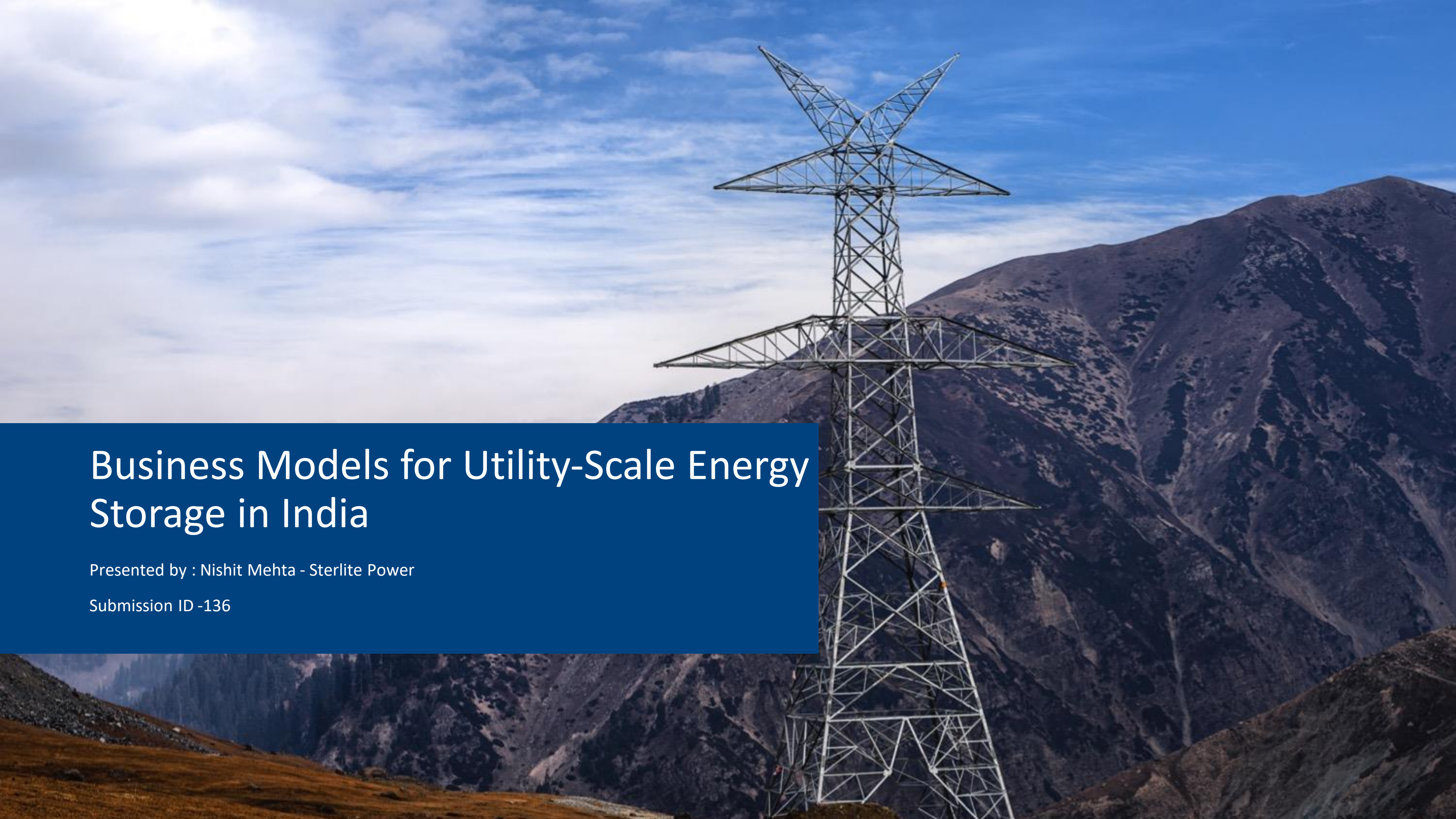


Business Models for Utility-Scale Energy Storage in India

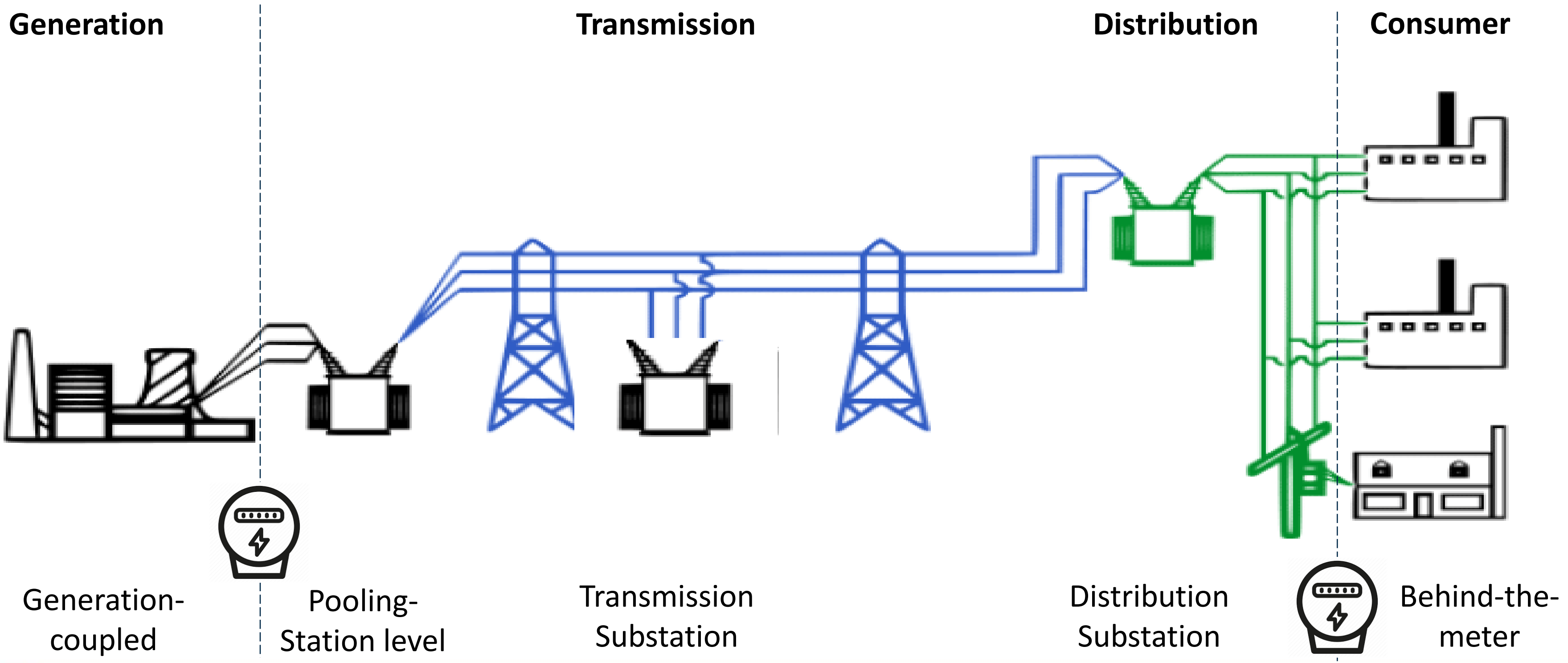
Presented by : Nishit Mehta - Sterlite Power

Submission ID -136

Agenda

- Applications of Grid-Scale Storage
- Business Models Around the World
- Pros & Cons of Business Models
- Applicability to Indian Context
- Sample Business Case

