IESA Knowledge Paper
On

Energy Storage for Grid Applications in India

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Introduction

The Indian Energy Storage market is gearing up with large scale pilot projects. While lack of reliable grid power was a driver for traditional energy storage systems, ambitious renewable energy goals, growth in sales of electric rickshaws and need for reduction in diesel usage will boost the sales of energy storage through-out the country. Government of India has set up target of 175 GW of renewable energy deployment by 2022 and it is evident that energy storage technologies has to play a key role in achieving this goal. Key applications at grid scale include provision of fast response ancillary services such as frequency regulation, renewable ramp rate control, smoothening and firming up of renewable power as well as optimization of transmission & distribution investments. Both policy makers and industry stakeholders are taking active steps for exploring energy storage integration in India.

Many of the RFPs for energy storage projects are either out or will be soon from institutions like SECI, PGCIL, MNRE, GIFT city, BHEL, CIL, NLC, NTPC and others. Recently, the much-awaited Solar - Energy Storage hybrid project RFPs by SECI have been released. IESA anticipates 50-100 MW of projects in total to be announced in 2016 for advanced energy storage technologies in India.

For successful deployment of energy storage, we need to learn from global experience of deployment of storage as well as understand the pain points of renewable developers and utilities in India to develop appropriate policy framework and business models. Renewable developers in India are facing mounting challenges due to curtailment of wind & solar in some of the states as well as restrictive regulations related scheduling of power. On the other hand system operators are struggling with ways to balance the grid with variable demand as well as supply. Energy storage technologies can provide the necessary flexibility for both by acting both as load and generation, thus helping in optimal utilization of renewable energy as well as T&D infrastructure.

India has a potential for not only becoming one of the largest markets for advanced energy storage technologies but also becoming a global hub for manufacturing for various energy storage technologies due to the attractive home market and firming business environment. With the Make in India program, the Government of India is looking to encourage various technology developers to set up manufacturing base in India. Although India missed the opportunity to set up main stream manufacturing for solar, energy storage is an upcoming industry and the Indian industry is more than capable of playing a key role in global supply chain as showcased in automobile and textile sectors.

India Energy Storage Alliance (IESA) is catalysing growth in market with its member companies and other stakeholders. The alliance works at promoting the right technologies for right applications, providing market & project information to members, arranging suitable tie ups among complimentary technology providers. The IESA also provides information on existing and upcoming policies of the governments to its members. The alliance is now also recognized as a platform to reach out the the regulatory bodies and policy makers and helping them in creating a suitable business environment

Indian Grid Scenario

India's national grid is currently fifth largest in the world and to maintain grid stability and power quality is a herculean task for the system. Managing variability of electricity load has been a difficult proposition for the grid operators in India, especially as over 59% of power generation capacity is met by coal thermal plants which do not have the capability to respond quickly to fluctuations in the power demand and supply. Apart from this, rise in the solar and wind power, which now consist of over 13% of the generation mix in India, has led to increased variability on the generation side. The cumulative Renewable Energy based capacity addition target set by MNRE till year 2022 is 175GW of which solar power target is 100GW (MNRE). Balancing of

variable renewable generation is possible when flexible resources are available to handle such variations. Inflexible grid leads to difficulties in balancing generation and load leading to frequency excursions or dropped load, significant renewable energy curtailments mostly due to excess supply and/or transmission constraints, state level area balance violations and high price volatility.

The major constraints in offering a reliable and stable grid operation from the perspective of supply side in India are as follows:

- Lack of Ancillary Service regulations which do not provide incentives to provide flexibility to the grid. This is being addressed in the new regulations proposed by CERC and thermal generators that are regional entities are expected to operationalize AGC by April 2017.
- The installed pumped storage hydro capacity is 4786MW (as of 2014, International Hydropower Association). Most of this capacity is not suitable for providing grid balancing services as they do not utilize variable speed drives and also suffer from significant operating constraints due to constraints on water utilization.
- In developed countries gas based generators are used for provide the operating reserves and ancillary services. In India the Gas based capacity of around 24 GW (CEA) is either operating at low CUF of around 30% or not functioning due to non-availability of gas. This limits ability of natural gas generators in India to provide necessary flexibility for grid.
- Anticipated high morning and evening ramp for the grid due to solar penetration to the grid

CEA is exploring various grid codes and interconnection standards that are required for enabling our T&D network to grow sustainably and reliably. Energy Storage integration at the grid level to address such issues, including to provide a reliable and quality power would be a significant step.

Anticipated Indian Camel Curve

Learnings from California

Due to growing solar generation. Under "Clean Energy and Pollution Reduction Act of 2015," California plans to increase the state's renewable energy target from 33 percent by 2020, to 50 percent by 2030. As more solar plants are installed, the net load (actual load – solar generation) is expected to decline rapidly in afternoon and increase rapidly in evening hrs. The phenomenon is commonly referred as the California duck curve as shown in Figure 1.

