Value Assessment of Energy Storage in Hybrid Renewable Projects

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Rushikesh Deshpande **Dr. Ravi Segal** **Arun Unni** **Partha Deb**

GE Energy Consulting,
Bangalore, India

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NON-GAAP FINANCIAL MEASURES:
In this document, we sometimes use information derived from consolidated financial data but not presented in our financial statements prepared in accordance with U.S. generally accepted accounting principles (GAAP). Certain of these data are considered "non-GAAP financial measures" under the U.S. Securities and Exchange Commission rules. These non-GAAP financial measures supplement our GAAP disclosures and should not be considered an alternative to the GAAP measure. The reasons we use these non-GAAP financial measures and the reconciliations to their most directly comparable GAAP financial measures are posted to the investor relations section of our website at www.ge.com. [We use non-GAAP financial measures including the following:

- Operating earnings and EPS, which is earnings from continuing operations excluding non-service-related pension costs of our principal pension plans.
- GE Industrial operating & Verticals earnings and EPS, which is operating earnings of our industrial businesses and the GE Capital businesses that we expect to retain.
- GE Industrial & Verticals revenues, which is revenue of our industrial businesses and the GE Capital businesses that we expect to retain.
- Industrial segment organic revenue, which is the sum of revenue from all of our industrial segments less the effects of acquisitions/dispositions and currency exchange.
- Industrial segment organic operating profit, which is the sum of segment profit from all of our industrial segments less the effects of acquisitions/dispositions and currency exchange.
- Industrial cash flows from operating activities (Industrial CFOA), which is GE's cash flow from operating activities excluding dividends received from GE Capital.
- Capital ending net investment (ENI), excluding liquidity, which is a measure we use to measure the size of our Capital segment.
- GE Capital Tier 1 Common ratio estimate is a ratio of equity

Contents

Acronyms

BESS	Battery Energy Storage System
SPV	Solar Photovoltaic
BESS Integrated Hybrid Plant	Wind + Solar PV + BESS
CapEx	Capital Cost
DSM	Deviation Settlement Mechanism
EIRR	Equity Internal Rate of Return
ES	Energy Storage
FRAS	Fast Regulation Ancillary Service
GBI	Generation Based Incentive
Hybrid Plant	Wind + Solar PV
IRR	Internal Rate of Return
Li-NMC	Lithium Nickel Manganese Cobalt
O&M	Operation and Maintenance
OpEx	Operation Cost
RE	Renewable Energy
RRAS	Reserve Regulation Ancillary Service
VGF	Viability Gap Funding

Preface

Background

- India has set an ambitious target (year 2015) of installing 175 GW (60GW wind + 100GW Solar) of RE Resources by year 2022
- Wind and SPV hybrid plants would have **higher utilization factor** as compared to individual plants due to **complementary** nature of wind and solar resources
- Hybrid plants would offer certain benefits in terms of investment as well plant operation which would augment with addition of BESS
- BESS addition would **help** hybrid plant as well as system (grid) by offering different services or applications.

"Value of BESS can be quantified with evaluation of benefits and economic assessment"

In this paper

Methodology of BESS value assessment is discussed

- Value assessment of BESS is discussed with ***Qualitative description*** of benefits offered by BESS to hybrid plant and to the system
- ***Quantitative analysis*** is presented for a case study with a BESS Hybrid plant in Southern region of India
  - ***16 MW Wind***
  - ***25 MW SPV***
  - ***10MW/15 MWh, Li-NMC BESS***

  (BESS designed to support 'Power' and 'Energy' applications)
- **Financial Evaluation** is performed to estimate impact of BESS on the plant's **Levelized Tariff** and **Profitability** of plant is calculated considering practical limitations

Issues of BESS Value Assessment

The Challenge of BESS Value Assessment

- The value of a technology may be correctly assessed with:
  - ➢ Thorough understanding of the benefits achieved with it
  - ➢ Capabilities which are attributed to the project by this technology
- In the context of ***BESS Integrated Hybrid***:
  - ➢ Value of BESS is intricate and may be evaluated with assessment of '**benefits** achieved by Hybrid Plant with BESS'
  - ➢ 'Hybrid plant's **ability** to provide additional services' at technical and regulatory front with BESS's addition

"Structure of business models for BESS's services is complex as value of some of the services can be explicitly expressed while some service's value is tacit"

