Business Models for Utility-Scale Energy Storage in India

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***Abstract*— India has embarked on an ambitious journey for 175 GW of renewable capacity by 2022. The high variability and unpredictability from renewable calls for an efficient and economical operation to maintain grid stability. Broadly there are three types of business models based on ownership, application, revenue stream and contract type: generation-coupled, transmission-coupled, and merchant-coupled storage asset. For a generation-coupled asset, ownership and dispatch is controlled by generators and the revenue earned is variable subject to volume-risk (units generated/supplied). A transmission-coupled asset is operated by the system operator providing generation, transmission, distribution, and merchant services based on fixed-annuity agreements. A merchant-coupled asset is owned, operated and dispatched by independent storage providers to participate in energy arbitrage, capacity and ancillary services where such market exists. This paper proposes a hybrid business model that maximizes system benefit while minimizing project financing costs by deploying storage as a transmission asset with dispatch controlled by system operator. The model ensures revenue security by means of a tolling agreement which reduces the debt service coverage ratio and thus the cost of capital.**

The business models for utility scale ESS are still evolving across the world with each having its pros and cons and same has been illustrated by taking a sample business case for a renewable rich state in India.

Keywords- Independent Storage Providers (ISPs), Resource Adequacy, Energy Storage System (ESS), Tolling Agreement, Deviational Settlement Mechanism

I. INTRODUCTION

For the modern electrical power systems, energy storage is a versatile, multi-use tool that is increasingly critical to a clean, reliable and carbon free future. Increasing renewable penetration has made power supply intermittent and unpredictable, while adoption of electric vehicle & like has made power demand volatile. Thus, it is imperative to dynamically balance the two for maintaining the grid stability.

The power sector in India is changing its characteristics rapidly with synchronization of national grid to one frequency and increase in power availability from deficient to surplus, at times to meet system demand. The achievement of significant capacity addition from RE projects in recent years and the target of integrating 175 GW of renewables by 2022-mark India's commitment towards greener future where significant power demand in the system will be fulfilled from renewable resources. Taking into consideration the high variability and unpredictability of generation from renewable, efficient and economical grid operation becomes one of the critical challenges for the power system. Energy storage can play an important role in addressing these challenges by meeting system peak requirements, providing steep ramping capabilities, shifting and smoothening renewable energy output, meeting scheduled generation/demand to reduce deviation penalties, relieving congestion, deferring and reducing transmission and distribution upgrades and providing ancillary services such as frequency regulation, spinning reserves and black-starts. Though in the electricity value chain, storage has a role to play in both front of the meter and behind the meter, the paper highlights the need for why it makes more sense to have front of the meter energy storage as a transmission asset.

II. GRID LEVEL APPLICATIONS OF ENERGY STORAGE

A. Peaking Capacity or Resource Adequacy (RA)

This is the need to maintain enough capacity to meet generation requirements during peak-consumption hours. It is generally met by hydro power, natural gas peakers or flex-coal power. In India, while there are significant hydro resources their potential is limited by seasonal and agricultural considerations and limited opportunities to develop additional hydro capacity due to environmental concerns, cost overruns and long lead times. While we have a surplus of natural gas power plant capacity, it remains largely unutilized due to gas fuel constraints. Flexing coal power plants not only requires upgrades and importing of higher quality coal but is also more harmful to the environment than baseload operation of coal. Given these circumstances, energy storage can play a key role to meet system peak requirements.

B. Renewable Energy Integration

Another use of a storage facility is to "firm-up" intermittent renewable power by storing RE output to serve clean, consistent electricity over a longer period. Both generation companies and distribution licensees could use storage facilities to optimize use of renewable generation. Generation companies could use storage facility to shift renewable generation to on-demand periods possible in future contracts. Hence storage enables both the generation and distribution companies to enter into contracts that require RE power to be delivered at a time aligned with end-user demand peaks. Additionally, distribution licensees could use storage facility themselves to store surplus renewable generation output and serve unanticipated changes in demand, hence avoiding deviation settlement (DSM) charges.

C. Optimization of Generation

Owing to shortage of peaking resources, baseload coal power plants are often required to ramp-up and down to match demand changes. This leads to efficiency losses, shortened asset-life and increase emissions impact. Fast acting energy storage assets can provide the ramping needs so that the coal plant can operate closer to baseload profiles. Additionally, it can help reduce the deviation settlement costs like those for RE generators and distribution licensee.

