Battery Energy Storage: Unlocking Potential in India

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Outline

- Developments creating opportunities for deployment of energy storage
- Potential for energy storage deployment in India in the short and long-term
- Assessment of energy storage coupled at generator end:
  - Benefits to cost ratio for individual applications
  - Benefits to cost ratio for stacked applications
- Suggestions for unlocking storage’s potential in India
Opportunities for storage are arising from several developments:

- **Increasing demand**
  - Generation capacity
  - Network capacity

- **Rising VRE portfolio**
  - Stability needs
  - Balancing needs

- **Electrification of transport**
  - Battery needs

### National Electricity Plan (2018)

<table>
<thead>
<tr>
<th></th>
<th>FY17</th>
<th>FY27</th>
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<tbody>
<tr>
<td>Electricity demand (BU)</td>
<td>1160</td>
<td>2047</td>
</tr>
<tr>
<td>Peak demand (GW)</td>
<td>161</td>
<td>298</td>
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### 2022 RE targets

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<table>
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<tbody>
<tr>
<td>Solar</td>
<td>100 GW</td>
</tr>
<tr>
<td>Wind</td>
<td>60 GW</td>
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### Programs

- FAME scheme
- State schemes
Opportunity for energy storage are higher in cost optimized dispatch scenario

- Cost optimal dispatch leads to almost doubling of peak ramping needs
- Aggressive RE adoption will lead to ramping needs of 60 GW per hour by 2027
As batteries become cheaper, they are expected to play a greater role in VRE integration.

**Key assumptions**
- BESS cost assumption (BNEF estimates)
- Use cases modeled: Time shifting, Transmission optimization, Price arbitrage, Supply capacity
- Model is free to build new transmission lines and non-RE generator

**Energy storage potential in short-term (2027)**
- All India potential: 30 GWh
- Solar: 32 GW, Wind: 8 GW, Storage: 5 GWh
- Solar: 13 GW, Wind: 22 GW, Storage: 2 GWh
- Solar: 7 GW, Wind: 8 GW, Storage: 1 GWh
- Solar: 9 GW, Wind: 12 GW, Storage: 2 GWh

**Energy storage potential in long-term (2041)**
- All India potential: 1,500 GWh
- Solar: 95 GW, Wind: 19 GW, Storage: 320 GWh
- Solar: 85 GW, Wind: 84 GW, Storage: 176 GWh
- Solar: 31 GW, Wind: 45 GW, Storage: 135 GWh
- Solar: 33 GW, Wind: 56 GW, Storage: 100 GWh
- Solar: 41 GW, Wind: 4 GW, Storage: 133 GWh
- Solar: 124 GW, Wind: 54 GW, Storage: 506 GWh
Case study for BESS coupled at generator end

- Wind-Solar hybrid plant in South-India
  - 100+ MW solar
  - 50+ MW wind

- Technical parameters:
  - Wind generation curtailment ~3% of annual generation (conservative estimate)
  - No solar generation curtailment
  - Deviation Settlement Mechanism (DSM) penalty levied on both wind and solar generators (for absolute error >15%)
  - DSM penalty levied in incremental steps of absolute error

- Financial implications in absence of storage
  - Wind curtailment loss of ~ INR 12 crores
  - Annual DSM penalty of ~ 40 lakhs on wind generator
  - Annual DSM penalty of ~4 lakhs on solar generator

1. Identify applications (Curtailment avoidance & DSM penalty minimization)
   - Regulatory compliance
   - Cost avoidance
   - Revenue streams

2. Identify technologies (lithium-ion BESS)
   - Matching applications requirements with technology characteristics

3. Storage sizing
   - Storage resource characteristics
   - Cost avoidance parameters
   - Market revenue parameters
Application 1: Curtailment avoidance (Benefits to cost assessment)

E/P in the range (2-3 h) has maximum benefits to cost

Benefits to cost ratio decreases as battery capacity (MWh) increases
Benefits to cost ratio is maximum for energy to power (E/P) ratio in the range 2-3h

Note: Benefits to cost ratio considers annualized benefits and annualized costs of BESS. Analysis considers replacement of BESS after it has utilized its cycle life.
Application 2: Wind DSM penalty avoidance (Benefits to cost assessment)

E/P in the range (2-3 h) has maximum benefits to cost

Note: Benefits to cost ratio considers annualized benefits and annualized costs of BESS. Analysis considers replacement of BESS after it has utilized its cycle life.
Application 2: Solar DSM penalty avoidance (Benefits to cost assessment)

Benefits to cost ratio decreases as battery capacity (MWh) increases.

Benefits to cost ratio is maximum for energy to power (E/P) ratio in the range 2-3h.
Stacking improves benefits to cost ratio by over 2 times but deploying storage at generator end does not look attractive.

Benefits to cost ratio is maximum for energy to power (E/P) ratio in the range 2-3h.
Suggestions for unlocking storage’s potential in India

- The assumptions on curtailment level and DSM penalty as well as levels of absolute error are dependent on geographic location. Thus, Policy makers, utilities and developers need to be prudent in storage site selection.

- The assumptions on curtailment level and DSM penalty as well as band are on the conservative side, more realistic assumption will improve benefits to cost ratio.

- Wind and solar are natural complimentary resources, the penalties on wind and solar generators in isolation will be higher. Thus, energy storage will realize higher benefits in isolated wind and solar projects.

- Energy storage is modelled as a regulated asset tied by long term PPA. Thus, there is a case to focus on improving its utilization as well. This is possible through ‘stacking’ of applications. Regulators, utilities and developers should work towards identifying ‘Stacking’ opportunities.

- Time of delivery based or Dynamic pricing will enable storage to realize more benefits.

- Policy makers have to acknowledge benefits of same storage resource to multiple stakeholders.
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