Applications & Business Models Depend on Location of Storage Asset on the Grid

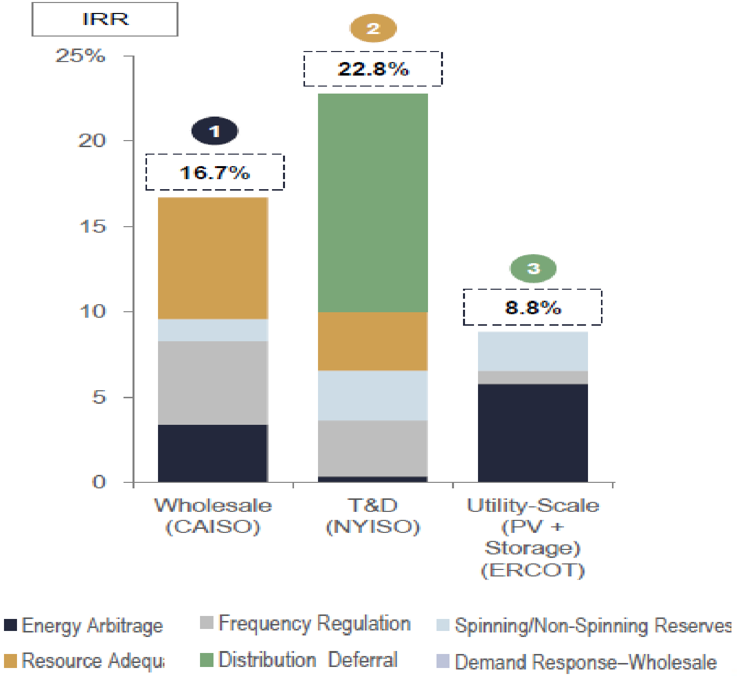


Energy Storage Systems can Serve Several Applications with Varying Values

ESS Applications

1. Peaking Capacity/ Resource Adequacy
2. Renewable Energy Integration
3. Optimization of Generation
4. Ancillary Services
5. Spin/Non-Spin Reserves
6. T&D Deferral

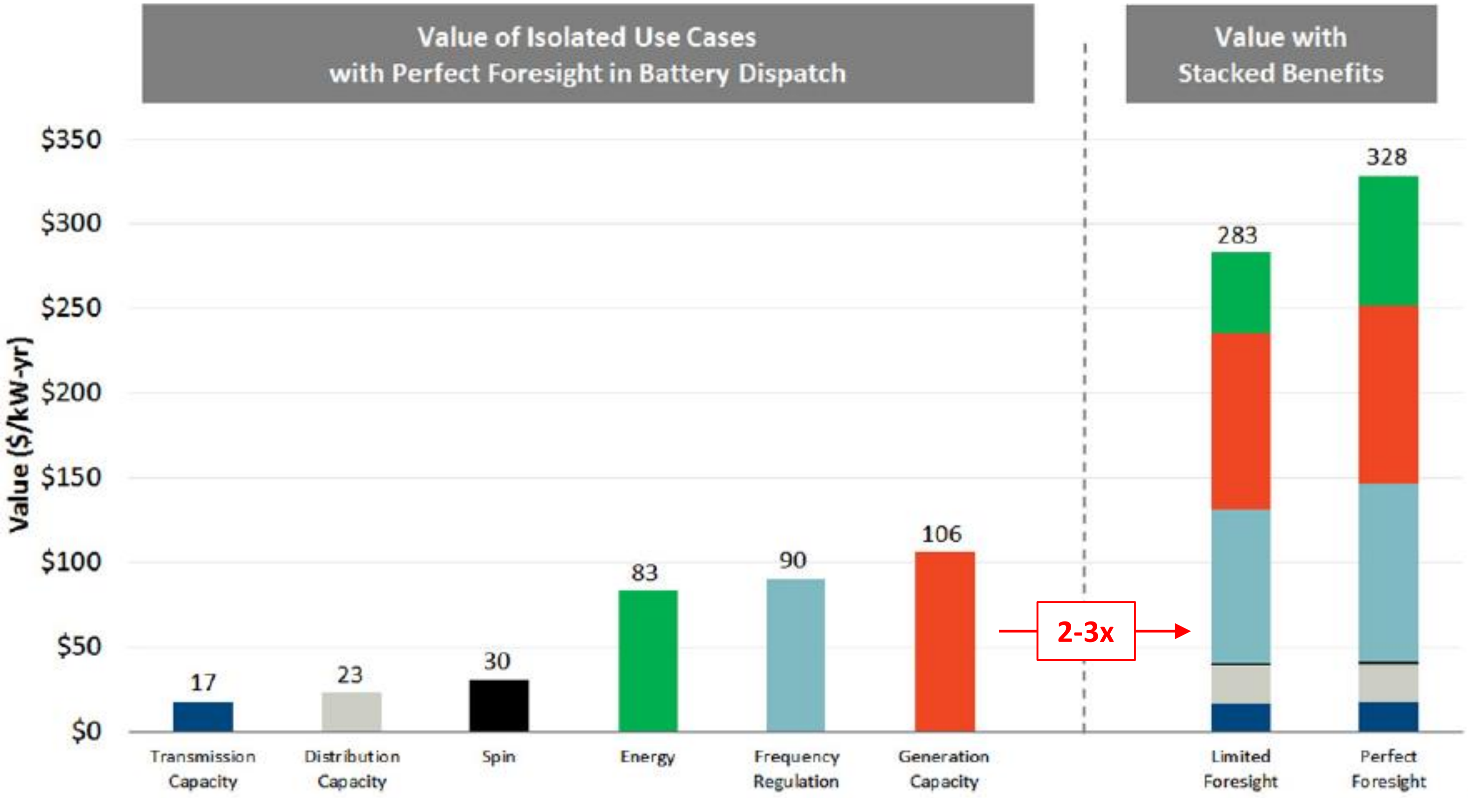
The relative value of each application in the stack is specific to location



