Batteries, Renewables, and Electrification of Transport

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SVP Corporate Development
EXECUTIVE SUMMARY

Reasonable penetration projections of batteries and renewables are not expected to disrupt Vistra’s core businesses and could lead to attractive investment opportunities

BATTERIES

• Price of batteries is forecast to decline to ~$200/kWh by 2020

• Many of the most economic applications of batteries involve pairing with traditional generation

• Grid-scale batteries are *complementary* to existing baseload and low-cost cycling generation
  - Lithium ion batteries currently have ~4 hours of storage; batteries will still require a sustainable source of charge
  - Adding load during periods when baseload and low-cost cycling generation is online will help to smooth energy prices and thus revenue streams for these generation sources
  - *New* peaking generation investments will likely be increasingly preempted by battery storage (5-10 year time frame); however, batteries will always require a source of charging and will compete with sunk investments in existing generation

• **Vistra has attractive opportunities to participate in battery storage at accretive returns**
  - Vistra has two of the best sites for battery storage in CA, which is the most attractive market for batteries
  - Any such investment would be *modest* as overall battery penetration is forecasted to be low in the next 10 years

RENEWABLES

• Given low resource potential, RPS requirements are more likely to drive renewable development, with the highest penetration rates in CA and NY where Vistra has a limited presence

ELECTRIFICATION OF TRANSPORT

• Reductions in battery storage costs are increasing attractiveness of electric vehicles (“EVs”)
  - In the ~10-15 year time frame, EVs may represent a significant source of power demand growth, helping to offset demand reductions from demand response and energy efficiency
BATTERIES

RENEWABLES GROWTH

ELECTRIFICATION OF TRANSPORT

KEY TAKEAWAYS
Multiple value streams contribute to battery economics for both in front of the meter (“FTM”) and behind the meter (“BTM”) applications; optimal configuration depends on value stream

### VALUE STREAMS

<table>
<thead>
<tr>
<th>Value</th>
<th>Type</th>
<th>Storage Can:</th>
</tr>
</thead>
<tbody>
<tr>
<td>Energy Price Arbitrage</td>
<td>Optimization</td>
<td>• Charge when power prices are low / discharge when power prices are high</td>
</tr>
<tr>
<td>Ancillary Services</td>
<td>Optimization</td>
<td>• Provide frequency regulation, load following, reserves, etc.</td>
</tr>
<tr>
<td>Policy Incentives</td>
<td>Financial</td>
<td>• Batteries may qualify for investment tax credit (“ITC”), bonus depreciation, and other incentives / subsidies by state / market / locality</td>
</tr>
<tr>
<td>Black Start</td>
<td>Reliability</td>
<td>• Restart offline thermal power plants</td>
</tr>
<tr>
<td>Voltage Regulation</td>
<td>Quality</td>
<td>• Absorb power to balance reactance in the grid</td>
</tr>
<tr>
<td>Defer Investment in Transmission &amp; Distribution (“T&amp;D”)</td>
<td>Reliability</td>
<td>• Install at T&amp;D bottlenecks to avoid the need to invest in additional T&amp;D infrastructure</td>
</tr>
<tr>
<td>Renewable Integration</td>
<td>Optimization, Reliability</td>
<td>• Avoid curtailments of renewables and reshape their output to match supply and demand</td>
</tr>
<tr>
<td>Capacity / Peaker Replacement</td>
<td>Reliability</td>
<td>• Provide system capacity similar to a peaking plant</td>
</tr>
<tr>
<td>Avoid Demand Charge</td>
<td>Financial</td>
<td>• Offset peak demand and lower demand charges</td>
</tr>
<tr>
<td>Pair with BTM Solar</td>
<td>Optimization, Reliability</td>
<td>• Optimize output of BTM solar plants and avoid curtailment</td>
</tr>
<tr>
<td>Power Reliability / Quality</td>
<td>Quality, Reliability</td>
<td>• Allow customers to avoid service interruptions due to grid events</td>
</tr>
</tbody>
</table>
STACKED VALUE STREAMS

BATTERY ECONOMICS

• To be economic today, battery projects require multiple sources of value
  - Market structure rules may limit the ability to capture full value
  - Impossible to capture 100% of individual value stream
  - Usage of batteries will impact lifetime cost

• Battery projects that are built adjacent to existing generation capacity will allow for the greatest optionality and value stacking proposition

ILLUSTRATIVE COSTS VS. STACKED BENEFITS

Taken individually, value streams often do not cover the cost of battery projects
When combined, value streams may cover the cost and required returns
Today, California is the most attractive market for batteries, followed by New York.