D. Ancillary Services

They are an indispensable part of power system operations, required to improve reliability. It includes several different operations such as frequency regulation, voltage or reactive power support, and system restoration (black start). Frequency regulation is required to ensure that system-wide generation is perfectly matched with system-level load on a moment-by moment basis to avoid system-level frequency spikes or dips, which create grid instability. The deviation attracts huge penalty particularly the deviation which is detrimental to the grid operation. Energy storage systems with quick response and ramp times are perfectly suited to meet this challenge

E. Transmission & Distribution Deferral

This refers to delaying, reducing the size of, or entirely avoiding utility investments in transmission and distribution system upgrades necessary to meet projected load growth on specific regions of the grid. Transmission and distribution deferral can be addressed by using energy storage. This deferral may be for short time, which will help to match the investment and growth. Addition of Renewable energy will need short time network upgrade to avoid the overloading of network element. This can increase and optimize the usage of network elements.

F. Spin/ Non-Spin Reserves

Spinning reserve is the generation capacity that is online and able to serve load immediately in response to an unexpected contingency event, such as an unplanned generation outage. Non-spinning reserve is generation capacity that can respond to contingency events within a short period, typically less than ten minutes, but is not instantaneously available. These represent unutilized/idle capacity in traditional generation assets that can be freed up using energy storage.

III. ENERGY STORAGE BUSINESS MODELS

Based on the ownership, application, revenue stream and contract type, ESS around the world is deployed under three broad categories. They are -

A. Generation-Coupled Asset:

The increasing share of renewable generations in the grid has impacted the traditional approach of balancing. In this model, the ESS is directly connected with the renewable energy generation facility with the ownership and dispatch of asset being controlled by the Independent Power Producers (IPPs). The primary application it caters to is to provide firm RE power and smoothening of output. The revenue earned is variable depending upon number of units generated/supplied by ESS.

B. Transmission-Coupled or Grid Asset:

In this model, the ESS is connected to the transmission grid operated by system operator providing generation, transmission, distribution, and merchant services. The ownership of the asset may lie with either independent storage providers or regulated utilities. The ESS asset in this model can conveniently serve as Peaker replacement, firming renewables (at pooling station), providing ancillary services, deferring T&D investment, and reliving congestion. Today we see increasing deployments of ESS under transmission asset model, as utilities and operators realize the network value of assets (as seen in Arizona & California). These are typically deployed under availability-based “tolling” or fixed-annuity agreements. Such agreements which lower the cost and risk leading to better bankability. The risk to which a tolling-based project is exposed, will typically be limited to the creditworthiness of the energy off taker. Specifically, the tolling entity is not exposed to volume risk. Considering the conservative risk profile of the tolling project, limited recourse financing becomes easier and cheaper.

Of late, the storage-as-transmission-asset business model is gaining traction in the USA since the Federal Energy Regulatory Commission FERC ruled storage assets can be used by transmission licensee just like any other transmission asset. We did an analysis on front-of- the-meter energy storage projects (>10MW) awarded in the US classifying them on basis of different types of contracts. Contracts for storage-as-a-transmission asset (Tolling contracts and tolling+merchant contracts) accounts for 47% of cumulative capacity. On the other hand, PPAs, signifying generation-coupled-assets account for only 15%. (Here ES-PPA: Energy Storage PPA)

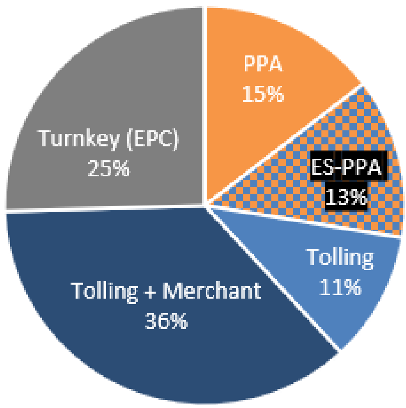

Figure 1: Front-of-the-Meter Energy Storage Projects in the U.S. business models by MWh

C. Merchant Asset:

In this model, the grid connected ESS participates in one or more electricity markets such as energy (arbitrage), capacity and ancillary services. They are typically owned, operated and dispatched by independent storage providers to meet market signals. However, owing to the uncertainty in revenue stream and offtake risk involved in merchant revenue streams project bankability is low. With the advent of real-time bulk power trading market like the Energy Imbalance Market in the USA, value stacking of ESS can be done along with other applications to mitigate the revenue loss risk. Hence, we see an increasing number of merchant assets set up on top of an anchor, fixed payment stream from a utility or grid operator. From a financing standpoint, arranging non-recourse debt financing generally be more difficult and costly for a merchant structure. Fees and interest margins will reflect the debt market’s perception of the merchant risks taken, and these will also impact the levels of DSCR (debt service coverage ratios) and hence the reserve requirements for financing. These three global models are further described in detail in Table-1.