Source: Lazard LCOS Analysis

Application-Stacking Leads to Value-Maximization

Brattle Report: "Stacked Benefits: Comprehensively Valuing Battery Storage in California" Sep 2017



Broadly, Three Business Models Used for Deploying Energy Storage Around the World

Storage as a…	Generation-coupled Asset	Grid Asset	Merchant Asset
Location of Battery	Generation	Transmission or Distribution grid Front-of-Meter	Anywhere
Ownership	Generators / IPPs	Independent Storage Providers, Regulated Utilities	Independent Storage Providers
Dispatch	IPPs	System operators	Independent Storage Providers
Applications	Firm-RE, Ramping for Thermal gen	All	Based on existence of market (in India – Energy Arbitrage)
Contract	PPA ($/kWh)	Tolling agreement ($/kW-year availability)	Market-based merchant revenues

Broadly, Three Business Models Used for Deploying Energy Storage Around the World (Contd....)

	Generation-coupled Asset	Grid Asset	Merchant Asset
Value Maximization	**Medium** as dispatch priority is to maximize generator value, not system benefits	**Maximum** as grid operator is the single dispatcher maximizing value both upstream and downstream	**Low** In the absence of multiple markets with deep volumes and participation
Bankability	**Medium** as there is volume uncertainty	**High** as there is a fixed capacity payment contract underlying the project	**Low** as the revenue stream is merchant with hourly or yearly price uncertainties