Steps of BESS Value Assessment

- Value of BESS is required to be deduced at planning level considering the services it going to serve recognized by regulatory framework.
- With this judgment, final BESS design (technology and sizing in terms of MW /MWh) is to be confirmed based on:
  - ➢ **B**ESS technologies
  - ➢ **C**apital Cost
  - ➢ **O**peration Cost
  - ➢ **R**eplacement Cost
  - ➢ **P**rofitability
  - ➢ **O**peration pattern
  - ➢ **W**ind and Solar Profiles
  - ➢ **C**ontrol Methodology
- This is the ***first and the critical stage*** at which the maximum value with BESS can be created.
- In the next step, commercial value of BESS's services can be estimated with financial evaluation ('Levelized Tariff' and investment performance indicators like IRR).

Benefits- Hybrid RE and BESS Integrated Hybrid Plants

Benefits of Hybrid RE Plant

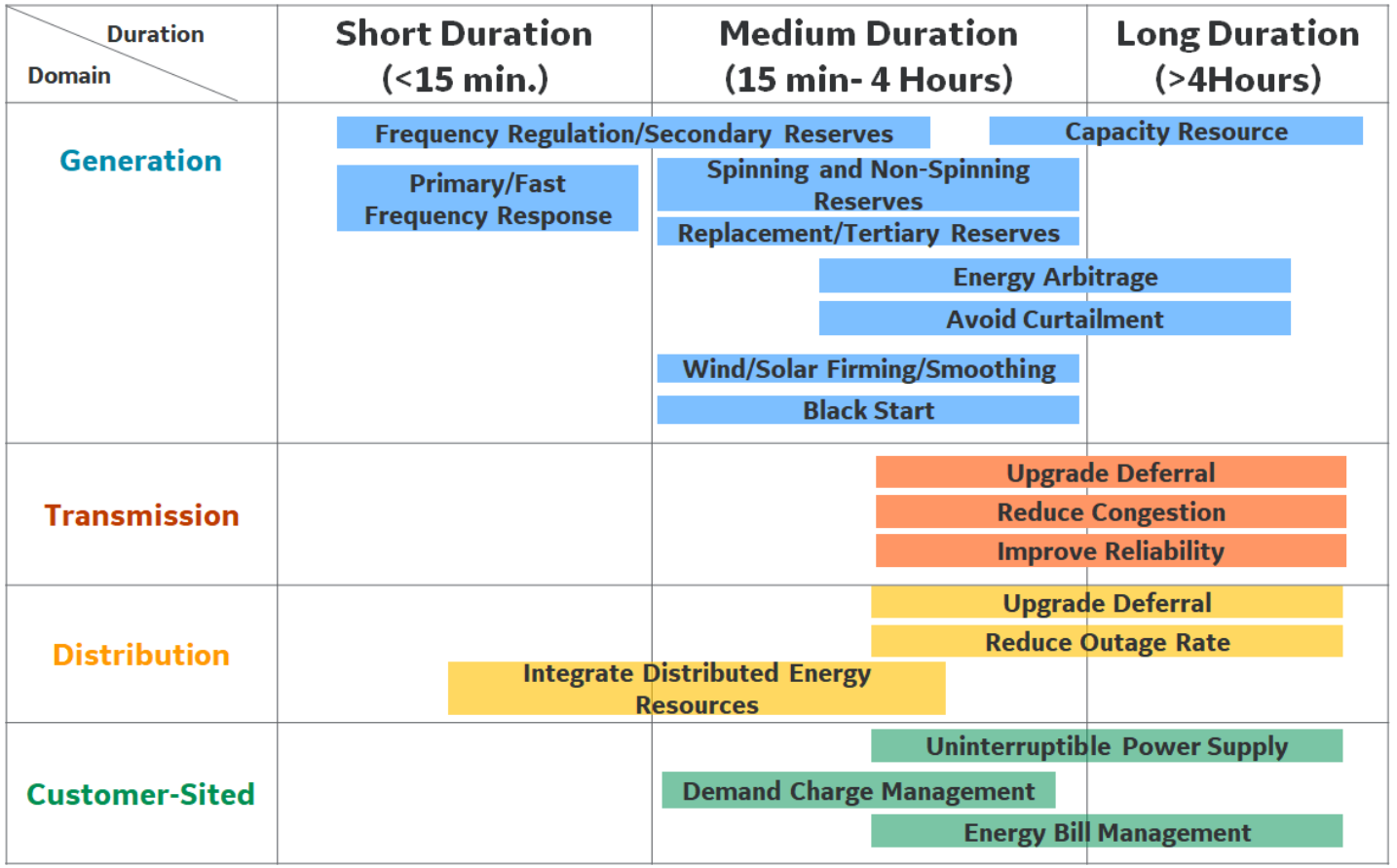
1. Optimization of project development costs
2. Effective land use
3. Lesser need of local balancing resources
4. Potential savings in evacuation and transmission upgrade costs
5. Sharing of Operations and maintenance expenses