In India Central Electricity Regulatory Commission (CERC) released a staff paper [1] in 2017 that proposed different models for storage assets. Table-2 outlines the different characteristics of the proposed models along with our analysis of the pros and cons.

These business models vary, firstly, in their potential for value maximization based on alignment of incentives amongst operator, system benefits and optimal location of asset on the grid. Maximum value is unlocked when the asset is located at the neediest point on the transmission or distribution grid and when the system operator (Regional or State Load Dispatch Centre) is the sole asset-dispatcher.

Secondly, business models vary based on bankability of the asset. Projects with fixed revenue streams and financially-sound, government-backed counterparties enjoy significantly lower interest rates and debt-service coverage ratio requirements. This leads to lower costs of financing which in turn reduces the cost to the end-user.

As you can see in the CERC paper, storage-as-a-transmission asset that is located optimally, dispatched by the Load Dispatch Centre for ramping, peak-shifting, frequency regulation, congestion relief and system reliability purposes, backed by a fixed, availability-based annuity contract from the state transmission company would be the optimal business model in the Indian context. In this and other models with multiple beneficiaries, there are still questions as to who pays for and owns the energy stored and how is the cost of the asset-shared between beneficiaries.

Table 1: ESS Business Model Comparison

	Generation Coupled Asset	**Transmission Asset**	**Merchant Asset**
Location of Battery	Directly connected to RE / Generation facilities	Any point on the grid allowing support of generation, Transmission, Distribution, and merchant services	Anywhere depending on presence of electricity markets
Ownership	IPPs	ISPs, Regulated Utilities	ISPs
Dispatch	IPPs	System operators	ISPs
Applications	Firm-RE, Power smoothing	Peaker replacement, Firming RE, Ancillary services, T&D Deferral, Congestion relief	Frequency Regulation, Energy Arbitrage, Capacity Market
Value Maximization	**Medium** as dispatch priority is to maximize generator value, not system / grid operator value	**Maximum** as grid operator is the single dispatcher maximizing value both upstream and downstream	**Low** hence all new installations utilize merchant revenues only as an additional revenue stream
Bankability	**Medium** as there is volume uncertainty	**High** as there is a fixed capacity payment contract underlying the project	**Low** as the primary revenue stream is merchant with hourly or yearly price uncertainties
Contracts	PPA ($/kWh)	Tolling agreement ($/kW-year availability) OR Cost-plus rate-of-return	Market-based merchant revenues
Hybrid Contracts	Energy Storage PPA for generation-tied storage that are paid an availability-based revenue		
		RA + Merchant Capacity (RA) contracts that allow storage asset to participate in merchant markets such as Energy Imbalance Market (EIM) or Frequency Regulation	

Table 2: Analysis of Business Models Proposed in CERC Staff Paper on Energy Storage (Jan-2017)

Owner	Operator / Dispatcher	Energy Ownership	Beneficiary	Contract Owner	Tariff Recovery / Cost Sharing	Value	Bankability	Pro	Con
Transmission Licensee / Independent Storage Provider	R/SLDC	DisCom	- System (DSM,FR) -DisCom (peaking), -TransCo & DisCom (T&D Optimization, voltage & reactive support)	TransCo	-TransCo ARR (Annual Rate Recovery), -DisCom ARR (Annual Rate Recovery)	High	High	+ Maximization of system benefit due to alignment of incentives between operator and beneficiary +Fixed, availability-based revenue and creditworthiness of TransCo enables highest bankable asset	-Complex Cost-sharing between beneficiaries
RE Generator	Generator	Generator	-Generator (DSM), -DisCom (peaking)	DisCom	-Self (DSM savings) -DisCom (Higher PPA unit price for dispatchable RE)	Low	Medium	+Simpler cost recovery	-Conflict of interest between operator and beneficiaries means max value not extracted -Volume (kWh) linked revenue risk reduces bankability
DisCom / Independent Storage Provider	DisCom	DisCom	-DisCom (DSM, peaking, -Distr.(only) Optimization, voltage & reactive support	DisCom	Annual Rate Recovery (ARR)	High	Low	+High value utilization as DisCom is both the operator and is the single biggest beneficiary from storage (although there are others)	-DisComs have limited capital to deploy storage under capex model -Not many providers under Opex model due to low DisCom credit rating -Still some value lost by not serving broader system needs
Merchant - Independent Storage Provider	Merchant	Merchant	-Merchant Arbitrage, DSM, FR	N/A	-Self (Energy Arbitrage, F.R. market participation) -DisCom/ Generator (bilateral DSM-service contract)	Medium	Low		-No FR market in India -Thin volumes on energy market for arbitrage -Revenue uncertainty leads to low bankability

