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Lazard's Levelized Cost of Storage Analysis—Version 3.0

The central findings of our LCOS analysis include: 1) selected 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 Alternative Energy advocates; 2) Industry participants expect costs to decrease significantly over 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; and 3) as the energy storage market continues to evolve, several potential sources of revenue available to energy storage systems have emerged; ultimately, the mix of available revenue streams for a particular energy storage system varies significantly across geographies.

1) Selected 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 Alternative Energy advocates

- Although energy storage technology has created a platform for discussions related to certain transformational scenarios, such as consumers and businesses “going off the grid” or the conversion of Alternative Energy resources to baseload/dispatchable generation, energy storage is not currently cost competitive in most applications. However, under some scenarios, certain applications of energy storage technologies are attractive; these applications relate primarily to strengthening the power grid (e.g., frequency regulation and 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, distribution investment deferral, demand charge mitigation and commercial applications. This finding illustrates the relative expense of incremental system duration as opposed to system power. This is likely why certain potentially transformational use cases (such as full grid defection) are not currently economically attractive
- The preceding finding highlights the importance of market and regulatory forces for the advancement of the energy storage Industry. For example, a regulatory initiative in PJM (e.g., Frequency Regulation D) was required to create appropriate price signals to reward

¹ Lazard conducted the LCOS analysis with the support of Enovation Partners, a 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. Our LCOS v3.0 analysis identifies five “use cases” and assigns detailed operational parameters to each. This methodology enables meaningful comparisons of storage technologies within each use case.

the attributes of energy storage (e.g., high performance, fast response times, etc.). 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 (e.g., frequency regulation)

- Energy storage differs from generation in that an individual energy storage system is capable of performing multiple functions (i.e., stacked use cases). To highlight this ability, as well as the potential value proposition of energy storage systems, we have incorporated analysis on the returns profile of several illustrative energy storage systems performing multiple use cases. Our analysis indicates that the stand-alone economic viability of an individual energy storage system 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 over 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

- 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 cycle in which energy storage cost declines facilitate wider deployment of Alternative Energy technology, creating more demand for, and spurring further innovation in, energy storage technology
- Cost declines projected by Industry participants vary widely between storage technologies—some Industry participants expect lithium battery capital cost declines of ~36% over the next five years, while flow and lead batteries are expected to experience lesser capital cost declines over the same period
- 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

3) As the energy storage market continues to evolve, several potential sources of revenue available to energy storage systems have emerged; ultimately, the mix of available revenue streams for a particular energy storage system varies significantly across geographies

- Revenue sources available for energy storage systems can be categorized according to the type of entity paying the system owner. Currently monetizable revenue sources available to deployed energy storage systems are paid by one of three stakeholder groups: (a) a wholesale market (e.g., PJM, CAISO, etc.); (b) a wires or integrated utility; and/or (c) a customer (potentially via a competitive retailer or aggregator). Available revenue sources for a given use case depend partially on the technical configuration of the energy storage system, including maximum power and usable energy, as well as permissible number of cycles per day and/or over the life of the system
- Among the currently identifiable revenue sources available to energy storage systems, demand response and demand charge mitigation represent potentially attractive revenue opportunities in selected geographies. However, other use cases, such as time-of-use energy arbitrage and spinning reserves, do not currently present economically viable sources of revenue for energy storage system owners

Conclusion

Both the LCOE and LCOS studies will continue to evolve over time by necessity, and we appreciate that there are various views regarding the merits of some of the data inputs utilized. Accordingly, we would be happy to discuss this work in detail with you.

Lazard has remained committed to the Alternative Energy sector because we believe that new technologies will continue to be developed and existing technologies will continue to be more widely deployed, particularly in light of increasing cost-competitiveness relative to conventional generation. Importantly, while energy storage could one day fundamentally change the way the U.S. and global power grids operate, Alternative Energy generation technologies, which remain intermittent despite significantly decreased costs, must for now be deployed as one element of a diversified generation fleet capable of meeting the needs of an advanced economy. In this regard, Lazard has been and remains a strong proponent of coordinated federal and state energy policy that is grounded in rational cost analysis and that will enable smarter energy development, sustainable energy independence, a cleaner environment and a strong economy.