Benefits of BESS Integrated Hybrid Plant

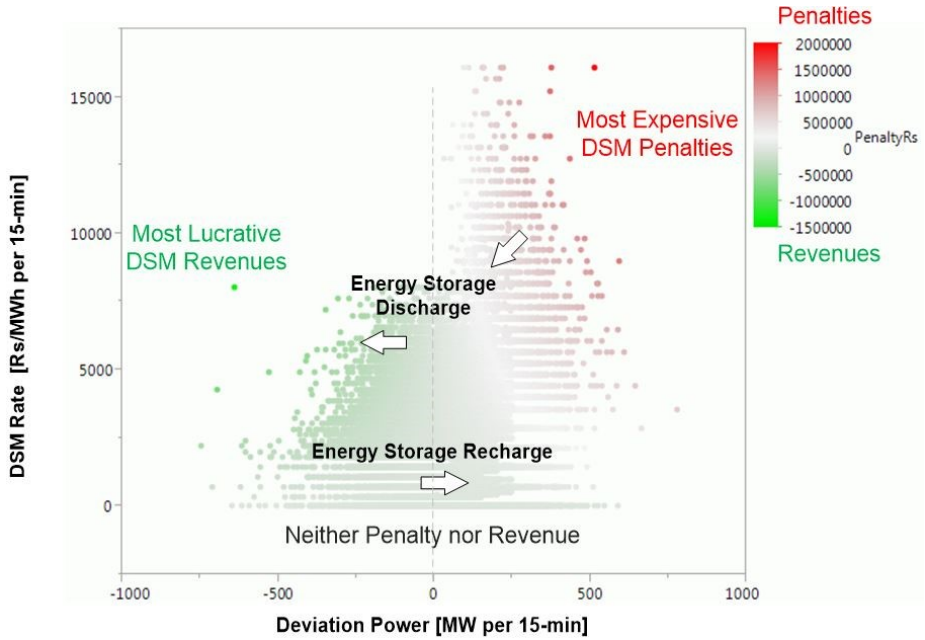
1. Potential savings in evacuation and transmission upgrade costs
2. Provide value added services to wind and solar plants
3. Assist the system in recovering from faults
4. Assist the system in maintaining tie line flows and frequency
5. Serve as a capacity and energy source during peak hours
6. Assist in managing transmission congestion
7. Assist in maintaining system voltage and power quality
8. Assist wind and solar plants in complying with technical standards
9. Provide black start capability

