Myth Busters Newsletter

Issue 3 **September, 2017**

Editorial Message

The Government of India (GoI) has made a 'clean energy' future for all citizens a priority. Some of the steps being taken by GoI include setting aggressive targets for Renewable Energy (RE) capacity addition by 2022 and plans for only electric vehicles (EV) to be sold in India from 2030. However, these initiatives will place a significant strain on the national electricity network. RE, being an intermittent and variable energy source, can cause frequency fluctuations and demand-supply imbalances. Significant RE injections can also lead to coal-fired plants being backed-down to run at inefficient load factors. Further, adoption of electric vehicles could change the demand profile being seen by the grid (due to charging patterns varying wildly amongst different EV consumer categories).

Energy storage systems can assist in ensuring stable, reliable and resilient grid operations. There are a variety of energy storage technologies available—pumped hydro energy storage (PHES), compressed air energy storage, batteries, flywheels, electrochemical capacitors, etc. As announced by the chairperson of the Central Electricity Authority, India has plans to build 10 GigaWatts (GW) of storage capacity at a cost of Rs. 80,000 crores over the next 5-6 years. This would be a great asset to the grid because PHES can be ramped up quickly to meet peak demand and can be used to store the excess thermal power that may be produced.

However, PHES alone is not enough. Battery-based storage is necessary for India; not only towards complementing PHES in the grid, but also to support other initiatives such as solar Rooftop PhotoVoltaics (RTPV) and EVs. There are a number of reasons for this: One, PHES is not very efficient as compared to battery options. Two, there are significant ecological and environmental drawbacks to PHES in India (it is location-dependent, India has strained existing water resources due to agriculture, there is possible displacement of communities, flooding, etc.). Three, battery storage can be expanded over time (as physical battery sizes and costs continuously reduce) and be set-up quickly. Fourth, batteries manufactured in India tie-in with the government's "Make-In-India" initiative as well as plans for the development of new and upcoming technologies.

There are some key challenges to the increased adoption of batteries in India that will have to be overcome. The production of modern-day lightweight, high-efficiency batteries relies on energy critical elements (Lithium in particular) that India does not possess in large quantities. So the government must not only define steps for securing the supply chain but invest in research and development of new materials. Further, the cost of battery-based energy is still very high (although costs are coming down dramatically). In addition, manufacturing of new and disposal of used batteries may come with the possibility of environmental damage. Hence, a mechanism for regulated secondary markets (e.g. use of retired EV Li battery in solar installations) and recycling must be put in place before batteries become prevalent.

As India moves toward a clean energy future, with reliable, uninterrupted energy available to all, it is imperative to integrate multiple initiatives in a cohesive and complementary manner. An important initiative is the development, manufacture and adoption of battery storage technologies. Creating a thriving ecosystem for this initiative should be a foremost action item for GoI.

- *Team CSTEP & SSEF*

Article

Myths: Battery storage is an expensive technology with limited immediate usage

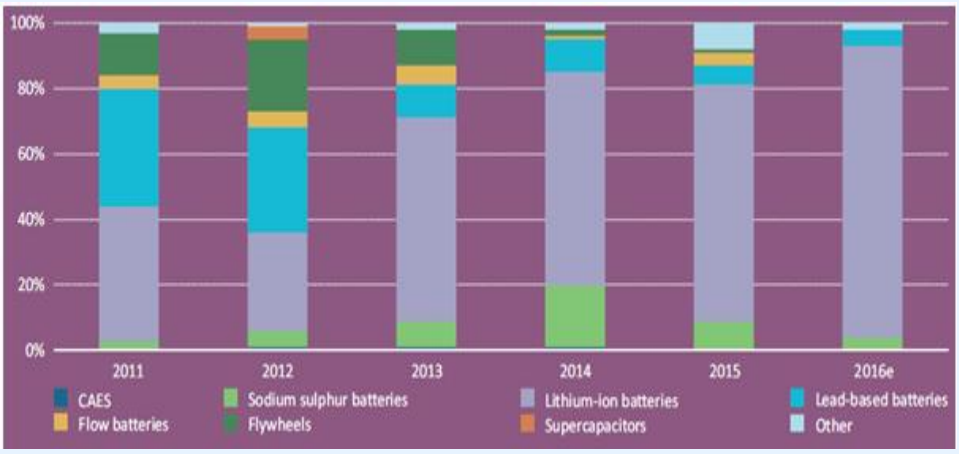
Emerging market for energy storage systems