IV. PROPOSED BUSINESS MODEL IN INDIAN CONTEXT

The storage-as-a-transmission asset model proposed in the CERC staff paper is promising and can be further built upon. We have outlined the model in Figure 2. The developer/ISP enters into fixed, availability-based annuity contract with TransCo to develop the energy storage system (ESS) undertaking the development, operations, maintenance and financing risk. The system operator (SLDC) controls the dispatch of ESS to maintain grid stability of grid and maximize system benefit by providing ramping, peak-shifting, deviation settlement mechanism (DSM) management and ancillary services. The DisComs who are the single biggest beneficiary of the ESS asset will pay TransCo. for availing services of ramping, peak-shifting, ancillary services and distribution deferral based on locational benefits. Additionally, a DSM management fee is charged by the system operator to conventional & renewable generators, DisComs and Open Access customers (OA) for reducing deviational penalties. The prominent features and advantages of this model are:

A. Asset ownership by an ISP:

This unlocks the power of competition by opening participation to non-generating entities who are willing to develop the unique expertise needed to competitively build and operate energy storage assets. Another challenge in the Indian context is the financial health of state distribution companies (discoms) which suffer from a shortage in capital and are accruing huge losses. In this context, the proposed model is especially attractive as up-front capital cost and most of the asset risk is transferred to the independent storage service provider/developer. Further, this model brings with it the advantage of cost reductions that come from competitive bidding pressure. Finally, there are multiple energy storage technologies with differing performance and degradation characteristics which make it difficult for operators and beneficiaries to compare proposals on a like-to-like basis. If the project requirement is stated and measured in terms of capacity and availability (as measured at the point of interconnection) which is to be maintained for the life of the contract, it requires the developer to take on the risk of technology performance, system degradation etc. in its own scope and allows for like-to-like comparison of competing technologies.

B. Asset dispatch and control by system operator:

Under prevailing cost structures, ESS deployed for only a single service cannot be maximally utilized for system benefit. Control of asset dispatch by system operator enables integrated operations, thus assuring greatest optimization of multiple value streams as all of them accrue to a single entity. According to study done by Brattle in California [2] , the stacked benefits of battery storage by optimizing its dispatch across all analyzed value streams significantly increases the total value of the battery by a factor of 2x to 3x over the most lucrative individual use case. Storage-as-a-transmission asset contracted by the TransCo can be dispatched by the system operator to maximize value across ramping, peak-shifting, frequency regulation, congestion relief and system reliability applications.

C. Tolling Agreement:

Tolling or annuity agreement is one in which the developer is paid a fixed, availability-based ₹/MW per year determined through a tariff-based competitive bidding process. It is sized to cover capital expenditure, operating and maintenance costs, debt service obligations and a base return on equity. The predictability of the tolling agreement enables the independent storage provider to borrow funds for the longest repayment periods available in its market. This improves the bankability of the project contributing to reduced project cost and hence lower cost to customer. Additionally, assured revenue streams drive greater participation and lower bid prices. An S&P analysis reveals that the expected debt service coverage ratio (DSCR) for energy storage projects with tolling contracts ranges from 1.2 - 1.4, whereas for projects built on merchant revenues the DSCR range varies widely from 1.4 - 2.6.