BESS Applications - 1

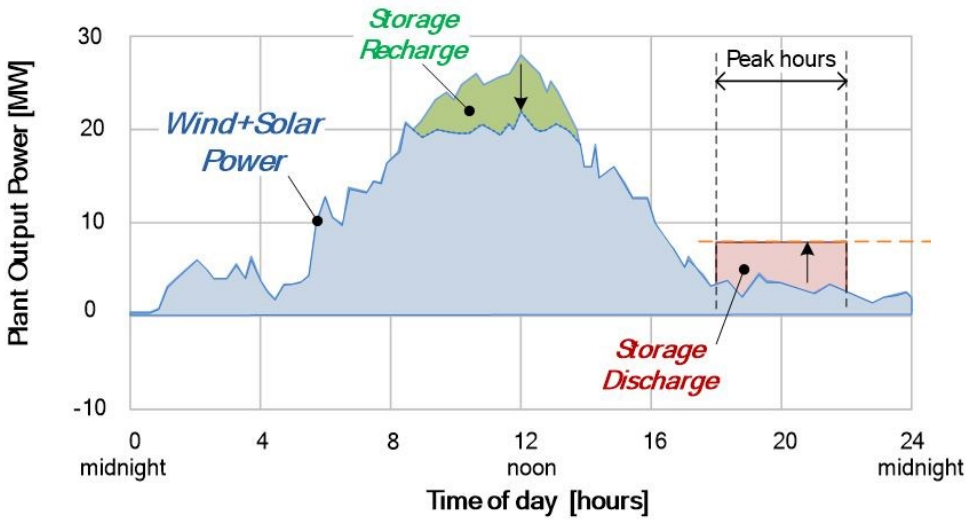
Sr. No.	BESS Application	Category
1	Deviation Settlement Mechanism (DSM) penalty charge management	Primary
2	Time shifting of renewable energy to peak hours	Primary
3	Forecast deviation reduction for wind and solar plants	Primary
4	Ramp management for wind and solar plants	Secondary
5	Synthetic Inertia and fast frequency response for the system	Secondary
6	Primary frequency response for the system	Secondary
7	Ramp management for the system	Secondary



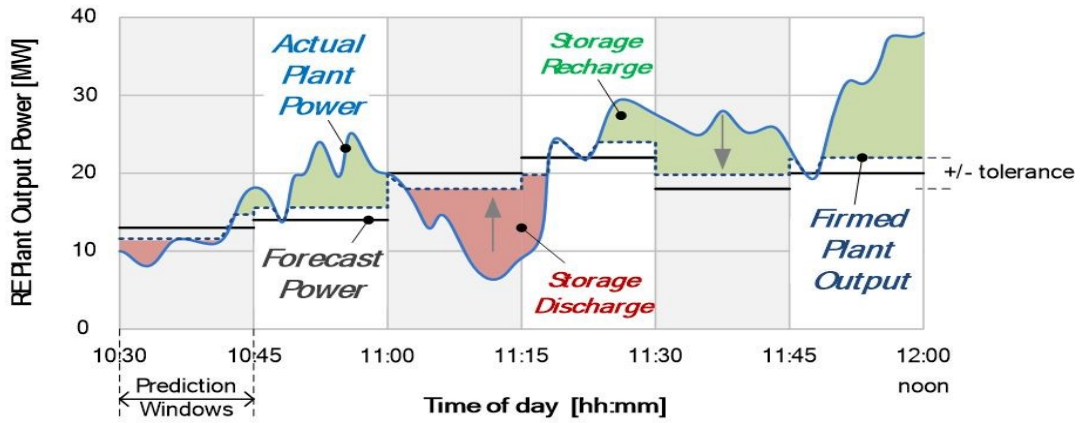
BESS Applications - 2



BESS Application for DSM* Penalty Reduction



BESS application for Peak Energy Shifting



BESS Application for firming Renewable Plant forecast

**Note: This case study was commenced in year 2015. Thus DSM penalty reduction was included as BESS service. However, authors are aware of initiatives in Indian power sector by CERC like RRAS, FRAS etc. which have reduced DSM penalties. On the backdrop of such developments, DSM penalty reduction service with BESS may not be attractive. It is discussed here for an illustration of methodology of finding value of BESS service.*

Financial Evaluation – Assumptions

Spreadsheet Modelling and Analysis

- This is the **second** step of BESS's value assessment
- At this stage, '**Levelized Tariff**' and '**Profitability**' over 25 years of operation life of the project is estimated
- Costs indicated in the 'cost summary' includes costs like land cost, communication device cost, project development cost, contingency, interest during construction, tax and duties etc. in addition to equipment cost
- **2015** is the **base year** for all costs as study **commenced** in this year
- **DSM saving** value indicated in assumption table ***is not considered*** for financial evaluation (profitability) since there was **no regulatory framework** available.
- The revenue stream of BESS is generated only with the sale of BESS power to the grid at Rs. 4.84 /kWh