Increasing focus on clean energy and steep fall in cost of renewable energy technologies have globally led to growth at 70 per cent CAGR in solar capacity and 24 per cent CAGR in wind capacity installations during 2010-16[3]. In 2016 alone, across the globe, around 76 GW of solar power capacity and 55 GW of wind power capacity[4] was installed in comparison with 50 GW of coal capacity addition[5]. With such high increase in penetration of renewable energy, power management solutions such as Energy Storage Systems (ESS) are required to address the variability in electricity supply due to wind and solar power.

With declining cost curve and improving maturity of technologies, the installation of non- Pumped Storage Hydropower (PSH) solutions have increased significantly globally in last six year[6].In non-PSH ESS, lithium ion batteries (LIB) are increasingly becoming more popular due to rapid fall in prices as evident in the trend of ESS installation in past few years. Lithium ion battery installation has increased from 100 MW[7] in 2010 to 1,394 MW in 2016[8]. IRENA estimated that the total installation of battery based energy storage systems is expected to increase to 250 GW by 2030.

[3] BP statistical review of world energy, 2017
[4] Advancing the global renewable energy transition, REN21, 2017
[5] Boom and Bust 2017, Tracking the global coal plant pipeline, Coalswarm / Sierra Club / Greenpeace, March 2017
[6] Total non-PSH solutions has increased from 976 MW in 2010 to 3,400 MW in 2016
[7] IEA technology roadmap for energy storage
[8] IEA Tracking the clean energy progress, 2017

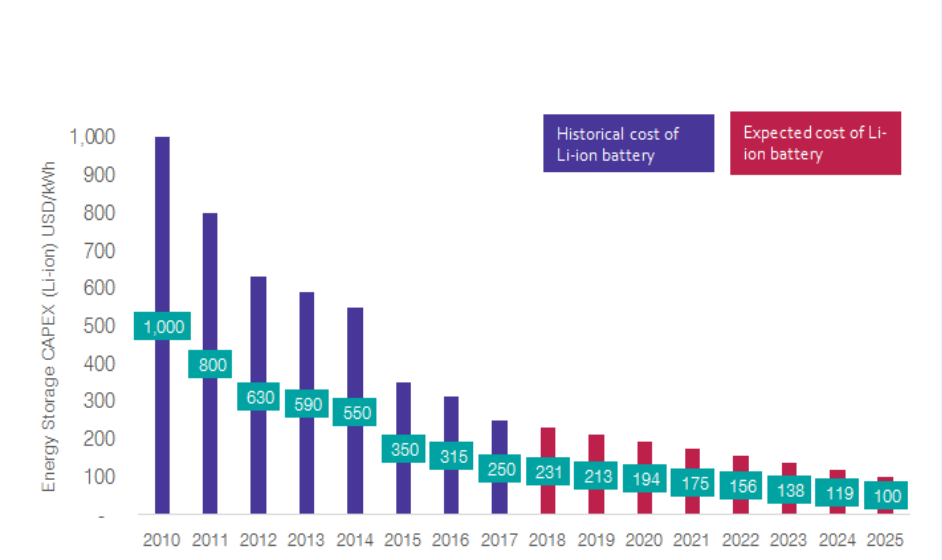
Figure 1: Share of Lithium ion batteries increased from 40% to 90% in last six years



Declining cost of lithium-ion batteries

In past seven years, cost of LIB technology has fallen by 75 per cent from USD 1,000 per kWh in 2010 to USD 250 per kWh today. In the next decade, the price of li-ion batteries is further expected to drop by 60 per cent to USD 100 per kWh as shown in Figure 2.