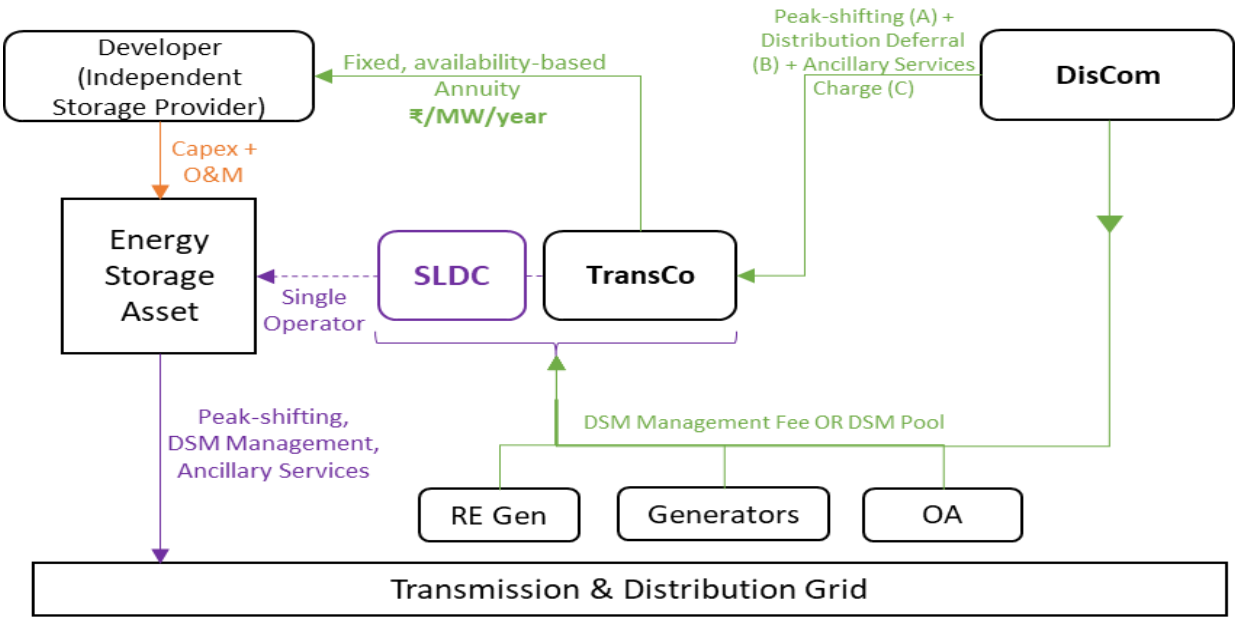

Figure 2: Proposed ESS Business Model

Table 3 below illustrates the methodology for scoring different types of project contract used by leading global rating agency Standard & Poor's.

Factors	Tolling Project	Merchant Project
1. Asset class operations stability score	2	2
2. Project specific contractual terms and risk attributes	Technology Performance: +1 Redundancies: -1 Uncertain O&M: +1	Technology Performance: +1 Redundancies: -1
3.Performance standards	Average	Average
4. Resource& raw material risk	Minimal/N/A	Minimal/N/A
5. Market risk	N/A	Low% 15-30%
6. Competitive position	N/A	Satisfactory
7. Market risk score	N/A	2 or 3
8. Operations Phase Business Assessment (OPBA)	3	5 or 7
9. BBB DSCR range	**1.2-1.4**	**1.4-2** (OPBA of 5) or **1.75 to 2.6** (OPBA of 7)

Table 3: S&P's Operations Scoring for Different Contract Types for Battery Energy Storage [3]

D. Cost Recovery:

The cost for operating the ESS can be shared amongst the various parties like discoms, SLDC, RE generators etc. based on three approaches. They are –

- Cycles based: Number of equivalent cycles used as a % of total. One equivalent cycle is when the sum of partial discharges (and charges) of the battery equal to the full MWh rating.
- Time based: Number of hours reserved per year as a % of 8760 hours. Here, the beneficiary/application gets an exclusive dispatch right for a times-slots, during pre-specified days every year.
- Value based: Value of the next most economically efficient substitute for an application. e.g. cost of flexing a coal plant for 2 hours every evening in the summer.

However, there are twin consideration which we need to resolve in this cost recovery framework as to who bears energy title i.e. pays for charging energy and benefits from energy attribute and how is the energy cost of efficiency loss shared.

Also, in the proposed model, if the off-taker (counter-party to the tolling agreement) is unwilling or unable to self-monetize all the revenue streams, they can demarcate the capacity and dispatch profile needs of their application (diurnal as well as seasonal) and allow the developer to utilize the remainder of the capacity and time periods of the asset. While not as optimal as the former approach, this would still allow the developer to monetize the remaining revenue streams and hence reduce the cost charged to the primary off taker. This model has been adopted to great success in California where storage assets are predominantly deployed through Resource Adequacy contracts that encourage the developer to cross-subsidize cost through revenues gained from additional market-based revenue streams. Such a hybrid model can start playing a significant role in cost-reduction once India develops a greater depth in existing markets such as real-time energy (for arbitrage) and builds new markets such as for capacity, frequency regulation and other ancillary services.