### ATTRACTIVENESS OF BATTERIES BY MARKET

<table>
<thead>
<tr>
<th>Value</th>
<th>CAISO</th>
<th>NYISO</th>
<th>ERCOT</th>
<th>ISO-NE</th>
<th>PJM</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>FTM</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Energy price arbitrage</td>
<td>●</td>
<td>○</td>
<td>●</td>
<td>○</td>
<td>○</td>
</tr>
<tr>
<td>Ancillary Services</td>
<td>●</td>
<td>○</td>
<td>●</td>
<td>○</td>
<td>○</td>
</tr>
<tr>
<td>Policy Incentives</td>
<td>●</td>
<td>●</td>
<td>○</td>
<td>○</td>
<td>○</td>
</tr>
<tr>
<td>Defer Investment in T&amp;D</td>
<td>●</td>
<td>●</td>
<td>●</td>
<td>○</td>
<td>○</td>
</tr>
<tr>
<td>Renewable Integration</td>
<td>●</td>
<td>○</td>
<td>●</td>
<td>○</td>
<td>○</td>
</tr>
<tr>
<td>Capacity / Peaker Replacement</td>
<td>●</td>
<td>○</td>
<td>●</td>
<td>○</td>
<td>○</td>
</tr>
<tr>
<td><strong>BTM</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Avoid Demand Charge</td>
<td>●</td>
<td>●</td>
<td>○</td>
<td>○</td>
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<tr>
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<td>●</td>
<td>○</td>
<td>○</td>
<td>○</td>
<td>○</td>
</tr>
</tbody>
</table>
BATTERIES COMPLEMENT EXISTING GENERATION

BACKGROUND

- Batteries are often supportive of existing generation
  - Daily cycle requires charging on a day-to-day basis
- Baseload coal, nuclear, and low-cost gas plants can benefit to the extent that batteries:
  - Charge overnight and raise off-peak prices
  - Smooth/eliminate extremely low priced hours from high renewable penetration
- Near term, batteries are most likely to threaten investment in new peaking plants
  - Short duration storage may allow peaking plants to provide non-spinning reserves (instant start)
- Penetration estimates are low relative to the size of markets

BATTERY PENETRATION ESTIMATES BY MARKET

<table>
<thead>
<tr>
<th></th>
<th>MW</th>
<th>% Installed Generation</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>2018 Operating Storage Capacity</td>
<td>2018 Projects in Development</td>
</tr>
<tr>
<td>CAISO</td>
<td>234</td>
<td>610</td>
</tr>
<tr>
<td>PJM</td>
<td>335</td>
<td>220</td>
</tr>
<tr>
<td>NYISO</td>
<td>1</td>
<td>115</td>
</tr>
<tr>
<td>ERCOT</td>
<td>103</td>
<td>10</td>
</tr>
<tr>
<td>ISO-NE</td>
<td>46</td>
<td>43</td>
</tr>
</tbody>
</table>

1 Base case estimates developed using fundamental modeling of projected cost decline curves and value propositions by market; high case estimates assume solar-like growth in battery penetration, despite the lack of ITC availability, or other incentives in most locations, for standalone batteries.
**ERCOT: UPTON 2 BATTERY PROJECT**

**PROJECT DETAILS**

- **Upton 2 Battery Project**
  - Located adjacent to solar facility
  - 10 MW / 42 MWh lithium ion batteries
  - Estimated COD: Q4 2018
  - Estimated unlevered returns: Mid to high teens

- **Upton 2 Solar Plant interconnect is for 180 MW; however, the plant is capable of producing nearly 200 MW during peak solar hours**
  - With batteries, some of this extra generation will be captured and discharged at peak times
  - Batteries can also be charged from grid at low power prices (*i.e.*, at night) and discharged in the morning

- **Attractive returns given its:**
  - Eligibility for the Investment Tax Credit and bonus depreciation
  - Ability to use excess solar generation that would have otherwise been clipped
  - Energy arbitrage opportunities
  - Low site and substation costs
  - Potential integration with retail product offerings
BATTERIES

RENEWABLES GROWTH

ELECTRIFICATION OF TRANSPORT

KEY TAKEAWAYS
Most areas with high solar and wind resource potential in the US are located far from population centers, and the PJM and ISO-NE regions have relatively low resource potential for both wind and solar.

In areas with low resource potential, RPS requirements are more likely to drive renewable development, whereas economics are more likely to drive requirements in areas with high resource potential.