Figure 2: Declining cost of Lithium ion batteries



The improvements in LIB were initially driven by smart phone industry. Post 2010, automotive sector is driving efficiencies in manufacturing of batteries as their share in LIB market has increased significantly[9].

[9] https://www.marketresearch.com/product/sample-8323376.pdf

According to various analyst reports, the future cost reduction in LIB will be driven by the following factors:

- **Economies of scale**: With upcoming Giga-factories, the cost of LIB will decrease due to consolidation of supply chain in one geography. Also, the material cost is expected to reduce as the bargaining power of manufacturers will increase with the advent of Giga-factories. Around 8 per cent of cost reduction is expected from economies of scale
- **Cell architecture change**: Technology improvements including changes in battery chemistry/ cathode composition will help reduce the overall costs of energy storage. It is expected that cell architectural change can reduce the cost by around 6 per cent from present levels[8]
- **Experience curve**: Several costs such as overhead costs, labour costs, supply chain etc. reduce with increasing supply/deployment. This learning curve effect has already reduced the costs by around 6-9 per cent per annum over the last 8 years[8]
- **Reduction in over-engineering**: Batteries are over-engineered to ensure the safety and reliability. With increasing standardisation and rise in deployment, the over-engineering will reduce leading to lower cost.

The last two factors are expected to reduce the cost of batteries by around 35 per cent.

Box 1: Industry targets for cost reduction in LIB

Tesla is leading the industry in driving downward the cost curve of batteries. Going forward, it is expected that Tesla may achieve US DOE target of USD 125 per kWh by 2020[8]. It is expected that around 30 per cent cost reduction will be achieved by improving the cell-level architecture of LIB and 70 per cent of cost reduction will be achieved by reducing the battery pack level costs. The below waterfall chart explains the elements leading to cost savings for Tesla batteries.

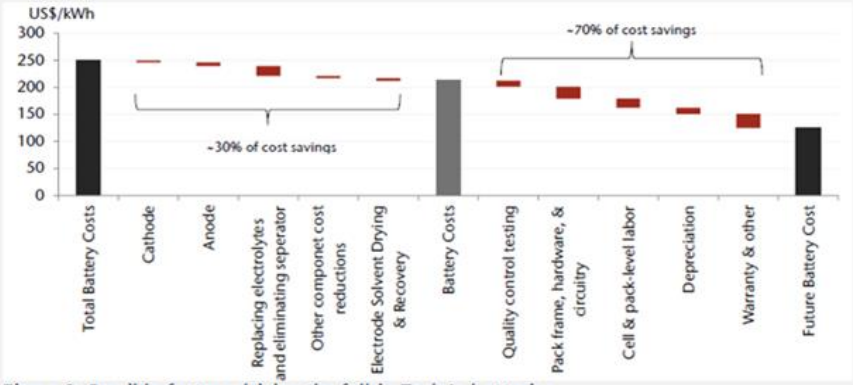


Figure 3: Possible factors driving the fall in Tesla's batteries

Future of batteries

- **US DOE** has set a target to achieve a cost of USD 125 per kWh by 2022 (DOE EV goals)
- **GM** announced cost of USD 145 per kWh for battery cell and expect battery cell to drop to USD 100 per kWh by 2022 (Media reports)
- **Tesla** has already achieved a price of USD 190 per kWh and expected to achieve less than USD 125 per kWh by 2020 (Jefferies Franchise note)

Source: Jefferies Franchise note

While the storage cost trajectory is clearly set to decline sharply, battery solutions for storing power is considered largely uneconomical today. In reality, battery storage is fast emerging as economical solution under various applications and are already economical under certain scenarios as discussed below:

Current applications for battery storage

a. Diesel generator replacement

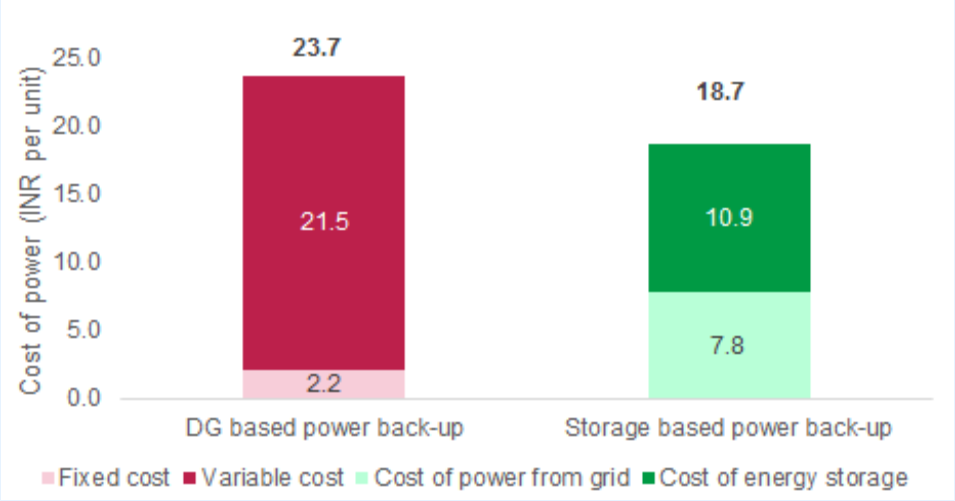
Upon interactions with few commercial building operators in a large city in South India, it was observed that consumers typically deployed Diesel Generators (DGs) for usage of around 30 hours per month (average one hour per day), when grid power in not available.

Variable cost to generate power from diesel generator as charged by building operators is around INR 18 - 25 per unit. Total fixed cost of diesel generator is around INR 2.2 per unit . Hence the total cost of power from diesel generator is around INR 20.2 – 27.2 per unit (fixed plus variable cost) which is significantly higher than the cost of power from the grid at INR 7.8 per unit and alternative sources such as solar roof top at INR 5-6 per unit.

This merits evaluation whether Energy Storage System (ESS) can be economically deployed to store (and subsequently retrieve) grid power or power from sources such as solar roof top, as an alternative to drawing power from DGs when the grid power is not available.

At today's battery pack prices, the cost of energy storage is estimated at around INR 10.9 per unit . At this price, storage solutions combined with power sources such as grid power or solar can actually be cheaper than power drawn from DG set as shown below:

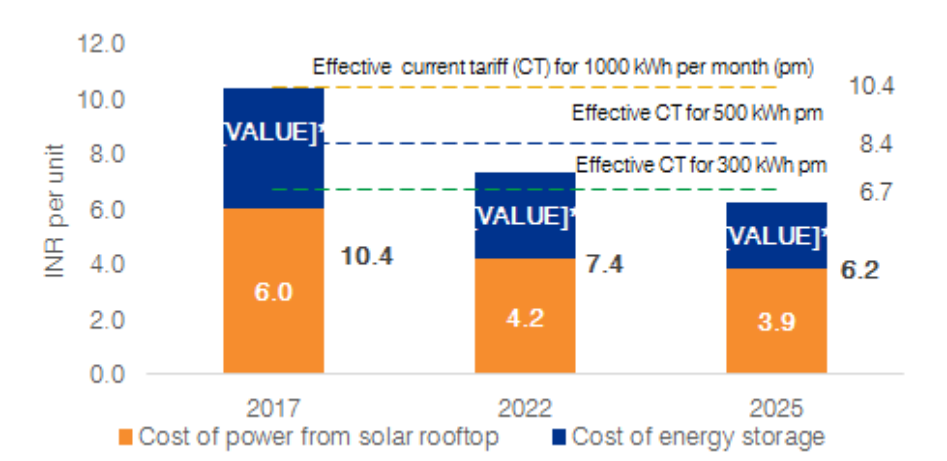
Figure 4: Replacing diesel generators with energy storage (Energy storage usage for 1hour/day)



b. Solar PV-storage solutions for high end residential consumers

In India, domestic consumers are paying more than INR 8 per unit for power consumption of more than 250 units per month. The effective current tariff for domestic consumers consuming more than 1000 units per month today for some discoms is comparable to the cost of power from solar roof top coupled with storage solutions, even today, as illustrated in following figure.