More generally, from a client perspective, Lazard’s commitment to the Global Power, Energy & Infrastructure sector is of the highest priority. In that regard, we believe that we have the greatest allocation of resources and effort among any investment bank. Further, we have an ongoing and

intense focus on strategic issues that require long-term commitment and planning. Our objective remains to be a long-term thought leader and the most committed and independent advisor in the sector.

A selection of our recent assignments demonstrates Lazard's presence in every substantive sector of the Power, Energy & Infrastructure sector, globally:

- Advisor to The Carlyle Group on its sale of ITS ConGlobal to AMP Capital
- Advisor to Sempra on its pending acquisition of EFH's 80% ownership interest in Oncor
- Advisor to Calpine on its pending sale to Energy Capital Partners
- Advisor to Peabody Energy on facilitating an ownership change of the Navajo Generating Station (2,250 MW)
- Advisor to FirstEnergy Solutions on its ongoing strategic review
- Advisor to Great Plains on its pending merger with Westar
- Advisor to Areva on its restructuring and associated capital increases
- Advisor to WGL on its pending sale to AltaGas
- Advisor to Invenegy on the capital raise for Lackawanna Energy Center (Winner of North America Conventional Power Project Finance Deal of 2016)
- Advisor to Dynegy on its restructuring of Illinois Power Generating Company (Genco)
- Advisor to BlackRock on its take private of Gas Natural
- Advisor to the Special Committee of the Board of Directors of SolarCity on its sale to Tesla
- Advisor to The Carlyle Group on its sale of Connecticut Highway Service Plazas to John Laing Infrastructure Fund
- Publication of the 2016 Lazard-Sponsored Alternative Energy Poll
- Advisor to the Official Committee of Unsecured Creditors in the Chapter 11 cases of SunEdison
- Advisor to Clean Line Energy Partners on a range of strategic advisory matters, most recently culminating in the DOE's support of its Plains & Eastern long-haul transmission project, and its investment from Bluescape Resources at the holding company level
- Advisor to Columbia Pipeline Group on its sale to TransCanada
- Advisor to Royal Dutch Shell on its ongoing asset sale program
- Advisor to Dynegy on its acquisition of Engie's U.S. fossil portfolio
- Advisor to SDIC Power on its acquisition of Repsol's UK wind assets
- Advisor to the Board of ITC Holdings on its sale to Fortis

- Advisor to Enel Green Power on its integration into Enel
- Advisor to Williams on its proposed combination with Energy Transfer Equity (terminated)
- Advisor to the Corporate Governance Committee of TerraForm Power on its proposed acquisition of the operating assets of Vivint Solar (terminated)
- Advisor to Iberdrola S.A. on the merger of Iberdrola USA and UIL and the formation of AVANGRID
- Advisor to the Corporate Governance Committee of TerraForm Power on its acquisition of the operating assets of First Wind
- Advisor to NiSource on the spin-off of Columbia Pipeline Group and formation of an MLP
- Advisor to Dynegy on its acquisition of the Duke Ohio and EquiPower generation portfolios
- Advisor to Integrys on its sale of Integrys Energy Services to Exelon
- Advisor to Acciona on its sale of one-third of its renewable generation business to KKR
- Advisor to Integrys on its sale to Wisconsin Energy
- Advisor to the Unsecured Creditors' Committee of Energy Future Holdings
- Advisor to Pepco on its sale to Exelon
- Advisor on a wide variety of strategic and capital-raising assignments for other Alternative Energy clients
- Much more significantly, Lazard continues to advise a large number of Industry participants on ongoing strategic and ordinary course matters on a strictly confidential basis