- RPS policies have driven 70-90% of the growth in renewables in the West, Mid-Atlantic, and Northeast, but in Texas and the Midwest, growth has far outstripped RPS requirements, largely due to attractive wind economics.
Given current RPS requirements, California and New York are expected to have the highest renewables penetration by 2030.

**Forecasted 2030 Renewables Penetration of Overall Generation**

- **CAISO**: 50%  
  Includes geothermal, solar (PV & thermal), wind, biomass, waste, landfill gas, tidal, wave, ocean thermal, small hydro, anaerobic digestion, & fuel cells (using renewables)

- **NYISO**: 50%  
  Includes solar PV, wind, biomass, tidal, small hydro, anaerobic digestion, & fuel cells

- **MISO Zone 4**: 25 – 30%  
  Includes solar (PV & thermal), wind, biomass, hydro, landfill gas, anaerobic digestion, & biodiesel

- **ISO-NE**: 30 – 40%  
  Varies across states; all have multiple types of technology included, including large hydro and nuclear in some cases

- **PJM**: 12 – 20%  
  Varies across states; all have multiple types of technology included

- **ERCOT**: 25 – 35%  
  Includes solar (PV & thermal), geothermal, wind, biomass, hydro, landfill gas, tidal, wave, & ocean thermal

Source: Berkeley Lab, DSIRE, McKinsey, & PA Consulting.

1 Certain state RPS requirements have targets for specific technologies (principally for solar and wind).
BATTERIES

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KEY TAKEAWAYS
• The Transportation and Power sectors are the leading sources of greenhouse gas ("GHG") emissions in the United States.

• In 2016, the Transportation sector overtook the Power sector as the largest contributor of GHG emissions:
  - Driven in part by coal-gas switching and an increase in renewables generation
  - Each EV that replaces an internal combustion engine vehicle results in a 3x savings in greenhouse gases

1 GHG includes carbon dioxide, methane, nitrous oxide, hydrofluorocarbons, perfluorocarbons, sulfur, hexafluoride, and nitrogen trifluoride. SOURCE: EPA and EIA.
• Battery advancement will impact Electric Vehicles
  - Improvements in battery storage costs, duration, and energy density, which have improved storage economics on the wholesale side, are making EVs more competitive

• EVs, ride-sharing, and automation is a virtuous cycle that we see playing out over the next ~10-15 years
  - Over the next ~5 years, EVs as a source of power demand will help to offset demand reductions from demand response and energy efficiency
  - In the ~10-15 year time frame, EVs may actually represent a significant source of power demand growth

• EV penetration confined primarily to metropolitan areas, particularly on the coasts

• Continued EV penetration will be affected by:
  - Low gas prices and easing fuel economy regulations
  - Availability of charging infrastructure
  - Improvements to driving range
  - Increased model availability

### Opportunity for EV Penetration

<table>
<thead>
<tr>
<th>EVs as % of US Motor Vehicle Fleet</th>
<th>EV Annual Load (TWh)</th>
<th>% of Overall Load</th>
</tr>
</thead>
<tbody>
<tr>
<td>5%</td>
<td>60</td>
<td>2%</td>
</tr>
<tr>
<td>10%</td>
<td>121</td>
<td>3%</td>
</tr>
<tr>
<td>20%</td>
<td>242</td>
<td>7%</td>
</tr>
<tr>
<td>30%</td>
<td>363</td>
<td>10%</td>
</tr>
<tr>
<td>40%</td>
<td>484</td>
<td>13%</td>
</tr>
<tr>
<td>50%</td>
<td>605</td>
<td>16%</td>
</tr>
<tr>
<td>60%</td>
<td>726</td>
<td>20%</td>
</tr>
<tr>
<td>70%</td>
<td>847</td>
<td>23%</td>
</tr>
<tr>
<td>80%</td>
<td>968</td>
<td>26%</td>
</tr>
<tr>
<td>90%</td>
<td>1,089</td>
<td>29%</td>
</tr>
<tr>
<td>100%</td>
<td>1,210</td>
<td>33%</td>
</tr>
</tbody>
</table>
BATTERIES

RENEWABLES GROWTH

ELECTRIFICATION OF TRANSPORT

KEY TAKEAWAYS
Grid-scale batteries have modest penetration forecasts and are complementary to existing baseload and low-cost cycling generation.

Renewable penetration in PJM and ISO-NE will likely be driven by RPS requirements and should not impact Vistra’s core assets.

Reductions in battery storage costs are increasing the attractiveness of electric vehicles ("EVs"), which will only increase electric demand.

Vistra has a variety of opportunities to participate in battery storage and renewables at accretive returns and with high cash flow conversion.