LAZARD LEVELIZED COST OF STORAGE ANALYSIS 1.0
KEY FINDINGS

Lazard has published its first Levelized Cost of Storage Analysis ("LCOS 1.0"), an in-depth study that compares the costs of energy storage technologies for particular applications.[1] The study's purpose is to compare the cost-effectiveness of each technology on an "apples to apples" basis within applications, and to compare each application to conventional alternatives.[2]

Key findings of LCOS 1.0 include: 1) select energy storage technologies are cost-competitive with certain conventional alternatives in a number of specialized power grid uses and 2) industry participants expect costs to decrease significantly in the next five years, driven by increasing use of renewable energy generation, governmental and regulatory requirements and the needs of an aging and changing power grid.

1) Select energy storage technologies are cost-competitive with certain conventional alternatives in a number of specialized power grid uses, but none are cost-competitive yet for the transformational scenarios envisioned by renewable energy advocates.

- Although energy storage technology has created a great deal of excitement regarding transformational scenarios such as consumers and businesses "going off the grid" or the conversion of renewable energy sources to baseload 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 investment deferral)

- Today, energy storage appears most economically viable compared to conventional alternatives in use cases that require relatively greater power capacity and flexibility as opposed to energy density or duration. These use cases include frequency regulation and—to a lesser degree—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, "battery life" is more difficult and costly to increase than "battery size." This is likely why the potentially transformational use cases such as full grid defection are not currently economically attractive—they require relatively greater energy density and duration, as opposed to power capacity

[1] Lazard conducted the Levelized Cost of Storage analysis with support from Enovation Partners, an leading energy consulting firm.

[2] 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, as well as against the appropriate conventional alternatives to storage in each use case.

- LCOS 1.0 finds a wide variation in energy storage costs, even within use cases. This dispersion of costs reflects the immaturity of the energy storage industry in the context of power grid applications. There is relatively limited competition and a mix of "experimental" and more commercially mature technologies competing at the use case level. Further, seemingly as a result of relatively limited competition and lack of industry transparency, some vendors appear willing to participate in use cases to which their technology is not well suited

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—lithium is expected to experience the greatest five year battery capital cost decline (~50%), while flow batteries and lead are expected to experience five year battery capital cost declines of ~40% and ~25%, respectively. Lead is expected to experience 5% five year cost decline, likely reflecting the fact that it is not currently commercially deployed (and, possibly, the optimism of its vendors' current quotes)

- The majority of near- to intermediate- 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 generation capacity, in particular as a replacement for peaking gas turbine facilities, enabling further integration of renewable generation