V. SAMPLE BUSINESS CASE

To illustrate the cost benefit analysis for the proposed hybrid model, we have considered a renewable rich state in India which requires reliable power supply round the year. The cost of the battery ESS is based on IHS Markit report, which projects fully installed system cost to be ₹6 Cr./MW for COD in 2023. There are four applications we have considered the ESS caters to –

- Deviational Penalties – We simulated charge/ discharge cycle with ESS to reduce the deviation from actual vs. drawl schedule of the state
- Peak Shifting – We analyzed the demand load data to calculate the equivalent peaking cycles/year ESS can help to arbitrage
- Transmission Deferral – The value of deferring transmission investment by using an ESS
- Reliability Charges – ESS can offset the standby charges the state discom pays to generator

A. System Design and Assumption:

- Power Rating of ESS – 50 MW
- Duration of Discharge – 3 hours
- System Round Trip Efficiency - >90%
- Cycles per year - 365
- ESS Asset Life – 20 years *(considering periodic capacity augmentation)*
- Cost of Capital – 13%

B. Cost Estimation:

Cost Type	Assumptions & Calculations	Cost (₹ Cr./yr)
Levelized Tariff	Annualized Capex for 50 MW * 3 hours system	42.7
	O&M and battery augmentation to counter cell degradation for total 365 cycles per year • Opex = 3% of Capex	9
Conversion Loss	50MW*3hrs * 365 cycles * 10% efficiency loss * 1.5 ₹/kWh off-peak energy cost	0.8
TOTAL (₹ Cr./yr)		**52.5**

C. *Application Benefits*

Application	Assumptions & Calculations	Value for ESS (₹ Cr/yr.)
DSM Savings	DSM Savings: ₹43 Lakhs/MW *(Based on DSM penalty calculation [4])*	21.5
Peak-Cost Savings	• Peak-Cost: 6 ₹/kWh • Off-peak Cost: 1.5 ₹/kWh • Peaking cycles per year: 200 • Energy arbitraged: 50MW * 3hrs * 200 cycles/year * 96% availability = 28.8MU • Peak Cost savings = 28.8MU * (6 – 1.5) ₹/kW	13
Transmission Deferral	• Transmission upgrade cost : ₹2 Cr./MW • Deferral = Upgrade cost * size * cost of capital	13
Capacity Availability / Reliability	• Comparable:₹100Cr/yr distribution utility pays as standby fees to generator for 500MW of standby capacity • Reliability Charge = (50/500)MW * 100Cr.	10
TOTAL (₹ Cr./year)		**57.5**

Thus, we can see when the various applications of ESS is stacked together we can derive economic benefit. In this case, net benefit for the state is approx. **₹ 5 Cr. per year**

VI. CONCLUSION

While there is growing consensus that energy storage systems will play a pivotal role in balancing the grid, market structures to deploy these assets are still evolving across the world with every approach having its own pros & cons. There is a lot to be learnt from the storage experiences of different countries with these structures and as the Indian power grid builds experience with developing and utilizing energy storage asset a hybrid approach is required.

In the short term, while varied power markets allowing the direct monetization of the various energy storage value streams are still being developed, and while financiers are building confidence in the market, it is recommended to adopt the storage-as-a-transmission asset with a fixed, annual, availability-based tolling-revenue. This will allow for maximum value extraction from the asset by a single dispatching entity, the grid operator, while simultaneously providing revenue assurance and driving down financing costs. Auctioning of such projects to independent storage service providers through established competitive bidding processes will further bring down these costs.

In the long run, as Indian markets develop and financiers develop confidence, one should adopt a hybrid model that allows ISP's simultaneous participation in merchant revenue streams, which will reduce the cost burden on the anchor-customer i.e. the utility and hence to the end-consumer.

REFERENCES

[1] CERC Staff Paper on Introduction of Electricity Storage System in India: http://www.cercind.gov.in/2017/draft_reg/SP.pdf

[2] Brattle Stacked Benefits: Comprehensively Valuing Battery Storage in California http://files.brattle.com/files/7208_stacked_benefits_-_final_report.pdf

[3] S&P: What Factors Power A Rating on A Utility-Scale Battery Storage Project

[4] Central Electricity Regulatory Commission (Deviation Settlement Mechanism and related matters) -Fifth Amendment May'19