Whitepaper

Energy Storage Systems (ESS) – is India ready?

A primer on Energy Storage Systems and what India needs to do to mainstream them

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Shareables

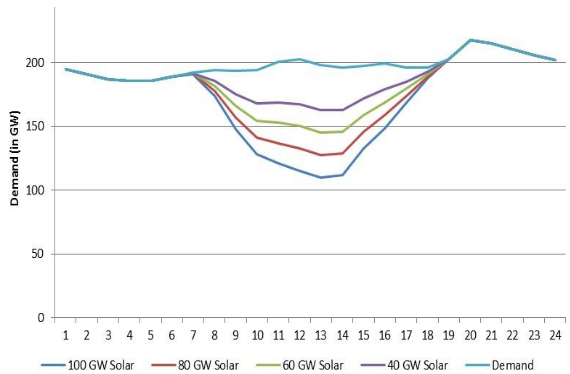
- ESS provides an attractive solution to manage the variability introduced by vast amounts of RE capacity to be added to the Indian grid
- Storage technologies are numerous; but choice is governed by their performance characteristics and the desired application
- Lifecycle costs of batteries are reducing rapidly with expectations of reaching grid parity in the near future
- India needs to quickly develop an enabling regulatory environment to allow storage operators to offer multiple services to improve reliability of the grid

Energy Storage will become essential to balance Indian grid

Indian electricity grid is in the midst of a paradigm shift as the country strives to achieve its target of 175 GW of installed renewable energy (RE) capacity by 2022. With such large RE capacity, a key challenge will be to manage **the significant variability in net demand that will be introduced in the system**.

The net demand "duck curve" (Figure 1) for India means that significant balancing capacity will be required to balance the renewables.

FIGURE 1: NET DEMAND CURVE FOR INDIAN POWER SYSTEM IN 2022



If the Indian ecosystem indeed meets the stated targets of RE capacity addition, then during **a typical day in 2022, solar power may meet up to 44% of the total demand**. In addition, wind capacity of 60 GW will bring about a variation of up to 8 GW in as little as 5 hours.

Such vast amounts of renewable energy will need to be backed up by a mix of fast response and high capacity energy storage to support sudden drops in output and the morning and evening ramping requirements. In addition, if there is a drop in demand, there would be a need to absorb the excess generation for later use and prevent curtailments.

Fundamentally, there are a number of sources that can be used to support the variable generation. However, each source has a specific purpose and can support only a certain type of use case with the right market structure. Of these sources, Energy Storage Systems (ESS) are the fastest emerging alternatives supported by very strong global R&D efforts and are likely to come of age much quicker than anticipated.

Options to meet variability

- ✓ Spinning reserves
- ✓ Peaking plants
- ✓ Virtual Power Plants (VPPs)
- ✓ Demand Response
- ✓ Energy Storage Systems (ESS)

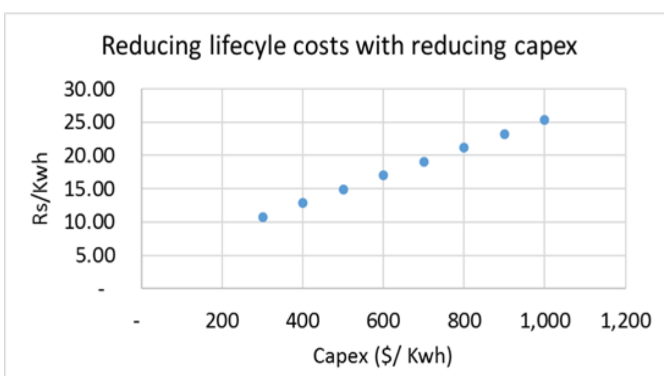
ESS technologies: Each has a different role to play

There are a myriad of energy storage systems ranging from flywheels and pumped hydro systems to batteries, double layer capacitors, and superconducting magnetic coils. These different technologies vary significantly in terms of their rated power as well as the timescale of their response. For example, batteries may be able to provide backup ranging from minutes to a few hours, whereas synthetic natural gas or hydrogen storage systems could provide backup up to a day. The **choice of technology is governed by the desired use case and its performance characteristics,** which make it optimally suited for certain grid services and less so for others.