Figure 5: Solar house is almost economical for certain consumer categories - an illustration*



***Assumptions:** It is assumed that battery storage would be required to store 60 per cent of power produced from solar PV. Cost to store power is around INR 7.3 per unit[10]. However since only 60 per cent of power produced from solar PV is stored, the effective cost of energy storage is INR 4.4 (60%*7.3) per unit.

Source: The Rising Sun, KPMG in India's analysis, Lazard's levelized cost of storage — version 2.0

As storage and solar PV costs decline, this market for storage solutions is likely to open up. Going forward, by 2022, solar roof top solution integrated with storage can make economic sense for a larger consumer base in many states. As per KPMG's Rising Sun, 2015 "Disruption on the horizon", grid independent solar houses could become a reality in FY 2025.

c. Energy access in rural areas through decentralised solutions

Similarly, batteries are also finding increased usage in decentralized supply of electricity in rural areas integrated with RE based mini-grid solutions, where cost of grid extension or centralized supply through the grid can be higher than decentralized supply with mini grid solutions combined with optimal storage solutions. Furthermore, decentralized solutions combined with storage can help manage local load requirements better in terms of

[10] The difference in cost of storage in figure 4 and 5 is due to different utilization of the battery capacity

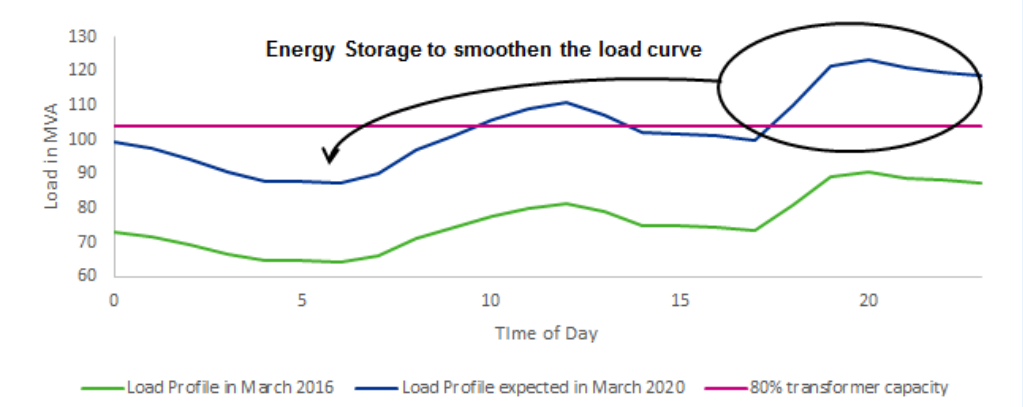
reliability, time of supply, hours of supply, etc.

Future opportunities

As the cost of energy storage decreases, many market avenues will open up for ESS. Market off-take will depend on the regulatory position on energy storage and costs of alternative investments. One such application is transmission and distribution (T&D) investment deferral.

Typically a new sub-station is planned when the peak load through substation reaches around 80 per cent of its maximum capacity. However when the maximum load reaches around 80 per cent, the average utilization of sub-station is just 50-60 per cent. Better load management (as explained in below figure) with the help of ESS can help improve the average utilization of sub-station by an estimated 10-15 per cent[11]. ESS can help smoother the load curve by storing energy in off peak hours and releasing energy in peak hours. This would help in deferring the network upgradation investment by 3-4 years.