Business Model and Contract Analysis of US Projects

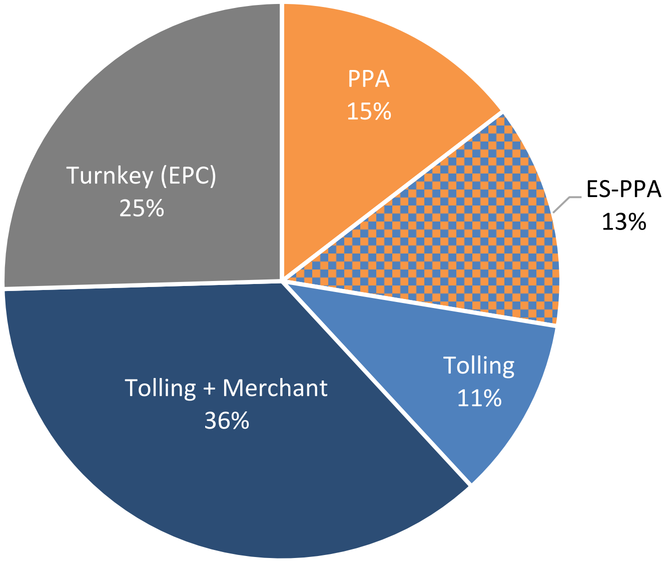


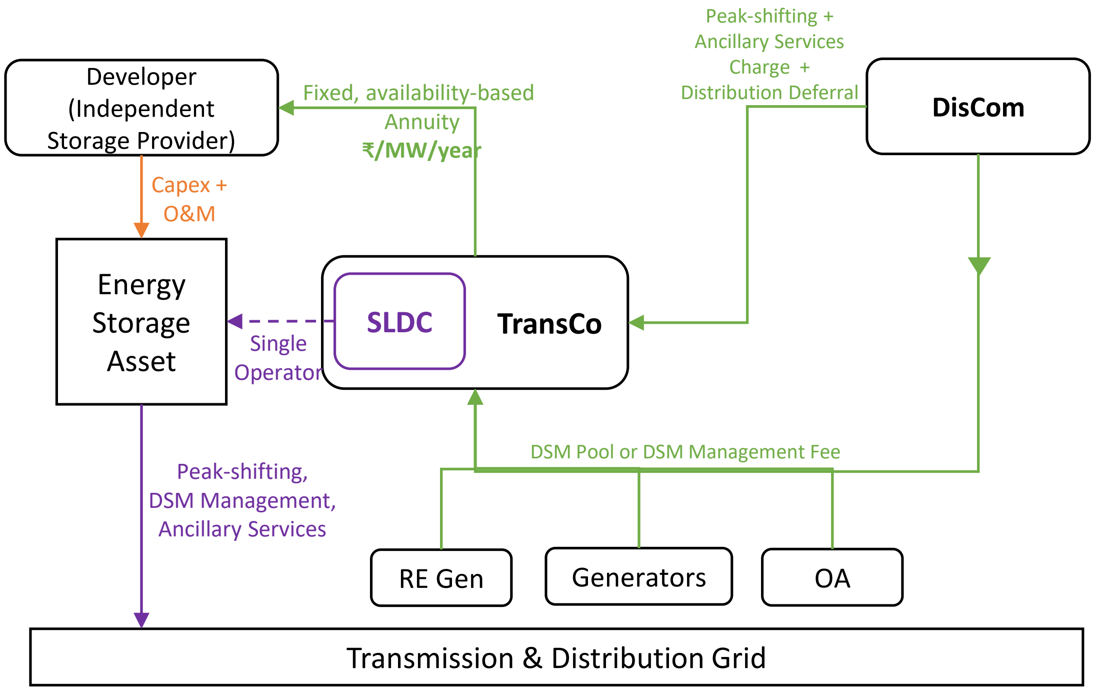
Figure: Front-of-the-Meter Energy Storage Projects in the U.S. business models by MWh

- Initially a lot of generation-coupled storage, to benefit from solar-ITC incentives which are being phased-out
- Increasing number of Tolling Contracts, representing Storage-as-a-Grid Asset business model
- Emergence of hybrid-models
  - Tolling + Merchant contracts are the most widely deployed benefiting from California's energy imbalance market
  - Energy Storage-PPAs *(ES-PPA)*