Balancing costs of ESS with stacked value streams

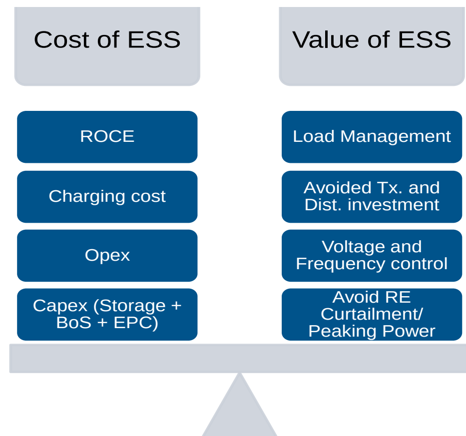
Capital costs of ESS, particularly batteries have declined steadily in recent years largely due to significant R&D efforts. It is expected that costs will drop rapidly over the next few years especially as Electric Vehicles become mainstream and '*Vehicle to Grid*' becomes a reality. Based on cost estimates published by Lazard in their second '*Levelized cost of Storage Version 2.0*' analysis, ICF has computed the lifecycle cost of sample grid scale Lithium-Ion battery in an Indian context. Based on today's technology, this comes in the range of ₹15-18 /Kwh (see Figure 2).

FIGURE 2: LIFECYCLE COSTS OF LI-ION BATTERY



While the lifecycle cost of grid scale battery storage is expected to reduce over the next few years, to justify these costs, it is important to **look beyond the primary service provided by an ESS and create the enabling policy/regulatory environment that allows storage operators to provide multiple services** (Figure 3). For example, analysis of an ESS in San Francisco by the Rocky Mountain Institute suggests that its primary service of commercial demand-side management was insufficient to cover its cost. However, additional services such as frequency regulation, resource adequacy, and energy arbitrage, when coupled with the primary service allowed it to generate sufficient additional revenue to cover its cost.

FIGURE 3: COSTS AND BENEFITS OF ESS



What India needs to do to mainstream ESS?

Historically, the most prevalent storage technology in India has been *pumped-hydro* with about 6.8 GW of capacity in operation and under construction. It was not until last year that SECI invited bids for grid connected battery storage projects in Andhra Pradesh and Karnataka. Storage now seems to be garnering the attention of policymakers with the Central Electricity Regulatory Commission (CERC) coming out with a staff paper on electricity storage in India in January, 2017. Although, these are great initiatives, a lot needs to be done to bring ESS into the mainstream:

1. **Pilots**: Pilots of different grid-scale ESS technologies in India to understand operating parameters in Indian conditions (temperature impact on battery operation is very significant)
2. **Services and benefits to stakeholder**: The services that can be provided to different stakeholders (generation, transmission, DISCOMs, consumers, off-grid, etc.) in the Indian context need to be assessed and incentivized
3. **Enabling regulatory framework**: Assessing how existing regulations like DSM, Time of Day (TOD) tariffs, ancillary services, etc., will impact ESS development
4. **Cost curve of ESS solutions**: It is important to understand the cost curves (supply side) of the different ESS technologies today in Indian conditions
5. **Stacking of services**: Creating the necessary regulatory/policy framework that enables ESS to provide multiple services (stacking) thereby reducing per unit usage cost of ESS

ICF's experience in storage

ICF's team of consultants and analysts have supported the analysis and integration of energy storage across various applications. We are providing **due diligence support for development and financing of a large utility-scale storage project in California**. We have conducted an **evaluation of advanced battery technology and compared it against alternative products** that were being developed. ICF was engaged to **assess possible value streams in the capacity, energy, and ancillary services for a battery storage system within a vertically integrated utility** in the southeastern, U.S.

About ICF

ICF (NASDAQ:ICFI) is a global consulting and technology services provider with more than 5,000 professionals focused on making big things possible for our clients. We are business analysts, policy specialists, technologists, researchers, digital strategists, social scientists and creatives. Since 1969, government and commercial clients have worked with ICF to overcome their toughest challenges on issues that matter profoundly to their success. Come engage with us at icf.com.

ICF's key areas of expertise in Renewable markets include:

Energy Storage Systems

- Policy review for mainstreaming
- Regulatory support for market development
- Value stream assessment
- Storage owner' advisory support/due diligence

Electric Vehicles

- Transportation electrification assessment
- Cost effectiveness of vehicle to grid integration
- Distribution grid impact analysis

Technology Trends

- International scenario – innovations & new developments
- Pilots for new energy access business models in telecom, irrigation, micro grids, hybrids

Transmission & System

- Strategies & solutions for sustainable RE including wind integration and flexible options
- Grid availability, curtailment issues

Project Financing &

- Bid support & PPA Structuring
- Financing tool kits for RE project development including risk assessment

Portfolio Development

- RE potential, resource assessment, site identification and clearances
- Project structuring for meeting RPO targets for industrial and Open Access consumers
- Net back price estimation

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