

## LAZARD'S LEVELIZED COST OF STORAGE ANALYSIS 2.0

### KEY FINDINGS

Lazard has published its second Levelized Cost of Storage Analysis (“LCOS 2.0”),<sup>1</sup> an in-depth study that compares the costs of various energy storage technologies for particular applications.<sup>2</sup>

Key findings of the LCOS study include: 1) select energy storage technologies are increasingly attractive for a number of specialized power grid uses and 2) Industry participants expect costs to decrease significantly in the next five years, driven by scale and related cost savings, improved standardization and technological improvements, supported in turn by increased demand as a result of regulatory/pricing innovation, increased renewables penetration and the needs of an aging and changing power grid in the context of a modern society.

#### **1) Select energy storage technologies are increasingly attractive for a number of specialized power grid uses, but none are yet cost-competitive for the transformational scenarios envisioned by certain renewable energy advocates**

- Although energy storage technology has created a great deal of excitement regarding certain transformational scenarios, such as consumers and businesses “going off the grid” or the conversion of renewable energy resources to baseload/dispatchable generation, it is not currently cost competitive in most applications. However, some uses of select energy storage technologies are currently attractive relative to conventional alternatives; these uses relate primarily to strengthening the power grid (e.g., frequency regulation, transmission/distribution investment deferral) and accessing cost savings and other sources of value for commercial and industrial energy users through reducing utility bills (e.g., lowering demand charges) and/or participating in demand response programs
- Today, energy storage appears most economically viable in use cases that require relatively greater power capacity and flexibility as opposed to energy density or duration. These use cases include, among others, frequency regulation, transmission and distribution investment deferral, demand charge management and microgrid applications. This finding illustrates the relative expense of incremental system duration as opposed to system power. Put simply, discharge duration (energy) is more difficult and costly to increase than peak output (power). This is likely why certain potentially transformational use cases (such as full grid defection) are not currently economically attractive—they require relatively greater energy duration, as opposed to power capacity

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<sup>1</sup> Lazard conducted the LCOS analysis with support from Enovation Partners, a leading energy consulting firm.

<sup>2</sup> Energy storage has a variety of uses with very different requirements, ranging from large-scale, power grid-oriented uses to small-scale, consumer-oriented uses. The LCOS analysis identifies 10 “use cases,” and assigns detailed operational parameters to each. This methodology enables meaningful comparisons of storage technologies within use cases.

- The preceding observation highlights the importance of market and regulatory forces for energy storage; the relative cost competitiveness of frequency regulation vs. other use cases for energy storage reflects the fact that a regulatory initiative (PJM Frequency Regulation D) was required to create appropriate price signals to reward the attributes of energy storage (e.g., high performance, fast response times, etc.) that make batteries inherently attractive for this use case. By the same token, uncertainty regarding the ultimate design and required capacity under this regulatory structure illustrates the exposure of energy storage to highly technical regulatory design choices, notwithstanding its fundamental attractiveness for a particular application
- Energy storage differs from generation in that an individual system is capable of performing multiple functions (vs. the single function of generating electrons in the case of generation). To highlight this ability, as well as the potential value proposition of energy storage systems to their commercial- and industrial-scale owners, we have incorporated analysis on the returns profile of several illustrative, behind-the-meter systems performing multiple use cases. Our analysis indicates that the standalone economic viability of individual energy storage units depends on market structure, incentives and regional power market fundamentals
- Further, although wide variation in cost is expected in any nascent industry, we have refined our survey methodology to limit significant outliers by excluding responses from pre-commercial technologies and from technologies ill-suited to perform under the defined parameters of a particular use case

**2) Industry participants expect costs to decrease significantly in the next five years, driven by increasing use of renewable energy generation, government policies promoting energy storage and pressuring certain conventional technologies and the needs of an aging and changing power grid**

- Industry participants expect increased demand for energy storage to result in enhanced manufacturing scale and ability, creating economies of scale that drive cost declines and establish a virtuous cycle in which energy storage cost declines facilitate wider deployment of renewable energy technology, creating more demand for storage and spurring further innovation in storage technology
- Cost declines projected by Industry participants vary widely between storage technologies—some Industry participants expect lithium battery capital cost declines of ~40% over the next five years, while flow and lead batteries are expected by some to experience roughly comparable five year battery capital cost declines

- Further, our current analysis indicates that the midpoint levelized costs for lithium-ion technologies have already decreased vs. last year's study by ~12%, ~24% and ~11% for peaker replacement, transmission investment deferral and residential use cases, respectively, partially attributable to declining capital costs, among other factors. Far from being "something in the distance," certain energy storage technologies and use cases are currently in the midst of rapid cost declines that will likely persist
- The majority of future cost declines are expected to occur as a result of manufacturing and engineering improvements in batteries, rather than in balance of system costs (e.g., power control systems or installation). Therefore, use case and technology combinations that are primarily battery-oriented and involve relatively smaller balance of system costs are likely to experience more rapid levelized cost declines. As a result, some of the most "expensive" use cases today are most "levered" to rapidly decreasing battery capital costs
- If Industry projections materialize, some energy storage technologies may be positioned to displace a significant portion of future gas-fired peaking generation, potentially enabling further integration of renewable generation