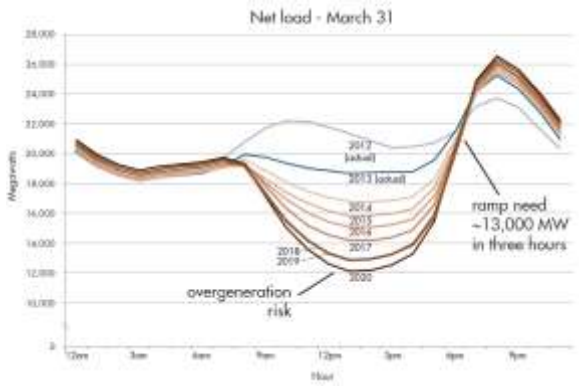

Figure 1: California Duck Curve

With addition of 100 GW solar the need for sustained ramping will be even greater especially in evening hours. Our analysis suggests that the max ramp rate which is currently at 150-200 MW/Min for 40 minutes, will increase to 340 MW/Min by 2022 for 3-4 hours, thus needing considerable increase in flexibility of the grid. Figure 2 shows major challenge for grid operators, due to reduction in net load considering solar generation during the day, which may reduce afternoon load from ~200 GW to under 130 GW. Thus with 100 GW solar – many base load thermal plants (coal and/or gas) would be needed to ramp down in late morning as solar generation picks up and ramp up in the evenings as solar output drops to zero.

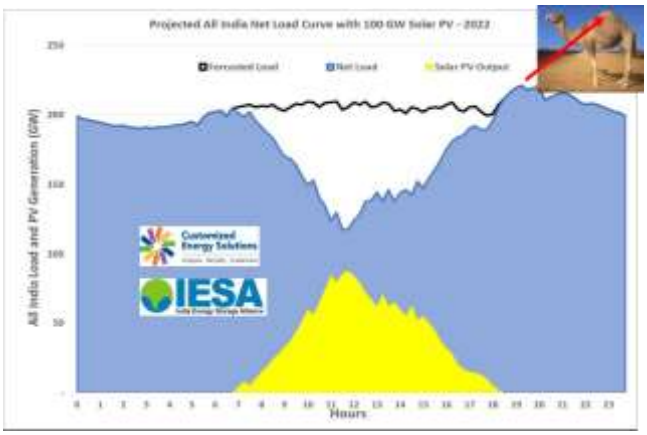

Figure 2: Anticipated All India Load Curve with 100 GW Solar in 2022

Energy storage and electric vehicles (with smart charging and / V2G capability) can provide a potential solution to help distribution and generation companies cope up with changing scenario.

Ancillary Services in India

Over past 4 years significant work has already been done by key stakeholders including CERC, CEA and MOP towards introduction of regulatory framework for ancillary services in India.

The draft Indian Electricity Grid Code 2010 defines ancillary services in power system as "services necessary to support the power system (or grid) operation in maintaining power quality, reliability and security of the grid, e.g active power support for load following, reactive power support, black start etc". Such services are also mandatory for security and reliability of the overall grid system in its physical operation. The Power System Operation Corporation Limited (POSOCO) in its approach paper on "Ancillary Services in Indian Context" has grouped the ancillary services into three major groups for application in Indian market. These groups are (i) Frequency Control Ancillary Services (FCAS), (ii) Network Controlled Ancillary Services (NCAS), and (iii) System Restart Ancillary Services (SRAS).

Figure 3: Policy Roadmap for India

The ancillary services markets are tied with the design of the energy market which needs careful consideration of the power system economics. As understood from such developed market, energy storage systems (ESS) have better capabilities to cater to multiple ancillary services like frequency regulation and, reactive power supply than the thermal, gas and renewable energy power plants. In India such possible facilitations could be provided through different policy and regulatory provisions for early adoption, market creation, localization of manufacture and achieving scalability. Appropriate road map may need to be created to work out tenure for possible initial support and commercial attractiveness in the long run.

CERC's Ancillary service Regulations

The CERC has acknowledged the need of three types of frequency control levels. The primary control is envisaged through the Automatic Generation Control (AGC). As on date, there is no specific monetary compensation mechanism in place for this service.

The scope of existing Ancillary Services Regulations is limited to tertiary frequency control through utilization of surplus capacity available in generating stations at the inter-state level or through Down service instructions on participating entities. The CERC has expressed its intention to move in a phased manner for introduction of full scale ancillary services.

Present set of regulations covers only Inter-State Generating Stations, which are regional entities. CERC intends to scale up to cover other forms of ancillary services based on the experience of implementation of the present framework. As on date, around 50,000MW conventional power capacity is lying idle either due to non-availability of Gas/Coal or suppressed demand (CERC). The PLF of interstate thermal generating stations has also reduced this year due to suppressed demand. CERC has indicated that as per its analysis the current requirement for tertiary frequency control services may be met with only the ISGS plants and these regulations will evolve as per needs of the national grid. Other entities may be allowed to participate at a later date.

Several stakeholders had recommended that RRAS should be designed keeping in mind the challenges posed by grid integration of renewables. In fact the new wind and solar plants can be used for frequency/voltage control with appropriate energy storage integration. The proposed regulations address only tertiary control requirement. The primary and secondary frequency response is required for balancing of intermittent sources of energy. CERC intends to include this at a later stage.