Analysis of CERC Proposed Models for Energy Storage

Owner	Value	Bankability	Pro	Con
Transmission Licensee/ Independent Storage Provider	High	High	• Maximization of system benefit due to alignment of incentives between operator and beneficiary • Fixed, availability-based revenue & creditworthiness of TransCo enables highest bankable asset	• Complex Cost sharing between beneficiaries
RE Generator	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	High	Low	• High value utilization as Discom is both the operator and has the most to benefit from storage	• Some value lost by not serving broader system • Discoms have limited capital to deploy storage under capex model • Not many providers under Opex model due to low discom credit rating
Merchant - Independent Storage Provider	Medium	Low	-	• No Frequency Regulation market in India • Thin volumes on energy market for arbitrage • Revenue uncertainty leads to low bankability

Potential Model for Implementation of Storage-as-a-Transmission Asset in Indian States



Prominent Features and Advantages of this Model :

1. **Asset dispatch and control by system operator**
   - Value maximization for system benefit
2. **Tolling-Contract**
   - Fixed, availability-based payment reduces cost of financing
3. **Asset Ownership by Independent-Storage-Provider**
   - Reduces capex burden on Discoms
   - Transfers technology and O&M risk to developers
   - Does not restrict competition to generators

Sample Business Case Study done for a Renewable-Rich State in India

Cost-Benefit Analysis for a 50MW x 3-hour system with 365 cycles/yr and more than 96% system availability *(Assumption ESS Capex – ₹ 5.88 Cr./MW)* *

ESS Application Value – INR 57.50 Cr./yr

Applications	Assumptions & Calculations	Value (₹ Cr./ year)
1. DSM Savings	DSM Savings: ₹43 Lakhs/MW	21.50
2. Peak-Cost Savings *(Source: Merit Order Dispatch)*	• 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) ₹/kWh	13
3. Transmission Deferral	• Transmission upgrade cost : ₹2 Cr./MW • Deferral = Upgrade cost * size * cost of capital	13
4. Capacity Availability / Reliability	• Comparable: ₹100Cr/year distribution utility pays as standby fees to generator for 500MW of capacity • Reliability Charge = (50/500)MW * 100Cr.	10
TOTAL (₹ Cr./year)		**57.50**

Break Even Period – 6.2 years

Item	Assumptions & Calculations	Cost
Capex	Including Battery cells, racks, containers, HVAC, software & SCADA, PCS, MV switchgear and transformer ₹ 5.88 Cr. /MW * 50MW system =	294 (₹ Cr.)
Opex	Long term Service Level Agreement (SLA) for 20 years = 3% * Capex =	9 (₹ Cr./yr)
Conversion Loss	50MW*3hrs * 365 cycles * 10% efficiency loss * 1.5 ₹/kWh off-peak energy cost	0.8 (₹ Cr./yr)
Break Even	Capex / (Annual Benefit Value – Opex – Conversion loss)	**6.2 years**

* *Source: IHS Markit*

Thank you

nishit.mehta@sterlite.com

www.sterlitepower.com

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Appendix: Tolling Agreements reduce cost of financing

S&P Report: "What Factors Power a Rating on a Utility-Scale Battery Storage Project"

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

Appendix: Application of ESS

Application	Description
Peaking Capacity/ Resource Adequacy	Resource Adequacy is the need to maintain enough capacity to meet generation requirements during peak-consumption hours.
Renewable Energy Integration	Firming up intermittent renewable power by storing RE output to serve consistent, on-demand electricity over a longer period.
Optimization of Generation	Frequent ramp-up and down to match demand changes leads to efficiency losses, shortened asset-life and increase emissions impact. Fast acting energy storage assets can provide the ramping needs .
Ancillary Service	Energy storage systems with quick response and ramp times are perfectly suited for frequency regulation, voltage support, and black start.
Spin/Non-Spin Reserves	Unutilized/idle capacity in traditional generation assets in form of spin/non-spin reserve can be freed up using energy storage systems.
T&D Deferral	Reducing the size of, or entirely avoiding utility investments in transmission system upgrades necessary to meet projected load growth on specific regions of the grid.