Figure 6: Typical load profile of a sub-station



At battery costs less than USD 150 per kWh (expected before 2023), energy storage technologies can be economically deployed to defer T&D investment. India can thus save on capital costs for building the network in future.

Other applications

In developed economies, energy storage is already used to manage the demand charges and frequency regulation. In a recently concluded tender by National Grid, UK for Enhanced Frequency Response (EFR), all of the 201 MW required EFR capacity was allocated to ESS at roughly half of the current EFR equivalent tender prices. Low demand charges and absence of regulations on energy storage hinders the take-off of these markets in India.

[11] KPMG in India's analysis

Conclusion

Today, energy storage technology is already economical for certain market segments such as T&D investment deferral and diesel generator back-up capacity segments. Declining cost curves for energy storage will open up more market applications such as managing intermediate and peak load, grid independent solar houses, RE integration and Electric Vehicles.

The evolution of energy storage technologies heralds a new paradigm of sustainable energy deployment globally. Cost effective storage technology solutions will help meet the objectives of energy security and clean environment for India.

- *Analysis conducted by KPMG*

Interview

Dr. Rahul Walawalkar,
President & MD, Customized Energy Solutions India Pvt. Ltd.

Q. ***Which sectors will dominate India's demand for batteries in the next 10-15 years and why?***

A. There are multiple applications that will drive growth for energy storage in India. Currently the market is dominated by the requirement of conventional storage technologies such as lead acid batteries for backup and automotive (SLI) applications. In the last two years the market for newer technologies, such as advanced lead acid and Li-Ion, is witnessing faster growth driven by applications such as diesel replacement, renewable integration and electric vehicles. Also consumer electronics, with growth of laptops and mobile phones, is also a key market.

Solar + Storage is anticipated to become a viable solution for off grid as well as for managing peak loads within next 12-18 months. This can fuel exponential growth for storage.

Depending on the policy developments and implementation by various government agencies, we anticipate that power quality and reliability will continue to be a key application for batteries, along with faster growth for EVs and energy storage for ancillary services. RE + storage hybrid projects will drive growth for the next 5-10 years.

Q. ***What are the key policy interventions required in storage technologies to ensure the transition to fully electrified transportation and greater renewable energy share in the future energy mix of India?***

A. The main policy intervention required is for transparent price signal and removal of barriers such as higher GST and import duties towards kick starting the market for advanced energy storage in India. Currently most of the investment decisions for power sector are being driven by average levelised costs. On the other hand, there are various applications where the marginal costs of current technologies, or solutions being planned, are significantly higher than current cost of storage technologies. For example, diesel replacement is a low hanging fruit, but due to various subsidies given to island consumers, they are not witnessing the true cost of power from such sources. Also even in case of areas where diesel generators are used, there is an opportunity to improve efficiency by increasing loading of the generators for certain hours and shutting them down at other times where solar + storage can meet the load. On part loaded condition the marginal cost of electricity from diesel generator

Interesting Reading & References

Newspaper/Blog Articles

Charging the future: Asia leads drive to next-generation EV battery market

http://www.automotivenl.com/images/November_2016/Goldman_Sachs_On_Batteries_-_2016.pdf

ESNA 2017: How storage enables SCE to avoid siting new gas plants

http://www.utilitydive.com/news/esna-2017-how-storage-enables-sce-to-avoid-siting-new-gas-plants/449068/

Reports

Global EV Outlook 2017

https://www.iea.org/publications/freepublications/publication/GlobalEVOutlook2017.pdf

When Does the Operation of a Battery Become Environmentally Positive?

http://jes.ecsdl.org/content/164/1/A6274.short

Mythbusters newsletter series will identify 1 myth per issue and try to dispel the same through analyses, articles, conducting interviews of experts, providing reference to name a few. This is a joint venture of Shakti Sustainable Energy Foundation (SSEF) and Center for Study of Science, Technology and Policy (CSTEP). The issues will also have relevant partners who will help in conducting the various analyses.

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