energy requirement and thermal storage can significantly reduce the peak power consumption leading to overall economic benefits. Industrially, thermal storage is used to store and time-shift the process heat which leads to higher process efficiency and reduced energy consumption. Overall, thermal storage is very beneficial when the stored energy is used only for heating or cooling applications.

  Large high temperature CSP coupled molten salt storage systems have been deployed for storage of electricity. However, the widespread deployment of the technology has not yet occurred. PCM based thermal storage has been very effectively employed for small scale systems such as solar dryers, reefer trucks, domestic space conditioning, cold storage, etc.

- **Advanced Lead acid (ALA):** These are a family of technologies which aim to improve the performance limitations of LA batteries via design improvements while retaining the basic fundamental chemistry. The proposed approaches of bipolar battery design and carbon additives for electrodes are able to improve the charging rate and cycle life of the batteries significantly. As a result of this, new applications are opening up for ALA batteries. However, due to the ongoing improvements in other technologies, ALA batteries are facing stiff competition for the new applications.

- **Supercapacitors (SC):** These are very high power devices which are ideally suited for applications where fast charge and fast discharge is required. They are also great at supplying or absorbing large currents required for a very short duration. Supercapacitors can operate over a very wide temperature range which covers extreme cold temperatures also (-40°C to +60°C). Due to its unique combination of properties SCs have been deployed for energy recovery and engine start/stop applications where they help in improving efficiency and/or reducing fuel consumption of systems. Higher energy density variants of SCs have been deployed in intra-city trams which take benefits of quick charging at every stopping station and also allow energy savings through regenerative braking.

- **Flywheels:** Similar to SCs, flywheels are also ideally suited for fast charge/discharge applications although they function on entirely different physical principles. These systems have a relatively very high self-discharge rate which means that they are not applicable where large waiting times are required between charge and discharge. Flywheels have already been deployed on a MW scale for frequency regulation applications where they have demonstrated reliability and good longevity. Another application where flywheels are currently being considered is for storage of regenerative braking energy of trains. This can help in reducing the energy consumption of transportation as well as smoothening out the power requirement. The widespread deployment of flywheels is currently limited due to its high cost.

Contents