Installed Capacity		
Wind	***MW***	***16***
Solar PV	***MW***	***25***
BESS	***MW/MWh***	***10/15***
Capacity Factor		
Wind	%	25.50%
Solar PV	%	22.90%
BESS	%	N/A
Cost Summary		
Wind	Rs Crores	118
Solar PV	Rs Crores	148
BESS	Rs Crores	77
Total Cost	Rs Crores	343
BESS Details **Cost assumptions are based in year 2015**		
Application	State DSM fee reduction + Peak Energy Shifting	
Power	MW	10
Energy	MWh	15
Technology		Li-NMC
Capital Cost – (Basic BESS)	Rs Crores	48
Capital Cost – (Basic BESS)	US $/kWh	478
Replacement Cost	Rs Crores	14.6
BESS Life	Years	19
Battery Efficiency	%	88%
DSM Saving – 1st Year	Rs Crores	2.61

Revenue Assumptions (Sale Tariff)		
Wind	Rs/kWh	4.84
Solar PV		
BESS		
Financial Assumptions		
Evaluation Term	Years	25
Discounting Rate	%	10.7%
Exchange Rate- INR to USD		67
Return on Equity - Expected	Assumptions as per CERC tariff guidelines	
Depreciation		
Working Capital		
Corporate Tax		
Minimum Alternate Tax (MAT)		
Debt	%	70%
Equity	%	30%
Domestic Loan	%	100%
Foreign Loan	%	0%
Operation and Maintenance (O&M) Assumptions (Year 2015)		
Wind O&M	Rs/Lakhs/MW/Year	11.5
Solar PV O&M	Rs/Lakhs/MW/Year	5.75
BESS	Rs Lakh/Year	90.8
O&M Escalation	%/Year	5.72%

Financial Evaluation – Tool (snapshot)

BESS Value Analysis Tool- Hybrid Projects

Plant Assumption

Parameter	Unit	Wind	Solar PV	Battery Storage
Basic Assumptions				
Capacity	MW			
Capacity Factor	%			
Auxilliary Consumption	%			
Revenue Assumptions				
Sale Tariff	Rs/MWh			
Sale Tariff Escalation	%/Year			
Operation and Maintenance Assumptions (O&M)				
O&M (1st Year)	Rs Lakh/MW			
O&M Escalation	%/Year			
Battery Storage (BESS) Assumptions				
Battery Application	"Select"	COMBINED APPLICATION - State DSM + Peak Energy Shifiting		
DSM Saving Application				
Grid Tariff for battery Charging	Rs/kWh			
Grid Tariff Escalation	%/Year			
Peak shifting Application				
Peak power Supply tariff (for Sale)	Rs/kWh			
Common Assumption				
Escalation - DSM revenue and Peak Power Supply Tariff	%/Year			

VGF Evaluation

VGF Evaluation Criteria

Expected Equity IRR (Complete Project)	%	
Calculated Equity IRR (Complete Project)	%	
VGF Tool 1 - Grant		
Grant Value	Rs Crores	

Adjust VGF

VGF Tool 2 - Generation Based Incentive (GBI)		
GBI to be considered	"Select'	
Generation Based Incentive	Rs./MWh	
Period for which GBI benefits are available	Years	
GBI capping	Lakhs/MW	

Financing Assumptions

Financing Plan

Parameter	Unit	Wind	Solar PV	Battery Storage
Capital Structuring				
Debt	%			
Equity	%			
Debt Structuring				
Domestic Loan	%			
Foreign Loan	%			

Exchange Rate

Currency	Conversion Unit	Conversion rate
USD	INR	
EURO	INR	

Links

Battery Inputs	Battery
Financial Statement	Fin Stat
Debt Assumptions	Debt Assup.