These regulations have come in force recently by CERC Order on "Roadmap to operationalize Reserves in the country" dated 13.10.2015. These regulations will provide dispatchability for some un-requisitioned generating stations and generation from such sources may earn revenue as part substitution of UI market. It has been observed that the UI rates in last four years have come down reasonably and also the volume being traded through UI has dropped down considerably.

A regulated framework in line with the Ancillary Services Regulations may be evolved for identification and utilizing of spinning reserves and implemented with effect from 1.4.2016. This framework may continue till 31.3.2017.

Implementation of AGC is necessary along with reliable telemetry and communication software. The AGC may be planned to be operationalized in the power system from 1.4.2017.

Spinning Reserves are required to be maintained of requisite quantum depending upon the grid conditions.

Operation at constant frequency target of 50.0 Hz with constant area interchange should be the philosophy adopted

Each region should maintain secondary reserves corresponding to the largest unit size in the region and tertiary reserves should be maintained in a decentralized fashion by each state control area for at least 50% of the largest generating unit available in its control area. This would mean secondary reserves of 1000 MW in Southern region; 800 MW in Western regions; 800 MW in Northern region; 660 MW in Eastern region and 363MW in North-Eastern region (total approx. 3600 MW on an All India basis). Primary reserves of 4000 MW should be maintained on an all India basis considering 4000 MW generation outage as a credible contingency.

Going forward, a market based framework may be put in place from 1st April 2017 for achieving greater economy and efficiency in the system.

Frequency is a global phenomenon and needs quick responses for stability. The 15 minute block average measurement may not be adequate to address system requirement. It will require some different market designs / products to address fast response requirements. Also, measurement time blocks may need to be revised early to specific solutions / applications for such requirements.

Given the current peak load of ~140 GW, and a conservative initial estimate of 1% frequency regulation requirement in India, the total requirement for frequency regulation for 2015 could be between 1.4 GW. Given the anticipated load

growth to 300-350 GW by 2022, the Indian grid will require 3.0-3.5 GW of frequency regulation by 2022. Depending on the comfort level of system operators and regulators we anticipate that 25% of this market could be available for energy storage.

Considering grid service opportunities, our analysis shows till 2022 market potential with benefits like accelerated depreciation to be ~2 GW and ~3.5 GWh. This is a small part of overall energy storage market that is expected to be over 70 GW – 200 GWh by 2022. The state of Maharashtra shows largest potential followed by Gujarat and Tamil Nadu. The analysis further shows greater deployment of short duration storage technologies than long duration for grid balancing services. By 2025, ~1 GW - 50% of total capacity would be deployed as short duration energy storage assets (less than 1 hour storage) mainly for frequency regulation1. First such project is already in implementation phase by Power Grid Corporation of India (PGCIL) at Puduchery with 3 energy storage technologies.

[1] Assumes that by 2018 markets would be open for providing ancillary services using energy storage.

About India Energy storage alliance (IESA):

The India Energy Storage Alliance (IESA) was launched in 2012 by Customized Energy Solutions to promote energy storage and microgrid technologies and their applications in India. IESA does this by creating awareness among various stakeholders to make the Indian industry and power sector more competitive and efficient, and by promoting information exchange with the end users to assist with more informed decision making. IESA also provides insights to technology developers and system integrators on the policy landscape and business opportunities in India through frequent interaction with key stakeholders. For more details visit www.indiaesa.info

About Customized Energy Solutions

Established in 1998, Customized Energy Solutions assists clients in managing and staying ahead of the changes in the wholesale and retail electricity and natural gas markets. Serving over 500 clients, Customized Energy Solutions offers best-in-class hosted energy market operations platforms and services. Customized Energy Solution operates in its 9 Regional offices in US, India, Canada, Japan & Mexico. It started its India operations as Customized Energy Solutions India Pvt. Ltd in 2010 with commercial and industrial customers to help reduce their energy costs through better utilization of the energy markets and emerging technologies. Customized has helped bring innovative energy services such as demand response to India and also pioneering in exploring integration of latest technologies such as energy storage, microgrids as well as smart grid maturity model to Indian consumers. Customized Energy Solutions, India Pvt. Ltd, executed first pilot demand response program for TATA Power, which received "Innovative Energy Service Award – 2012" by Confederation of Indian Industries (CII) at national level in September 2012. For more details visit www.ces-ltd.com

About World Energy Council India:

WEC India (formerly known as World Energy Council-Indian Member Committee) is country member of World Energy Council (WEC), a global and inclusive body (estd. 1923 with over 90 country members) for thought leadership and tangible engagement in the pursuit of sustainable supply and use of energy. WEC Activities cover the entire energy spectrum from conventional to renewable. World Energy Council India, the country member of World Energy Council (WEC), is a body functioning under the patronage of Ministry of Power and supported by all Ministries and leading organisations in the energy sector of the country. For more details visit: http://wecindia.in

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