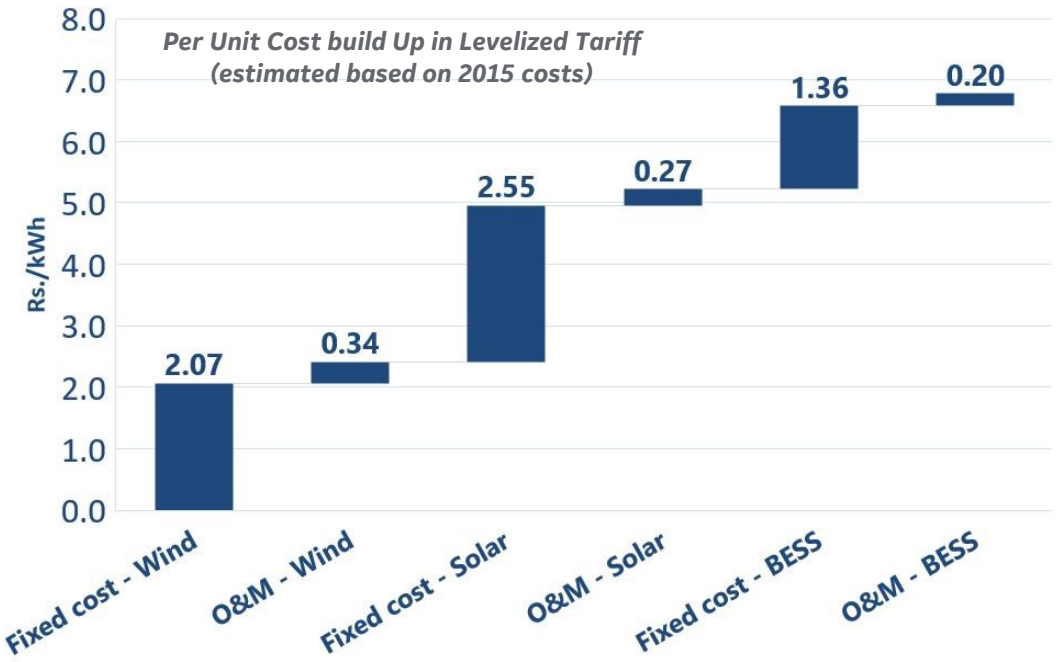
Financial Evaluation – Results 1

Spreadsheet Modelling and Analysis

Levelized Tariffs (Rs/kWh)		
Tariff Component	**Year 2015**	**Year 2019**
Levelized Fixed Charge	5.97	5.42
Levelized O&M Charge	0.81	0.80
Levelized Total Charge	**6.78**	**6.22**

Final Costs				
Project Module	**Year 2015**		**Year 2019**	
	Rs. Crores	**% of Total Cost**	**Rs. Crores**	**% of Total Cost**
Wind	118	34%	117	38%
Solar PV	148	43%	146	47%
BESS	77	23%	48	16%
Total Cost	343	100%	311	100%

- Levelized Tariff based on year 2015 and year 2019 prices are tabulated
- BESS price in 2015 considered to be 478$/kWh
- It is **assumed** that BESS price have reduced to 250$/kWh in year 2019
- Prices of other components (wind and SPV) are considered to be at same levels in year 2015
- Levelized tariff in year 2019 is reduced than in year 2015 with the drop in BESS prices



- The purpose of the above figure is to indicate the 'per unit cost build up' in BESS Integrated Hybrid Plant
- As seen in figure, fixed and O&M cost of wind constitutes major portion of levelized tariff (Rs. 5.23/kWh)
- BESS adds Rs. 1.55/kWh (Rs. 1.36/kWh as fixed cost and Rs.0.20/kWh as O&M cost)

Financial Evaluation – Results 2

Profitability				
Scenario	**EIRR**	**VGF Requirement for 16% EIRR**		**Total VGF IN PRESENT VALUE TERMS (RS. Crores)**
		Grant (Rs. Crores)	**GBI for 10 Years (Rs/kWh)**	
Base Case	5.30%	76	0.67	112
Annual DSM revenue @ 2.61Cr. escalated @5% annual rate (Optimistic case)	7.5%	76	0.30	92

Funding or support required to bridge the viability gap of the project is termed as 'Viability Gap Funding (VGF)'

- VGF requirement for hybrid tariff of 4.84 Rs/kWh in present value term is Rs.112 Crore
- Recognizing the revenues from DSM application could reduce the total VGF support by nearly Rs. 20 Crore

Key Observations -1

- Value assessment of BESS is **a complex process** as business models need to be developed for justification of investment in BESS

- Business model (revenue streams) should take into consideration the potential **BESS's services** offered to **hybrid plant** and to **the grid**

- Viability of BESS integrated hybrid plant depends largely on the **regulatory framework** of the region as possible recognition of revenue generated by BESS services are at the core of revenue model

Key Observations -2

- The **first step** towards value assessment would be identification of BESS applications followed by technology selection and sizing

- Different **benefits** of BESS Integrated Hybrid plant were **qualitatively** discussed in this paper

- **Quantitative analysis** suggested that viability gap funding would be required if the project is not financially viable

- Thorough **feasibility study** with sound **financial evaluation** would be required to correctly ascertain BESS value

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